Climate change, water and future cooperation and development in the Euphrates-Tigris basin

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Report | November 2021

Content

Acknowledgements

We would like to thank our interview partners and regional experts for their time and for sharing their expertise with us: Charles Iceland, Dursun Yildiz, Hamza Shareef, Jeroen Warner, Kamal Jalouqa, Mara Tignino, Martina Klimes, Nadim Farajalla, Rami Zurayk, Sadeq Al Jawad, Ömer Lütfi Şen, Sadeq Al Jawad, Tessa Terpstra, Tobias von Lossow, and all other participants of our scenario planning workshops.

We would also like to thank, Ornella Maggi, Nora Hinrichs, Sophie Desmidt, and Veronica Lisini Baldi for supporting the organisation and facilitation of our workshops and assisting our research; Francesco Bosello and especially Ayşegül Kibaroglu, for their conceptual support and review; as well as Adrian Foong for an excellent edit of this report.

Executive Summary

This study examines future impacts of climate change on water resources and the ensuing economic and political challenges in the Euphrates-Tigris basin shared by the countries of Iran, Iraq, Syria and Turkey. The study focuses on three different risks that are affected through climate-related water challenges: (1) livelihoods and food security, (2) political stability and violence, and (3) interstate conflict and cooperation.

Drawing on a review of existing literature and publicly available data, expert interviews, and scenario-building workshops, it identifies social, economic, institutional, and political factors that will shape the future vulnerability and resilience to the effects of global warming. Based on an assessment of current interventions, it derives recommendations for adaptation measures that the riparian countries and regional institutions can implement to mitigate future risks and to seize opportunities for increased cooperation and resilience building.

The main findings of the study are the following:

- Compared to direct human interventions, climate change has so far played only a minor role in changing the basin's hydrology and freshwater ecosystems. However, climate change impacts including decreasing soil moisture and river flows, as well as an increasing frequency and severity of extreme climatic events like droughts, will gradually become more significant and may eventually outweigh those impacts caused through water abstractions or infrastructure impoundments.
- Climate change will complicate and aggravate water-related challenges that are already significant in the region, especially in Iraq and Syria while the incurred economic losses, in turn, will reduce the government's resources for an adequate adaptation response. Yet, climate change might also entail opportunities for improving water security and development more broadly.
- More severe water shortages and water quality problems aggravated by climate change will make it harder to sustain farming and livelihoods depending on ecosystems. A failure to mitigate climate-related water risks can contribute to poverty, food insecurity, and unemployment in rural farming communities, and eventually lead to displacement and internal migration at a larger scale than is seen today.
- Our work shows that the impacts of climate change are different but also significant in urban areas. Deteriorating water quality in the rivers will directly affect drinking water supply in cities while demographic changes in rural areas, such as rural-to-urban migration due to the abandonment of rural livelihoods, could put additional pressure on urban water systems.

- In rural areas, growing water scarcity is likely to increase competition over water and could lead to more local violence (e.g. between different communal groups). Rising poverty and unemployment caused by declining agricultural productivity and the loss of rural livelihoods are likely to raise discontent with political authorities and aggravate existing grievances with regard to poor service provision and natural resource mismanagement. In politically fragile and highly water insecure countries, water weaponisation could become a yet more widespread political tool used by non-state and state actors.
- Rethinking and ramping up basin-wide water cooperation could unlock significant opportunities, including deeper economic integration of the water and energy sectors. If the riparian states are unable to scale up cross-border action in managing water, in contrast, climate change will intensify water insecurity in the future. This, in turn, may fuel social turmoil in Syria and Iraq where water-dependent livelihoods, communities, and economies will be increasingly affected, gradually contributing to regional destabilisation.
- The likelihood and severity of climate change impacts on livelihoods, (human) security, and riparian relations in the Euphrates-Tigris basin will largely depend on the future evolution of the region's socio-economic and political conditions, including for example the type of water management and pollution, demographic changes, or economic conditions.
- The riparian countries have started to bring adaptation efforts underway. Besides limited awareness and understanding about the risks and opportunities that climate change poses, the institutions, capacity, and policy frameworks across the Euphrates-Tigris basin are, however, currently insufficient to cope with the looming challenges of climate change. As for many aspects in this study, Turkey's adaptive capacity is considerably greater than those of the other riparian states.
- Limited progress in climate adaptation is not resulting from a shortage of approaches and solutions embraced by the riparian states. Many key adaptation measures that would increase the climate resilience of water-dependent sectors are known and outlined in national water and adaptation strategies developed by the riparians or regional organisations.
- Various economic, political, security and institutional challenges undermine policy reforms and technical implementation. Barriers range from corruption to lack of finances and a broken state-citizen relationship, creating a "vicious cycle" that is hard to break. Enabling conditions necessary for ushering in a more sustainable, climate-resilient water management are becoming less supportive. As a consequence, the possibilities for mitigating growing water-related climate risks or taking advantage of the opportunities climate change entails are diminishing.
- There is hence not only a need for increasing adaptation efforts considerably, but for improving the governance mechanisms that enable their effective implementation. The riparian states may not have the capacity to shoulder these interventions alone but depend on engagement by the international community.

Based on these insights we propose the following recommendations in four areas:

1. **Help individual basin countries reform water management in water-intensive sectors**

Given the uncertainty about (and low likelihood of) substantial advances in cross-border multilateral water cooperation in the near future, there is a particular need for Iraq and Syria to make the best use of available water by establishing a more sustainable water management approach, e.g. by improving demand management and reuse of wastewater. Given the distinct challenges they face, riparian countries will have to pursue different priorities. For Syria and Iraq, it will be critical to rebuild essential infrastructures for water supply and wastewater treatment. In their own interest in terms of regional stability and prosperity, Turkey and Iran should seek to reduce negative cross-border impacts (e.g. by conducting environmental impact assessments that explicitly study downstream effects).

2. **Help the region devise adaptation options that strengthen overall water security**

Measures that should be prioritised include mutual learning, data-sharing, joint risk assessments, and exploration and identification of effective adaptation options. Advancing climate adaptation will require strengthening efforts for international policy processes (such as the NDCs) and for accelerating implementation. The international community can assist the riparian countries, for example, in accessing climate finance and ensuring that sustainable water resources management is adequately considered in climate adaptation strategies and projects. At the same time, it is critical to make sure that climate resilience is an integral part of water management. The international community can ensure this, for example, by making climate resilience conditional in the finance it provides for rebuilding water infrastructures or improving water management. Adaptation efforts should also support individual countries in their respective efforts to increase alternative livelihood options, manage internal friction over resource access, and prepare strategies for coping with larger numbers of internal and cross-border refugees.

3. **Support the conditions that enable advancements in institutionalised cross-border water cooperation**

Improving knowledge will be important, not only to make water resources management more effective but also to help the riparian countries build trust with one another and with cross-border water institutions. Knowledge creation will also be essential in the context of benefit-sharing and economic cooperation, for example, by promoting studies that map out mutually beneficial development pathways (such as on joint water and energy projects discussed in this study). Moreover, it will be crucial to strengthen the capacity of existing institutions (including those working in agriculture, irrigation, and other water-relevant sectors) to cope with future changes, as well as to support the process of establishing a future platform for multilateral cooperation. Interventions in this regard must also improve stakeholder participation, extending processes to a broader range of stakeholders from civil society and the private sector. The international community may play an increasingly important role in mediating inter-state conflicts, as water stress in the basin is increasing. This is

especially true in the absence of transboundary institutions and mechanisms that could mediate conflicts.

4. Help strengthen the water governance system in the riparian countries

Efforts should aim at making environmental and water legislation more robust, and ensuring more systematic enforcement of such legislation. While central water agencies exist in all riparian countries, these tend to be largely incapable of implementing effective and sustainable water resources management (except in Turkey). Growing future challenges will widen the gap between resources and know-how. River basin organisations need to be established to allow for basin-level water management, but these only exist in Turkey. Without significantly larger interventions in capacity-building and resource provision, government institutions will not be able to accomplish major reforms of water management, given the range of discussed structural challenges. As experts are not in a position to overcome many of the structural challenges of governance systems, it will be critical for the international community to consider approaches that enable them to provide effective development assistance in contexts that may become yet more dysfunctional and ineffective. This could include support for decentralised governance, including irrigation associations, empowerment of civil society (e.g. for women), and trying to leverage private sector actors for positive change (e.g. in the realm of renewable energy).

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1. Introduction

This report examines the complex interactions between climatic stresses, water and food security, as well as conflict risks and riparian relations in the Euphrates-Tigris basin. In doing so, it identifies key socio-political conditions in the region and how they could shape future vulnerability[1] and resilience to the effects of global warming. Based on an assessment of current interventions, it derives recommendations to mitigate future climate risks and to seize opportunities for increased cooperation and resilience building.

Climate change will affect millions of livelihoods and large parts of the economies in the Euphrates-Tigris basin. Adapting to the looming impacts of climate change as well as to other foreseeable demographic, socio-economic and political challenges will be crucial for the riparian countries Iraq, Turkey, Syria, and Iran. In a basin that has undergone rapid population growth and development and has been constantly engulfed in conflict, institutions, governance systems, and policy frameworks struggle to manage water resources in a sustainable way. Because of its close proximity to Europe, development, stability, and peace in the basin are a particular concern for the EU's external action and development policy.

In our analysis, we consider a wide range of social, economic, institutional, and political factors that moderate the effect of climate change on livelihoods, (human) security, and diplomatic relations in the Euphrates-Tigris basin. In doing so, we avoid reductionist perspectives on climate change and security and consider climate-related pressures as part of broader social-environmental dynamics. The scholarly debate about the role of climate change in the Syrian civil war, as a prominent example, highlights the value of a more careful analysis and more attention to the socio-economic and political contexts, in which climate impacts on (human) security unfold (see Selby et al., 2017a, 2017b; Daoudy, 2021b).

This study is part of the CASCADES[2] project and builds on a theoretical framework of cascading climate risks that has been developed by the CASCADES research team. This framework focuses on climate triggers (CT) from a biophysical, meteorological, and hydrological point of view. It covers their knock-on effects on agricultural production, livelihoods, and social relations along so-called impacts transmission systems (ITS), possibly leading to risks that spread beyond borders and sectors (Hilden et al., 2020). Importantly, the study also considers key scope conditions, i.e. contextual factors that shape exposure, vulnerability, and resilience to impacts along the impact transmission chain. The Euphrates-Tigris case study contributes to the CASCADES project by

[1] We use a definition of vulnerability by the IPCC (2014), where it is defined as "the propensity or predisposition to be adversely affected. Vulnerability encompasses a variety of concepts and elements including sensitivity or susceptibility to harm and lack of capacity to cope and adapt." The vulnerability of human or natural systems, together with their exposure, interact with climate-related hazards to shape the risks from climate change.

[2] See: https://www.cascades.eu/.

diagnosing risks and vulnerabilities in that region and by discussing possible risk reduction measures.

Drawing on a review of existing literature and publicly available data, expert interviews, and a scenario planning exercise with regional experts and stakeholders, the report is divided into three main sections. First, it describes key characteristics of as well as historic and current developments in three risk areas affected by climate change: livelihoods, water and food security, political stability and violence, and transboundary conflict. Second, it assesses how possible impacts of climate change affect these risk areas in the year 2050, considering the important factors that shape vulnerability towards climate change. Third, it outlines the most essential measures to reduce previously outlined future risks and seize opportunities with an emphasis on water management, climate adaptation, transboundary cooperation, and governance systems.

1.1 Methodology

This report uses a mixed methods approach, combining qualitative literature review, analysis[3] and visualisation of both historical data and future climate impact projections from the ISIMIP[4] project, semi-structured interviews, as well as a participatory scenario planning exercise conducted with regional experts. Desk research included academic papers, grey literature, technical reports, and policy briefs, in order to prepare for semi-structured interviews with experts and stakeholders. Following the snowball method, 16 semi-structured online expert interviews were conducted between September 2020 and January 2021 with representatives of national, regional, and international organisations; civil society, academia, and think tanks; and experts in hydrology, climate adaptation, security, water diplomacy, and other relevant disciplines. Given their distinct expertise, the interview questionnaires focused on different aspects of the subject analysed in this study.

The scenario planning exercise had the objective of projecting possible climate risks and vulnerabilities into the future and deriving recommendations for climate adaptation, foreign policy, and development cooperation. The exercise was initially planned as an on-site workshop in Beirut, Lebanon, but was finally implemented in the form of eight virtual sessions over a period of four weeks due to travel restrictions in relation to the COVID-19 pandemic. Following an inaugural session to discuss the topic of our research and identify major risks and vulnerabilities in the region, three breakout sessions with smaller groups were organised to develop three scenarios for the future development of the region's vulnerability and resilience to climate-related risks. Subsequently, another plenary session to discuss risk reduction and adaptation options with the whole group was organised. It was followed by another three breakout sessions. Great care was taken to recruit participants from the three countries and from diverse professional backgrounds (e.g. academics, policymakers and advocates, as well as development and security sector practitioners).

The exercise resulted in the development of three scenarios for the region for the year 2050. The scenarios are not exhaustive but rather meant to offer insights into different plausible futures and to inform policies and adaptation strategies; our methodology is discussed in more detail in a forthcoming paper (Mueller & Detges, forthcoming). Implications of the scenarios for regional vulnerability and resilience to climate-related security and development challenges are discussed in section 3.

[3] Through maps, figures, and descriptive statistics that are partly shown in this report.

[4] The Inter-Sectoral Impact Model Intercomparison Project (ISIMIP) "offers a framework for consistently projecting the impacts of climate change across affected sectors and spatial scales. An international network of climate-impact modellers contribute to a comprehensive and consistent picture of the world under different climate change scenarios" (https://www.isimip.org/).

1.2 Basin characteristics, water endowments and use

The Euphrates-Tigris basin is a system comprising two rivers. Both originate in Turkey and cross northern Syria before entering Iraq. In Southern Iraq, they merge to form the Shatt al-Arab river which discharges into the Persian Gulf. The Tigris also receives discharge from several tributaries originating in Iraq and Iran. The region between the two rivers is called Mesopotamia. More than 98% of the Euphrates' discharge originates in Turkey. About 51% of the Tigris' discharge is generated on Turkish territory, while the remainder, 39% and 10%, comes from Iraq and Iran, respectively (Food and Agriculture Organization, 2009).

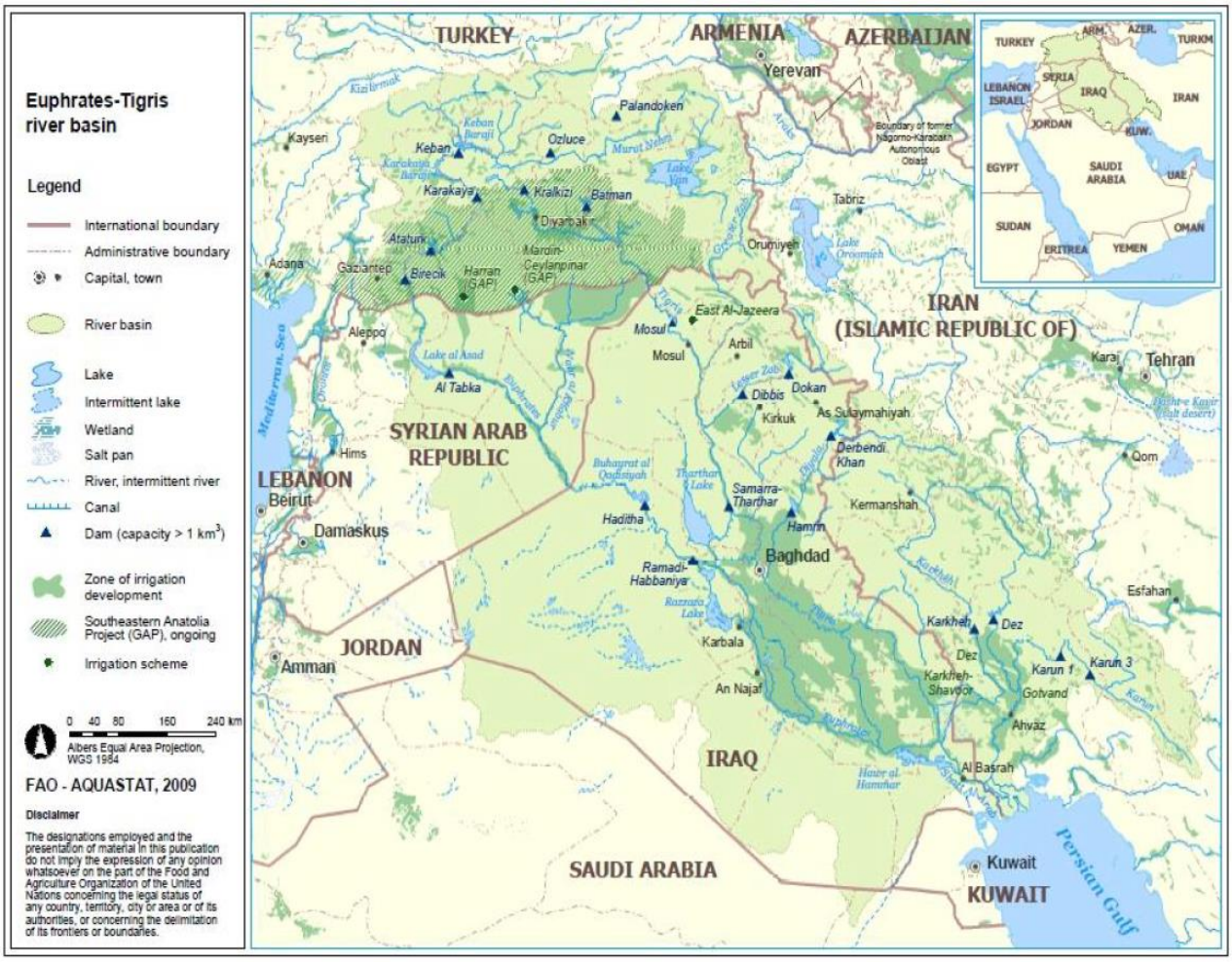

Figure 1: Map of the Euphrates-Tigris basin[5]

The Tigris and its tributaries supply water to approximately 30 million people, while the Euphrates is the source of water for around 60 million people. As it comprises the largest share of the basin's population, Iraq dominates water use from the two rivers, thereby being the most dependent on them (see Table 1). Similarly, Syria is highly

[5]Source: Food and Agriculture Organization (2009).

dependent on the transboundary waters. In all riparian countries, agriculture is responsible for the bulk of water abstractions from the two rivers (around 78%[6]). Turkey uses the two rivers for hydropower production to a significantly higher degree than the other riparian countries.

Table 1: Key metrics on water endowments and use[7]

	Turkey	Syria	Iraq	Iran
Basin population (million inhabitants in 2014)	11.9	11.8	28.8	12.9
Renewable water resources per capita (in m3/year) in 2017	2609	983	2393	1699
Dependence on transboundary water resources (%) in 2017	1.5	72	61	7
Total abstractions (km3/year) in 2014	20	14	51	28
Water withdrawal in agriculture (%) in 2017	85	88	92	92
Water withdrawal per capita (m3/year) in 2017	727	980	1027	1157
Baseline water stress: Ratio of total withdrawals to renewable resources in 2017	45	124	54	81
Share of hydropower in electricity production (%) in 2011	23	8	8	/

All countries in the basin struggle with water stress. In Iraq, Syria, and Iran, close to 80% or more of the population is exposed to high or very high levels of water stress, far above the global average of 40% (World Bank, 2018). Table 1 shows that water stress is highest in Syria, when looking at nationally aggregated data. Yet, pockets of high to extremely high water stress can also be observed in the Iranian part of the basin, as well as in the southern Turkish part and along the border between Iraq and Iran (Figure 2). Because of overexploitation in some parts of the basin, mostly of groundwater, total water resources in the basin have decreased over recent decades (Rodell et al., 2018). Moreover, the gradual deterioration of water quality is rendering a significant proportion of water unusable, thereby further aggravating water stress.

[6]Own calculations based on DSI (2013); MoWR (2014); Mahmoud and Sayegh (2017).

[7] Sources: TWAP (2014); Shamout & Lahn (2015); Food and Agriculture Organization Aquastat (2017).

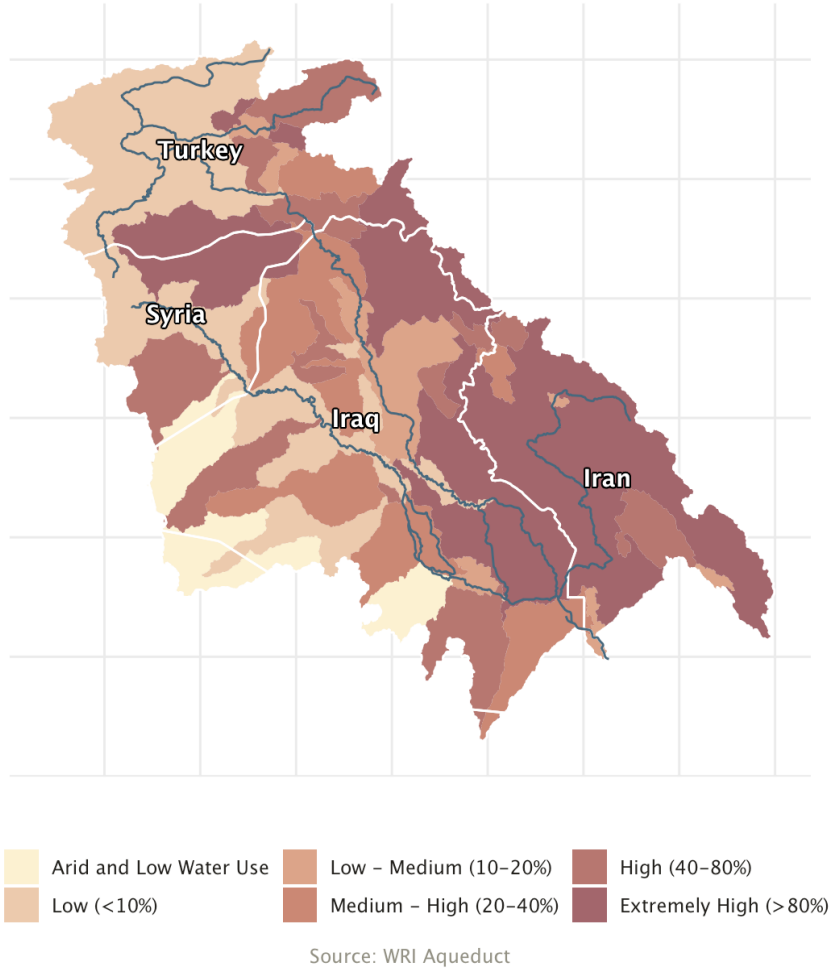

Figure 2: Baseline Water Baseline Water Stress in the Euphrates-Tigris basin[8]

[8]Baseline water stress measures the ratio of total water withdrawals to available renewable surface and groundwater supplies. Water withdrawals include domestic, industrial, irrigation, and livestock consumptive and non-consumptive uses. Available renewable water supplies include the impact of upstream water consumption and large dams on downstream water availability (Hofste et al., 2019). Data on water stress are taken from WRI Aqueduct (World Resource Institute, 2019).

2. Current water-related socio-economic and political challenges

This section presents key water-related socio-economic and political challenges in the Euphrates-Tigris basin. The focus here is on water availability and its implications for livelihoods and political stability, as well as diplomatic relations between the riparian countries.

2.1 Livelihoods and water and food security

Water security is fundamental to a large share of the basin's livelihoods, and especially for low income households and for people who eke out a living from smallholding farming, livestock rearing, and fishing. At the same time, water security is a crucial issue as poor drinking water supply and access to sanitation undermine human health and well-being.

Water availability has significant implications for **agricultural productivity** in the basin. A large part of the basin's population depends on agriculture and is employed in this sector. The agricultural sector is the largest employer in Syria and Iraq. However, the contribution of agriculture to GDP in all countries is declining (see Appendix). Crop production, mostly on small farms, is the dominant livelihood, next to livestock rearing. Yet, as a result of the modernisation of agricultural systems, urbanisation, and rural-to-urban migration, the employment share of agriculture has decreased over the past two decades in all riparian countries and dramatically so in Syria and Turkey (see Appendix).

Figure 3 shows the ratio between rainfed and irrigated agriculture. In all riparian states except Syria, rainfed and irrigated agriculture are deployed to a similar extent. . The degree to which water-related risks affect agricultural areas today can indicate how vulnerable they are towards climate change in the future. Rainfed agriculture in Turkey faces only low drought risks. In Syria, in contrast, high to extremely high levels of drought risk affect nearly all areas of rainfed agriculture (see figure 4). In Iran and Iraq, medium to extremely high levels of drought risk and water stress affect nearly all agricultural areas, although water stress is a greater risk for agriculture in Iran than in Iraq.

Furthermore, a considerable part of the population is dependent on **ecosystems** that are highly sensitive to shifts in available water resources. Among them, inland fisheries and aquaculture are particularly important for the Iraqi and Syrian economies and livelihoods (Bachmann et al., 2019). 60% of the fish consumed in Iraq comes from the Mesopotamian Marshes (Alwash et al., 2018).

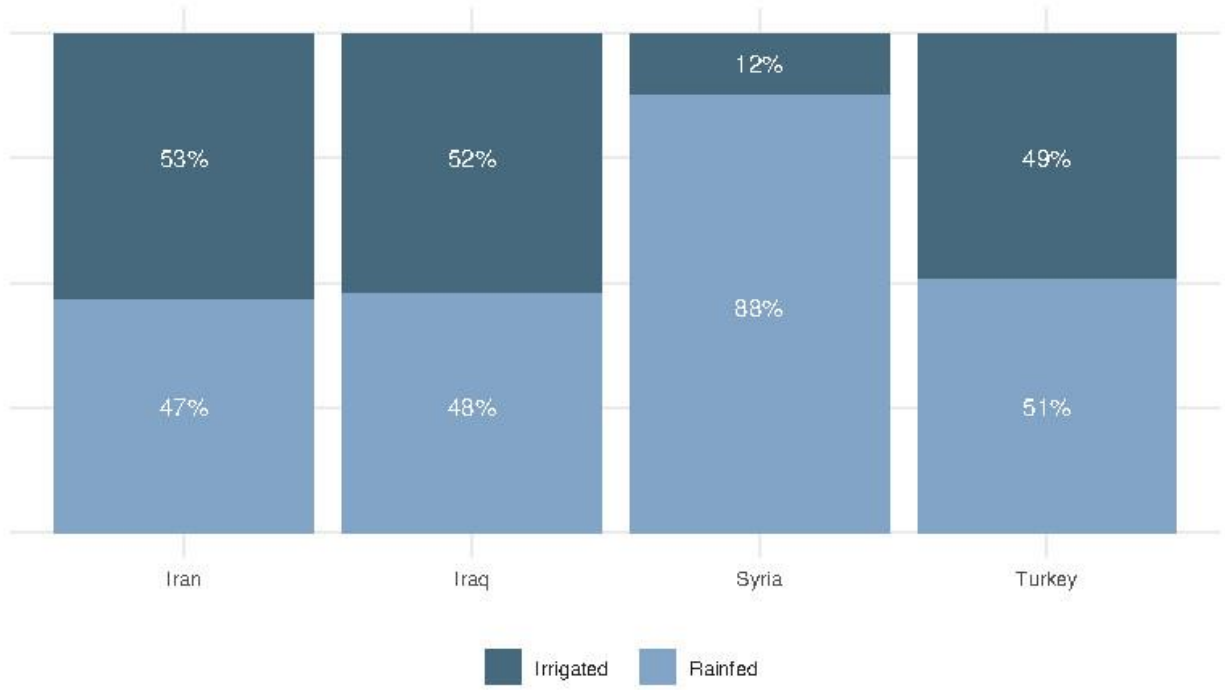

Figure 3: Ratio between irrigated and rainfed crop area in the riparian countries[9]

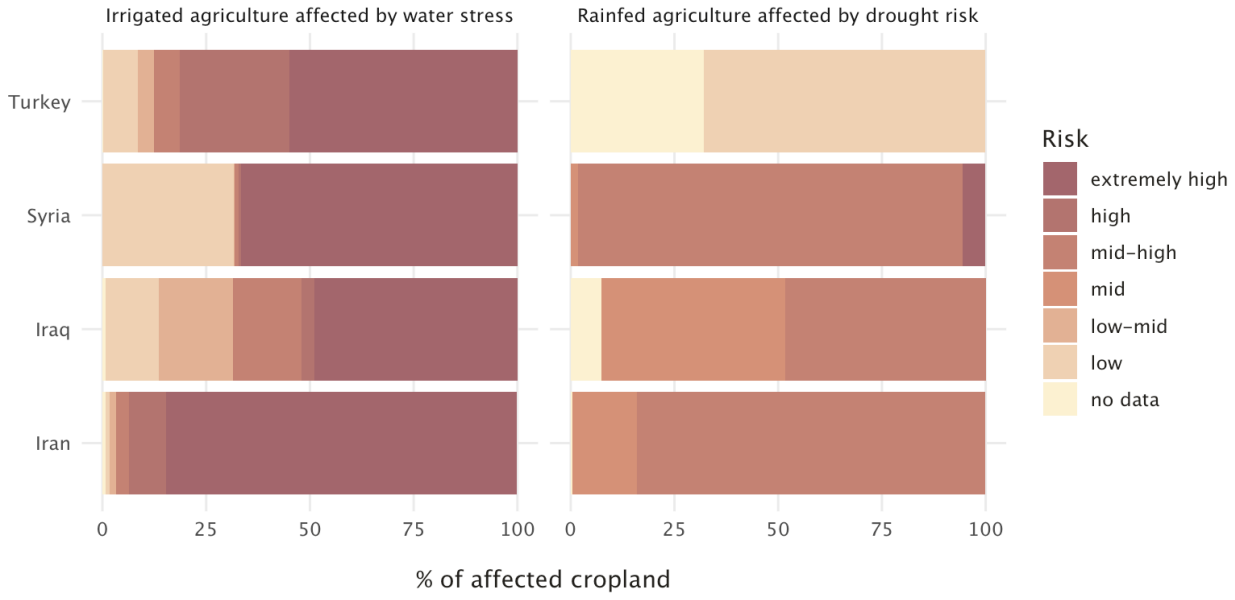

Figure 4: Water related risks for crops in the Euphrates-Tigris basin[10]

[9] Source: World Resource Institute (2019)

[10] Source: World Bank (2018)

However, many ecosystems are in decline, and with them the ecosystem services that provide for millions of livelihoods in the basin. The flows of the Euphrates River have decreased by 40-45% since the 1970s due to the construction of more than 30 dams and barrages (Shamout & Lahn, 2015). Other studies find evidence for decreasing flows of the Euphrates as well, but associate them with changes in precipitation (Venturi and Capozzoli, 2017). Many small rivers across the basin have dried up completely due to over-abstraction of water. A recent study shows that environmental flows[11] in the Euphrates remain far below the thresholds to sustain ecosystems and biodiversity in the river (Jägermeyr et al., 2017).

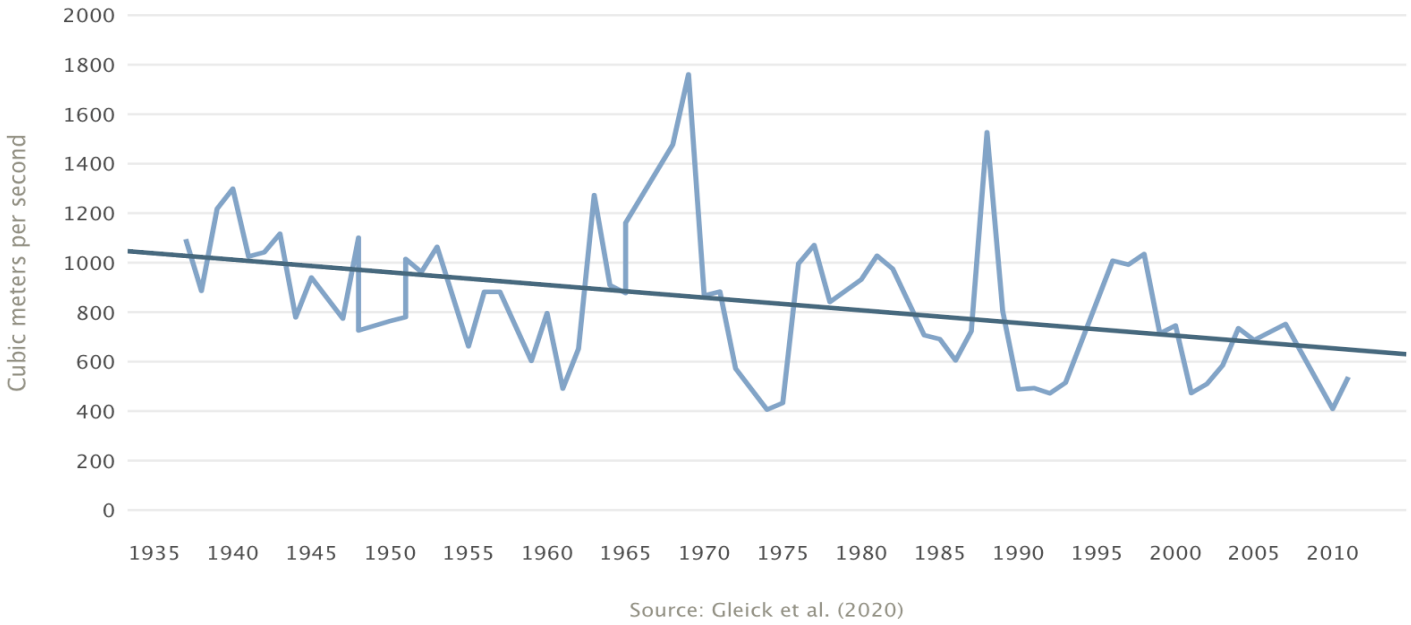

Figure 5: Annual average discharge of the Euphrates River and trend, 1937-2010[12]

The Mesopotamian Marshes in Iraq are by far the most important freshwater ecosystem in the Middle East, which provided livelihoods for nearly half a million Iraqis in the 1970s, while also supporting significant biodiversity. In the early 1990s, Saddam Hussein drained the Marshes to starve the local population. The majority of the inhabitants were forced to leave the Marshes, significantly reducing the number of people living in that area. Nevertheless, the Marshes' water resources continued to sustain the livelihoods of some 20,000 people in 2003 (United Nations, 2013). The Marshes were restored in the early 2000s, with 40-60% being reflooded, but they are still suffering from declining flows and water quality problems (Gleick et al., 2020).

The **water quality** of the Tigris, including water originating in both Turkey and Iraq, is presumably good, yet it becomes poorer downstream, with major pollution inflows from urban areas such as Baghdad due to sewage discharge. The water quality of the Euphrates entering Iraq is poorer than that of the Tigris due to agricultural return flows

[11] Environmental flows are defined as "the quantity, timing, and quality of freshwater flows and levels necessary to sustain aquatic ecosystems, which in turn support human cultures, economies, sustainable livelihoods, and well-being." (Arthington et al., 2018).

[12] Measured at Jarabulus, downstream of the border between Turkey and Syria.

in Turkey and Syria, and is expected to get worse as more land comes under irrigation (Alwash et al., 2018). In addition to increasing salinity, intense agricultural activities and the dumping of untreated sewage in the Euphrates and its tributaries have polluted the rivers, with increasing nutrient levels and coliform bacteria counts in all three riparian countries. Natural characteristics of the Euphrates, such as high evaporation rates, strong climate variability, salt and sediment accumulation, poor drainage, and low soil quality in the river's lower reaches, exacerbate the damaging effects of pollution from human activities (Bremer, 2013). The Euphrates' water quality is further degraded as flood flows are diverted into off-stream storage in Tharthar Lake, where salts in the lake are absorbed by the stored water, and later returned to the river system. The amount and quality of water entering southern Iraq from Iranian territory is largely unknown, although it is clear that flows are impacted by irrigation return flows originating in Iran.

Drinking water supply and **sanitation** are also poor in many parts of the basin, with serious consequences for human health and well-being. Annex B in the Appendix shows that there are important differences among the riparian countries regarding the water available per person, with high values for Turkey and Iran, and much lower values for Iraq and especially for Syria. Available data show that access to water and sanitation has improved over time, but full coverage is far from being achieved. At the same time, only 52% of households connected to the public water network report that their water supply is stable (World Bank, 2018). Overall, people living in urban areas have better access to water than in rural areas (United Nations, 2021).

The consequences of poor access to water and sanitation are severe. **Diseases** such as cholera and diarrhoea can be transmitted via contaminated water. For example, because of high salt concentrations in the public water supply system, which rendered the supplied water undrinkable, around 90,000 people in Basra had to be hospitalised in 2018 (Independent, 2018). Moreover, water-borne diseases increase mortality. Compared to other countries in the MENA region, Syria has very high rates of children under five dying from diarrhoea (World Bank, 2018).

Over recent decades, an increasing number of people in the basin have been exposed to **food insecurity**, in part also because of reduced water resources. The prevalence of undernourishment has remained relatively stable in Turkey and Iran. In Iraq, the situation is better than in the embargo years of 1990-2003, but rates of undernourishment have been constantly increasing since the early 2000s (see Appendix 3). However, the number of undernourished people in Iran and Syria has been increasing. According to recent data from the World Food Programme (2021), 60% of Syria's population is currently food insecure, mostly due to the war in the country. Overall, food insecurity is more prevalent in rural areas (ibid.).

Syria and Iraq also provide indicative evidence that stress on agricultural livelihoods and a subsequent rise in food insecurity, poverty, and unemployment have an influence on population **displacements** and accelerated **rural-urban migration** in the region. This adds to pressures in relation to violent conflicts and other push and pull factors, such as natural population growth, economic reforms, the cancellation of subsidies, and more general patterns of seasonal, labour, and rural-to-urban migration (see Gleick, 2014; De Châtel, 2014; Werrell et al., 2015; Gleick, 2017; World Bank, 2018; Selby et al., 2017a). In particular, rural-urban migration in Syria has also been driven by changes in land laws in 2007 and 2008, restricting land sales and allowing landowners to terminate tenant contracts with immediate effect (Ababsa, 2015).

Rural-urban migration is a challenge in the region, and numerous cities struggle with crumbling infrastructures and rapid growth of informal settlements in peri-urban areas. Violent conflicts in Iraq and Syria have accelerated this process by displacing large numbers of people (Werrell et al., 2015; Selby et al., 2017a). The number of internally displaced persons in the Euphrates-Tigris basin is high: for Iraq alone, this figure was estimated at 1.2 million, according to the International Organization for Migration (2021). High numbers of displacees and rural-urban migrants create challenges in terms of access to essential services (including health and education) and per capita water availability (Werrell et al., 2015; Waha et al., 2017). In Syria, for example, rural-urban migration has increased competition for employment and access to water among low income households (Femia & Werrell, 2013).

People who leave their homes to escape environmental changes and settle elsewhere may not necessarily be something negative. Indeed, it can be a useful coping or adaptation strategy if carefully planned and implemented. While resettlements can have benefits for both migrants and the society at large, those affected may prefer to abandon their homes. Migration can also involve high financial and social costs (Ionesco et al., 2016). In countries that receive migrants, migration can have local benefits and create opportunities. A study by Hussein et al. (2020) finds that the high number of Syrian refugees in Jordan and Lebanon have shaped national discourses on water governance. While the arrival of refugees in water-short countries can easily foster narratives in which refugees are portrayed to exacerbate water scarcity, the study also finds that such discourses have evolved into a recognition of the challenges posed by climate change and water scarcity, leading to positive actions (such as the mobilisation of finance to reinforce the climate resilience of water systems).

2.2 Water, political stability and violence

According to the Fragile States Index, **political instability and fragility** have generally decreased in recent years in the Euphrates-Tigris basin, with the exception of Syria, which experiences a worsening situation, and Iran, where the situation has been constant for some time, but is recently also deteriorating (Fund For Peace, 2021). Political stability in the region is obviously challenged by a number of factors, many of which are extensively discussed elsewhere. This section focuses on how political stability is affected by water stress and other water-related challenges, as described in previous sections, and on how they contribute to fragility in the basin, considering in particular three types of conflictual situations: citizen-state interactions, communal water conflicts, and water weaponisation.

Indeed, water is related to different forms of conflict and social turmoil in the basin, including disputes over access to water and control of water systems, the strategic targeting and weaponisation of water infrastructure, as well as through grievances in relation to mismanagement and poor access to water resources (see Gleick, 2014; De Châtel, 2014).

In particular, **civil unrest and protests** can erupt in a context where public authorities fail to provide adequate access to water, and to shield populations against the adverse effects of droughts and other extreme events. Protests can also occur where reforms to the agricultural and water sectors stand at odds with the needs of farmers and rural communities.

Water is so essential to peoples' lives and livelihoods that governments have a special obligation to ensure adequate access for their citizens. Failure to fulfill this obligation is likely to strain state-citizen relations, fuel grievances, and pave the way for civil unrest. In particular, tensions will rise when access to water and water services is insufficient for large parts of the population, and also when access is perceived to be unequally distributed or profiting only a small minority of well-connected elites (see Detges, 2018:29ff).

Examples of such a conjuncture are found in several countries of the basin. For instance, de Juan and Bank (2015) describe how Ba'athist governments in Syria have privileged certain regions and prioritised service delivery to political supporters, thereby fuelling grievances and discontent among neglected communities. Focusing on power cuts prior to the Syrian uprising, they show for example that underserviced areas were later to become hotbeds of contestation against Bashar al-Assad.

De Châtel (2014) makes a similar argument about the water sector in Syria. She explains how widespread discontent with the regime was partly also driven by the removal of subsidies for water-intensive crops, as well as changes in the licensing system for wells, thus encouraging corruption and making it harder for politically less well-connected people to access water. For years, the Ba'athist government had heavily subsidised water-intensive crops like wheat and cotton (Gleick, 2014; Werrell et al., 2015). This, together with inefficient water policies and a laissez-faire attitude led to the deterioration of water resources and soils and the overpumping of aquifers, thereby spurring discontent with the government (Sowers et al., 2013; De Châtel, 2014; Werrell & Femia, 2013). Moreover, when Bashar al-Assad decided to cut agricultural subsidies and instead redirect public investments to industries controlled by his supporters, this

did not bode well with many Syrians who had been struggling under a poorly managed agricultural and water sector.

Further examples of the political sensitivity of water-related issues can be found in Iraq and Iran. For instance, at least 14 people died in 2018 when protests against poor water services, quality and shortages in central and southern Iraq turned violent (Gleick et al., 2020). More people were injured in the same year in protests over poor water quality in Khorramshahr at the border between Iraq and Iran (ibid.). Similar incidents were also reported in the same year in major population centres in Iran and Iraq (Dehghanpisheh, 2018). In particular, the city of Basra in Iraq saw at least 15 people dying in protest over contaminated water that turned violent (VOA News, 2018).

These examples highlight how poor water management and past failures to provide adequate access to water have deteriorated state-citizen relations and compromised political stability in the Euphrates-Tigris basin.

Conversely, violence and political instability also pose a serious threat to water security in the basin. Studies have shown how conflict-affected areas struggle to ensure water security for local communities and especially for low income households (e.g. Sadoff et al., 2017). For example, access to safe water and sanitation declined by 70% in Iraq and Syria as a result of armed conflict, with water-borne diseases becoming more prevalent at the same time (World Bank, 2018).

Furthermore, competition over water resources can incite **violent conflicts** between families or communities. Casualties because of disputes over water are common in Iraq (Kool et al., 2020). The online water conflict prediction tool by the Water, Security and Peace Partnership (2021) finds that many areas of Iraq and Syria are affected by ongoing conflicts over water, while in some areas new local conflicts over water are emerging. Haphazard liberalisation policies, the erosion of customary systems of resource governance, as well as corrupt officials and fuzzy or poorly enforced rules often play an important part in these conflicts (see Saleeby, 2012; De Châtel, 2014). Figure 6 displays instances of communal violence in the Euphrates-Tigris basin over the past three years. Interestingly, a number of communal conflicts have occurred along the Euphrates in Syria and in the Mesopotamian Marshes in the south-eastern part of Iraq. The Shatt al-Arab river in Iraq's south, as aforementioned, is particularly affected by salinisation and water pollution, which may have contributed to the increased number of conflicts there.

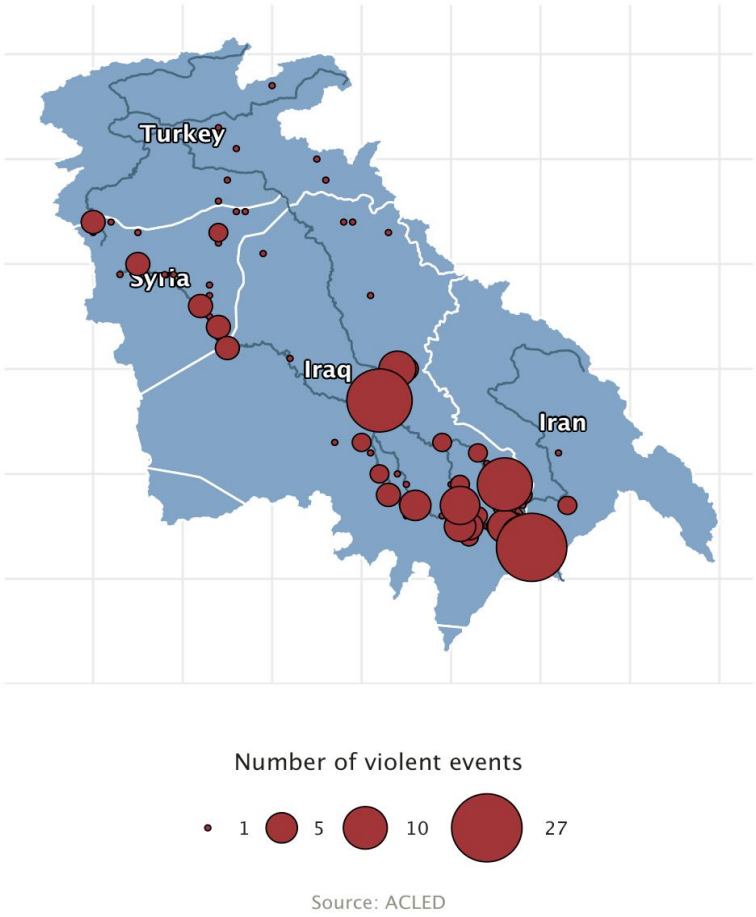

Figure 6: Recent communal violence in the Euphrates-Tigris basin[13]

Lastly, peace and political stability in the Euphrates-Tigris basin are influenced by the disposition of conflict parties and armed groups to use **water as a weapon** (Gleick, 2014). Water weaponisation refers to incidents where different actors, both state and non-state, have used or deliberately targeted water systems to pursue strategic goals, including the poisoning of wells or releasing water from dams to flood downstream areas (King, 2016). The Euphrates-Tigris basin ranks among the five transboundary basins with the world's highest rate of incidents of water weaponisation, and the first in terms of the number of people being killed in these events (Veillux & Shlomi, 2019).

In recent years, water weaponisation has been common, both in Syria and Iraq (von Lossow, 2016; Daoudy, 2020). Figure 7 shows the number of terrorist attacks on water systems over the past 20 years. Events have been more frequent in Iraq, but have also more recently occurred in Turkey and Syria. It should be noted, however, that water systems are and have also been frequently targeted by state actors. In both Syria and Iraq, the regimes under Bashar al-Assad and Saddam Hussein manipulated water supplies to put certain population groups or regions at a disadvantage. To this end, the drainage of the Mesopotamian Marshes serves as a prominent example (von Lossow, 2016).

[13] Source: Armed Conflict Location & Event Data Project, available at: https://acleddata.com.

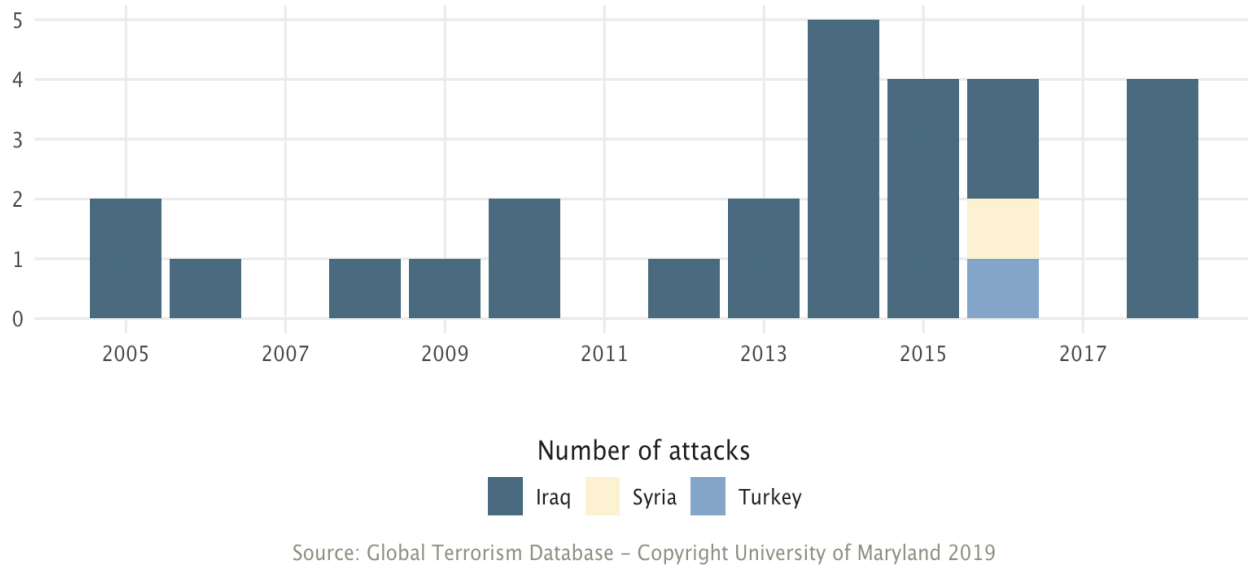

Figure 7: Terrorist attacks on water systems over the past 20 years[14]

[14] Source: National Consortium for the Study of Terrorism and Responses to Terrorism (START), University of Maryland. (2019). The Global Terrorism DatabaseTM, available at: https://www.start.umd.edu/gtd/.

2.3 Transboundary conflict and cooperation

The history of the Euphrates-Tigris basin is marked by various incidents of both conflict and cooperation. While relations have generally been harmonious between Turkey, Syria, and Iraq until 1960 (Kibaroglu, 2019), tensions have increased since then. In the 2000s, cooperation efforts in the basin restarted, but were halted due to several factors. Between 1990 and 2008, the basin featured a comparably high number of interactions between the co-riparians (see Figure 8). Despite a multitude of cooperative events that have occurred in the basin, it is at the same time among the regions that have faced the highest number of hostile interactions worldwide (Rüttinger et al., 2015). Overall, the basin's cooperative and conflictive history can be chronologised according to four periods presented as follows.

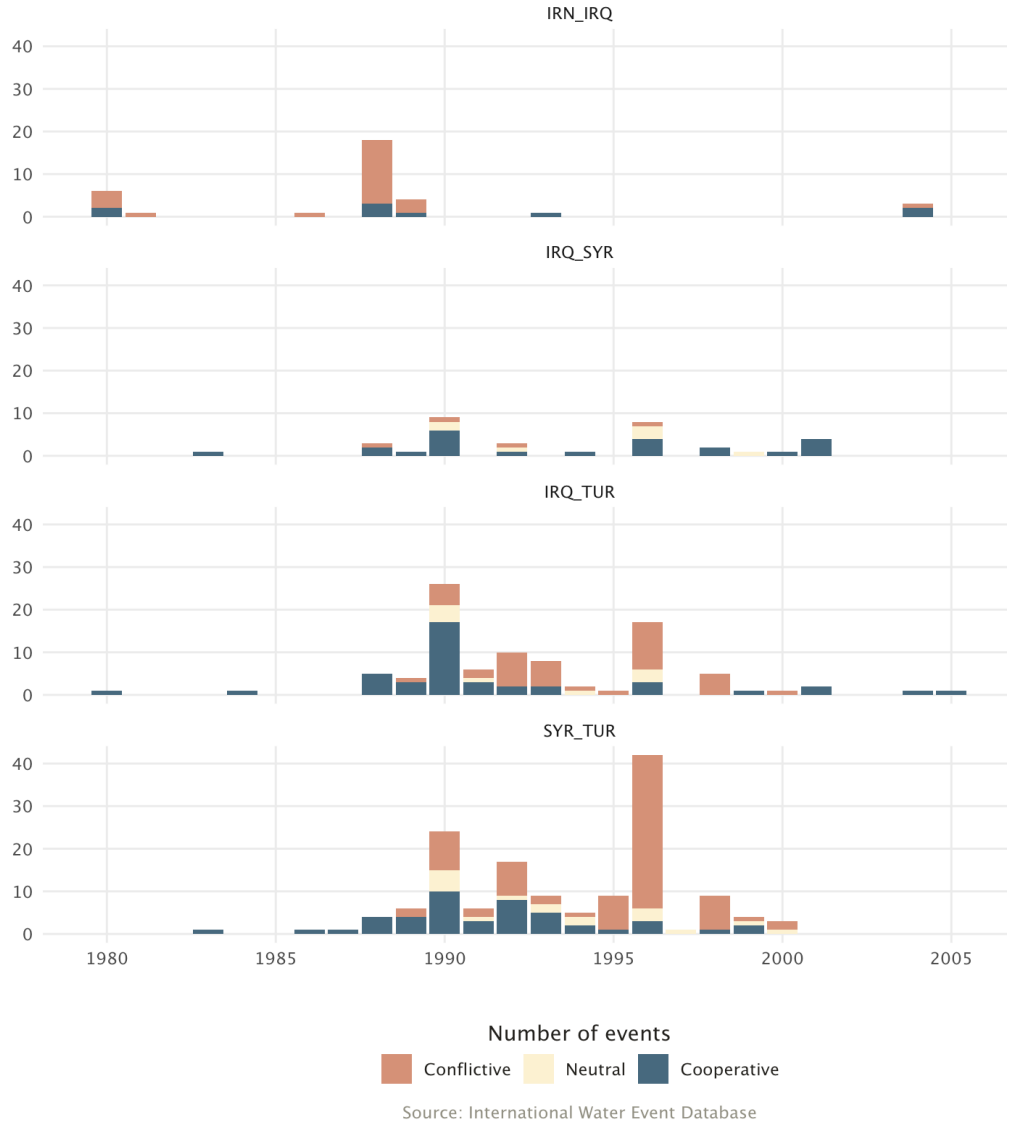

Figure 8: Conflict and cooperation over water in the Euphrates-Tigris basin[15]

[15] International Water Event Database: https://transboundarywaters.science.oregonstate.edu/content/basins-risk.

In the 1960s, the unilateral and uncoordinated development of large-scale irrigation projects by the main riparian countries led to tensions in the region. One of the first political conflicts over water was triggered when Turkey and Syria simultaneously started using the Keban reservoir and the Tabqa dam during a drought period in 1975 (Kibaroglu & Sayan, 2021).

Between the 1980s and 1990s, tensions in the Euphrates-Tigris basin reached a peak, when riparian states started instrumentalising water by linking it to non-water-related issues as a means to pressure each other (Gleick, 1994). As a consequence of the Iraqi invasion of Kuwait in 1990, Turkey, as an upstream country, cut off the Euphrates flow for a month, and cooperation levels hit a low (ibid.; Vajpeyi, 2012). This was further mirrored in Turkey's refusal to sign the 1997 UN Water Convention.

Despite these unfavourable conditions for water collaboration, the construction of Turkey's Atatürk Dam and its associated exploitation of the Euphrates made cooperation inevitable, leading to the establishment of the Joint Technical Committee (JTC) in 1983. The JTC involved all main riparian countries and aimed at defining the modalities to determine water allocation patterns. Since no joint resolution could be agreed on, mostly due to non-water-related topics, the negotiations were suspended in 1993 (Kibaroglu & Sayan, 2021).

The two agreements on the use of regional waters – the Turkish-Syrian Protocol on Economic Cooperation from 1987, and the Syrian-Iraqi water agreement from 1990 – illustrated mutual interdependence among the riparian countries. However, these have not resulted in a comprehensive and effective transboundary water management framework (ibid.).

The highly conflictive period between 1980 and 1990 was followed by significant improvements in the riparian countries' relations during the **late 1990s and early 2000s**, leading to an increase in water cooperation (Kibaroglu, 2014). Important events in this regard have been Syria's willingness to re-start the JTC meetings, as well as the expulsion of the leader of the Kurdistan Workers' Party (PKK) from Syria (Erikson & Lorenz, 2013). A major turning point in the riparian states' relations was further marked by the adoption of a Joint Communiqué between Turkey and Syria in 2001, which stressed the importance of sustainably using the basin's water resources (ibid.). As a result of the regime change in Iraq, and the improving Turkish-Syrian relations, the Euphrates-Tigris Initiative for Cooperation (ETIC) was established as an informal Track two diplomacy initiative in 2005, promoting water-related transboundary dialogue and scientific collaboration (Kibaroglu & Sayan, 2021). The election victory of President Erdogan's AKP in 2002, and a Turkish foreign policy approach characterised by "zero problems with neighboring countries" until around 2013, further contributed to improving the relations in the Euphrates-Tigris basin during that period (Djavadi, 2016).

Overall, the Memoranda of Understandings (MoUs) on water management between Turkey and Iraq and Turkey and Syria from 2009 are considered as being most significant in contributing to the improvement of riparian relations (Kibaroglu, 2015). Turkey and Syria signed four MoUs in 2009, in which they agreed that water would be a focal point of their cooperation, including the construction of joint dams and water pumping stations as well as the management of water quality and the development of water policies (UN-ESCWA & BGR, 2013).

Although relations in the basin have significantly improved **since the early 2000s**, cross-border cooperation has stalled, given that both MoUs were not ratified. The Iraqi Parliament also rejected an agreement established by the High Level Cooperation

Council between Iraq and Turkey because it did not sufficiently address the issue of water (Erikson & Lorenz, 2013).. In recent years, however, water cooperation between the two states has been improving, as the recent opening of a joint water centre in Baghdad suggests.

The Syrian civil war that started in 2011 caused a major setback to the relationship between Turkey and Syria. The Damascus government changed sides to become a de facto ally of the Syrian affiliate of the PKK, which, among other things, culminated in the withdrawal of its forces from areas in north-eastern Syria. Syria therefore retreated from an earlier agreement with Turkey, namely the Adana/Ceyhan Security Agreement (1998) in which it agreed to combat the PKK, whose insurgencies are a major security issue for the Turkish government (Daoudy, 2009; 2020).

3. Climate change impact and risk analysis

This section discusses possible water-related impacts of climate change in the Euphrates-Tigris basin on the three risk areas described in sections 2.1 to 2.3. Moreover, it presents key factors determining the vulnerability and resilience of the region to these impacts. The list of vulnerability and resilience conditions considered here is not exhaustive, but includes the factors deemed most relevant by the research team and the regional experts consulted during our scenario planning exercise. Short scenarios for the future evolution of these factors are presented in separate boxes in sections 3.2 to 3.4.

3.1 Future impacts of climate change

In the Euphrates-Tigris basin, available water resources have been strained by human activities such as groundwater abstractions for irrigated agriculture, while climate change has only played a minor role thus far (Voss et al., 2013; Rodell et al., 2018). However, climate change is increasingly affecting various elements of the global hydrological cycle, and will continue to do so at ever greater scales in the future (Schewe et al., 2014; Gudmundsson et al., 2021). The Middle East region suffers from most of the adverse effects of climate change, including water shortages, salinisation of water in coastal areas and aquifers, and more frequent extreme weather events such as droughts and excess rainfall leading to floods (Şen, 2019). According to a report by the World Bank (2018), climate change will be a key driver of future increases in water stress in the region, especially in Iraq and Syria.

Meteorological and climatic impacts

Climate change will affect **rainfall** patterns in the Euphrates-Tigris basin. Conditions will generally become drier in the future (Verner, 2013). The IPCC (2013) predicts that rainfall and snowfall across the basin will decline by 30-40% until the end of the century, most significantly over the Turkish part of the basin, which generates the bulk of run-off for the Euphrates-Tigris basin. Under different scenario simulations (A1FI, A2, and B1), another study found that shifts in precipitation could decrease run-off in the Eastern Anatolian Mountains in Turkey by as much as 25-55% (Bozkurt & Sen, 2013). Moreover, according to a recent regional study on the upper Tigris River basin in Turkey, precipitation levels in the area are expected to decrease by 13% after 2021, and by 26% after 2030. Run-off estimates further indicate decreases of 30% after 2040 due to climate change (Şen, 2019).

Our analysis of ISIMIP data for the next 30 years reveals declining levels of average annual rainfall in both RCP2.6 and RCP6.0 scenarios. In particular, the northern part of the basin as well as the border area between Iraq and Iran could see declines in rainfall of up to 40mm per year (see Figure 9). These areas are particularly important for the generation of discharge, and they also accommodate significant proportions of rainfed agriculture, both of which will be affected through lower rates of rainfall (UN-ESCWA & BGR, 2013).

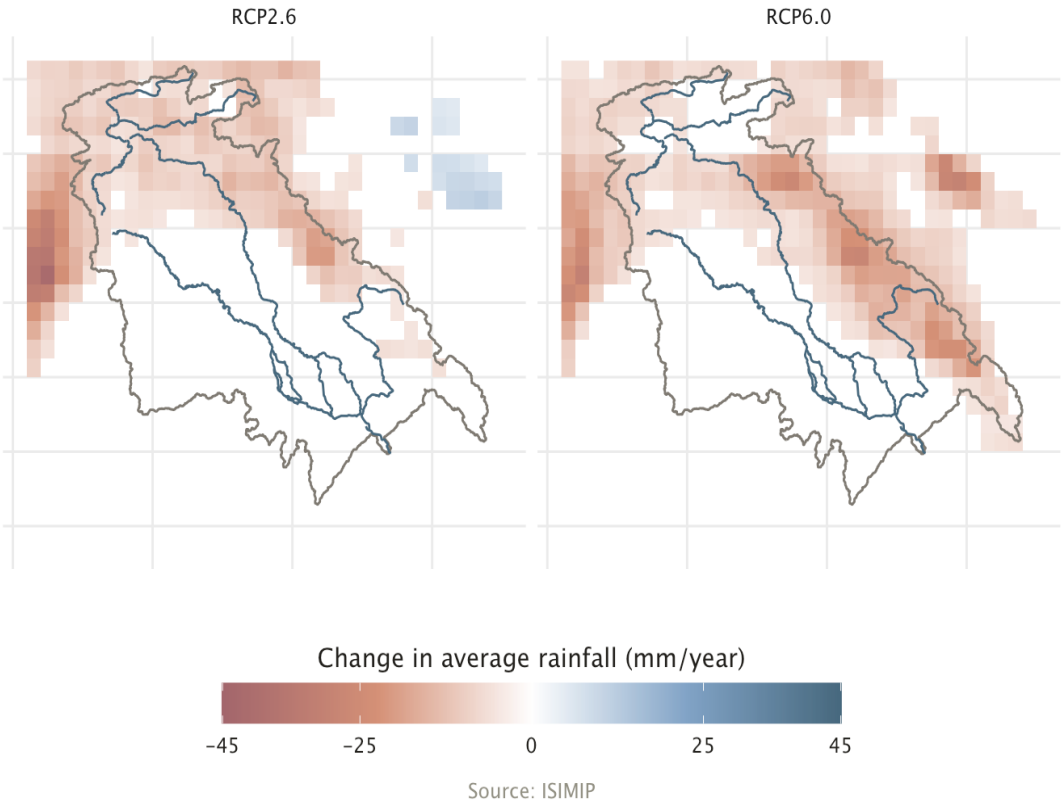

Figure 9: Projected changes in average annual rainfall over the next 30 years

The region as a whole is expected to become warmer. Mean winter **temperatures** are expected to increase by 1-5°C across the basin between 2071-2099 compared to 1961-1990, as the aforementioned study by Bozkurt and Sen (2013) finds. Winter temperatures are particularly important as they influence snow cover and the timing of snow melting. Certain regions in the basin will be affected more severely than others. ISIMIP data for the next 30 years show temperature increases of up to 1.2°C in the southern part of the basin, as well as east of the Tigris along the borders between Iraq and Turkey and between Iraq and Iran. Overall, temperatures are expected to rise more rapidly in the RCP6.0 scenario, which assumes a more rapid increase of greenhouse gas concentration levels in the atmosphere (see Figure 10).

Rising temperatures will also increase **evaporation**, which would further impact available water resources. Evaporation matters, as it decreases soil moisture, for example, thus increasing water needs for irrigation, or extending the time that rainfed agriculture would need to cope without water. In the study by Bozkurt and Sen (2013), evaporation is estimated to increase between 2041-2070 in both lowlands and highlands, while decreasing between 2070-2099.

Rising temperatures, in combination with changes in rainfall patterns, will alter the **snowpack** in the mountains of southern Turkey. It is projected that snowfall and snow water storage will decrease, thereby shifting peak flows of melt water to earlier months. This, in turn, entails severe consequences for downstream water availability in Iraq and Syria. For example, changes in flow dynamics could lead to lower river discharge during the summer months when scant precipitation does not allow for rainfed agriculture and when demand for irrigation is particularly high, thus increasing water shortages (Waha et al., 2017).

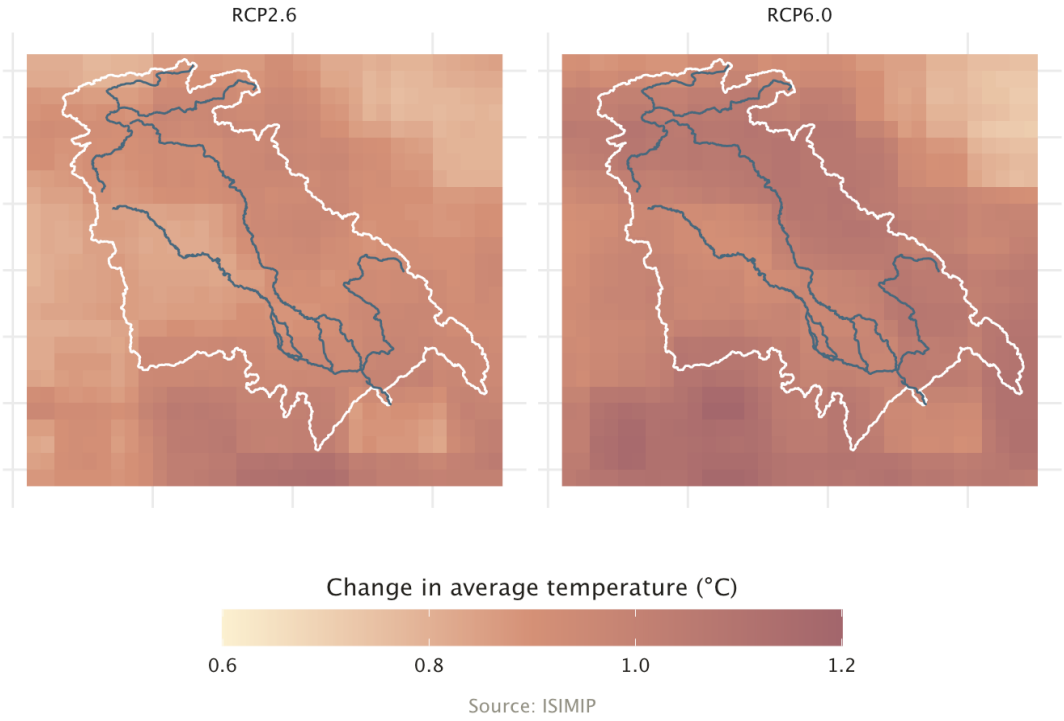

Figure 10: Projected changes in average temperatures over the next 30 years

Hydrological and biophysical impacts

The effects described above will interact with existing water challenges in different ways. River flows of the Tigris and Euphrates in the Turkish part of the basin are expected to decrease significantly by 2100 due to the impacts of climate change (i.e. by 28.5% and 23.5% respectively). This is due to lower precipitation levels and higher evaporation rates due to higher temperatures (Bozkurt & Sen, 2013). ISIMIP data show an overall reduction of daily levels of discharge in the basin over the next 30 years, both

in the RCP2.6 and RCP6.0 scenarios. Regardless of the scenario, the highest reductions in discharge are expected to occur in the Tigris around Baghdad (see Figure 11).

Decreasing precipitation levels and lower run-off, in combination with higher evapotranspiration due to regional warming, will lead to **reduced soil moisture** and groundwater recharge. This, in turn, will affect both rainfed and irrigated agriculture in the Euphrates-Tigris basin (Shamout & Lahn, 2015).

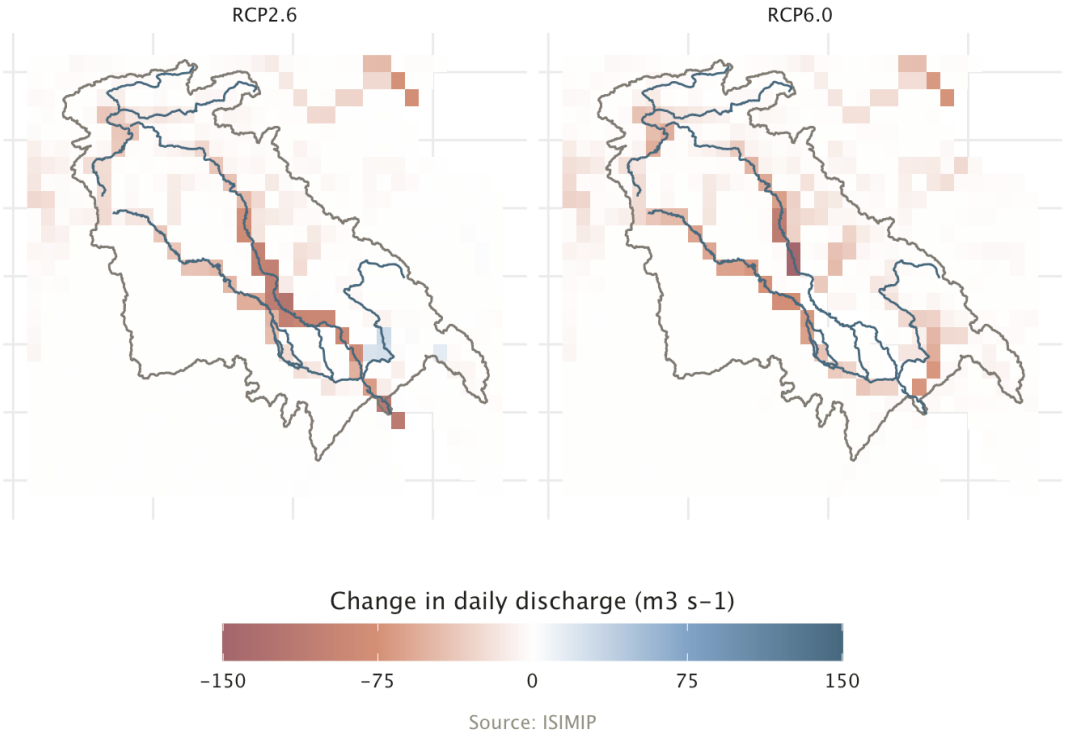

Figure 11: Projected change in average daily discharge over the next 30 years

Recent droughts have been exceptional relative to the natural variability observed over the past thousand years, leading to concerns that **drought conditions** will be further exacerbated by climate change. Evaluating data between 1931 and 2008, Kelley et al. (2015) state that droughts as severe and long-lasting as the one that affected Syria in 2007-2011 have become twice as likely with global warming over this period, even though the role of anthropogenic forcing behind this particular drought is debatable (Selby et al., 2017a, 2017b; Gleick, 2017; Kelley et al., 2017). Despite varying forecasts regarding future droughts, there is a consensus among different studies that extreme drought conditions around the Mediterranean and the Middle East will become more frequent in the future (Bachmann et al., 2019; FAO & IBRD/World Bank, 2018).

Moreover, **heat waves** are expected to occur ten times more frequently and over longer periods (Max-Planck-Gesellschaft, 2016). While the number of extremely hot days per year in the region has been 16 on average at the beginning of this century, it

is projected to increase to 80 days per year by 2050, and to 118 days per year towards the end of the 21st century (ibid.).

Another key impact of climate change is the likely increase in the frequency and severity of **floods** in the Euphrates-Tigris basin. Changes in rainfall variability will lead to more extreme run-off and, combined with increasing snow melt, both more frequent and more extreme floods can be expected. This in turn could lead to higher flood-related mortality and severe damages to vital infrastructures and ecosystems (Waha et al., 2017).

Climate change will also likely compound water quality issues, in particular through **sea-level rise** and saltwater intrusion in groundwater aquifers and rivers. The Shatt al-Arab river in Iraq is among the deltas most at risk in the world when it comes to sea-level rise and flooding. Freshwater resources in coastal areas and especially for the city of Basra are thus at high risk of being contaminated (Tessler et al., 2015).

Taken together, these impacts of climate change are likely to affect water security in the basins. They are expected to reduce water supply in almost all parts of the basin (Gleick et al., 2020), with the highest reduction projected in the northern and western parts of the basin. Consequently, water stress is likely to affect an even larger part of the basin's population. Changes in rainfall patterns and increasing evapotranspiration will also put pressure on natural vegetation, accelerating land degradation and desertification. Meanwhile, heat waves could increase both the psychological stress and mortality of humans and livestock.

3.2 Possible effects on livelihoods and food and water security

Impacts on water resources could have serious consequences for ecosystems, rural livelihoods, and food and water security in the Euphrates-Tigris basin.

Recent droughts, such as the one in 2007-2011, have highlighted the vulnerability of agricultural and livestock production systems in Turkey, Syria, and Iraq, as well as the potential impact of extreme weather events on **food security and livelihoods** in the region (in Voss et al., 2013). For example, during the drought's peak in 2008, wheat production was 47% lower than in the previous year (World Bank, 2018). Between 2006 and 2009, around 1.3 million people in eastern Syria were affected by crop failures, and an estimated 800,000 people lost their livelihoods (Solh, 2010). Moreover, in north-eastern Syria, 85% of livestock died between 2005 and 2010 (Selvaraju, 2013).

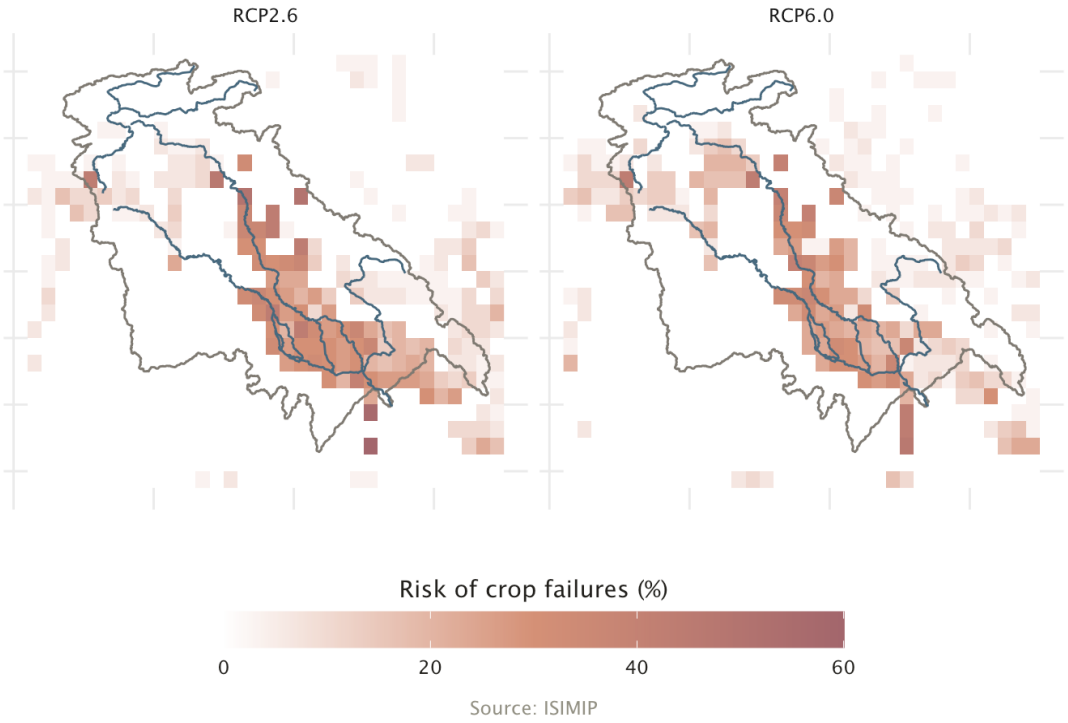

Figure 12: Projected risk of crop failures over the next 30 years

Future drought episodes, heat waves, and other extreme events will further challenge agricultural systems in the basin. Our analysis of ISIMIP data suggests a high risk of crop failures in the southern part of the basin and along the Tigris. Agriculture in these areas has already been strongly affected by water shortages (especially through poor water quality), resulting in some of the highest rates of water-related loss of livelihoods and displacements across Iraq (World Bank, 2018). This holds for both the RCP2.6 and RCP6.0 scenarios. This means that, even if we assume a more optimistic climate

scenario such as the RCP2.6,[16] crop failures are a likely threat in the region (see Figure 12).

In the long term, declining river flows and water quality might worsen the livelihoods of water-dependent rural communities, especially along the Shatt al-Arab river at the southern end of the basin. Climate change is also expected to affect livestock production through changes in available rangelands and drinking water for animals (Thornton et al., 2009).

Climate change is further expected to modify water bodies and substantially affect **freshwater ecosystems**, mostly in negative ways and especially those already under high pressure from human activities (Le Quesne et al., 2010). Climate change is likely to further degrade the basin's rivers and wetlands, their biodiversity, and compromise livelihoods, particularly those that are dependent on agriculture, fisheries, and aquaculture. Climate change is also likely to affect pastoralism by accelerating desertification and reducing grasslands and pastures. Declining river flows will also affect the marine environment of the Persian Gulf, for which the Euphrates and Tigris are the main sources of freshwater. In the past, shifting river flows have already led to a loss of spawning and nursery habitats for coastal fish and shrimp in the Marshlands.

Moreover, climate change is likely to reduce **access to safe drinking water and sanitation**. This will increase the prevalence of water-related diseases, for example, due to higher salt concentrations in public water supply, which have been a recurring challenge in the past (Independent, 2018). In the Mesopotaminan marshes, people have had to purchase water for drinking, as waterborne diseases continue to occur more frequently (Schwarzstein, 2015). Poor water access has various ramifications. Waterborne diseases such as cholera, already prominent in the MENA region, are associated with dry conditions and poor sanitation and can lead to higher mortality rates. For example, it is estimated that about 15% of deaths of children in Syria are related to poor water services and exposure to waterborne diseases (World Bank, 2018). These risks are likely to increase as water supply, water quality, and access to sanitation are affected by climate change (Waha et al., 2018).

There are also concerns that increasingly frequent extreme weather events, such as droughts or heavy rains and floods, would **displace** more people and accelerate **rural-urban migration**, thereby creating additional socio-economic and political challenges in bulging cities. The 2007-2011 multi-year drought in Syria provides an example of how drought-induced crop losses, poverty, and unemployment can push rural populations into already crowded cities, and how this can add to existing socio-economic and political grievances; even though the extent to which climate change and drought conditions have contributed to migration and public discontent with the Assad regime remains debatable (Selby et al., 2017a, 2017b; Gleick, 2017; Kelley et al., 2017). If this example makes one thing clear, it is that the effects of climate change and extreme events like droughts need to be considered in the broader socio-economic and political context of the region. These considerations particularly need to account for interactions with factors like high inflation, haphazard economic reforms, social inequalities, cronyism, and mismanagement of resources, as well as a poor commitment to protect vulnerable communities from adverse climatic shocks in the

[16] In the RCP2.6 scenario, the rise in global temperature is expected to remain below 2 °C by the end of the century (IPCC, 2021).

case of Syria (see De Châtel, 2014; Selby et al., 2017a; Femia & Werrell, 2013; Saleeby, 2012).

Future vulnerability and resilience

Thus far, this section has discussed the potential consequences of climate change on livelihoods, food and water security, as well as displacements in the Euphrates-Tigris basin. But ultimately, future risks will be determined by the interaction of climate hazards with a number of socio-economic and political conditions in the basin that determine its vulnerability or resilience to the adverse effects of climate change. According to experts consulted during our scenario planning exercise, a number of factors deserve particular attention in this context:

- Natural resource governance, including the management and development of water resources and maintenance of essential infrastructures
- The state of freshwater ecosystems and levels of water pollution
- Water resource development (e.g. dam building)
- Land use and agricultural policies
- Other factors such as conflict and violence, economic policy, trade, and energy production

The **type of water management** is among the most critical factors determining the vulnerability of agriculture and ecosystem-based livelihoods to water-related climate impacts. Across the basin, water management is highly unsustainable, including inefficient irrigation methods and high losses due to aging water infrastructures and evaporation from dam reservoirs. Most of the irrigation schemes in the basin are equipped with inefficient infrastructure. For example, some irrigation schemes in the region still use open channels as a means to transport water, rather than using solid gutters or enclosed pipes, which lose far less water through seepage and evaporation. Furthermore, large areas of the Euphrates-Tigris basin are irrigated not with sprinklers or drip irrigation, but rather using so-called simple surface irrigation, which consists of indiscriminately flushing water onto fields, the result of which is inefficient use of irrigation water. For example, Gleick and colleagues (2020) estimate that system losses in Iraq's water infrastructure stand at around 70%, while the basin's groundwater depletion rates are among the highest worldwide (Famiglietti, 2014).

Climate change and variability will negatively affect aquifers, mostly indirectly through encouraging groundwater abstraction to compensate for reduced rainfall, in addition to direct negative changes to recharge and discharge (Taylor et al., 2013). Groundwater depletion has been the single largest factor contributing to a stark decline of the basin's total water storage, which amounted to 143 giga tonnes between 2002 and 2015 (Voss et al., 2013).

Box 1: Possible future trends of key vulnerability and resilience factors based on results from the scenario planning exercise

Natural resource governance: The majority of regional experts consulted during our scenario planning exercise deemed the future trajectory of natural resource governance for the Euphrates-Tigris basin (including the management and development of water resources) as uncertain. Both negative and positive changes seemed plausible over the next 30 years, although a sizable number of experts leaned towards a more pessimistic scenario. Natural resource governance was considered the most important factor for the region's vulnerability or resilience to climate impacts on livelihoods, human security, and riparian relations. By ensuring that water consumption takes place within sustainable levels or by reducing the sources of water pollution, good governance of natural resources limits the pressure climate change will exert on water supply systems and natural ecosystems.

In an optimistic scenario for the year 2050, water management could become more sustainable. In particular, Syria and Iraq could have adopted overdue reforms of water and agricultural policies in the wake of declining flows in the Euphrates and Tigris (e.g. by greatly expanding wastewater treatment). Iran and Turkey, on the other hand, could have made efforts in water management to reduce adverse downstream effects, as they increasingly recognise their vulnerability to water-related crises downstream (such as an increasing number of displaced persons crossing the Turkish or Iranian border).

In a worst-case scenario, poor water quality is the greatest environmental challenge in Iraq and in parts of Syria. The implementation of major reforms to provide adequate environmental flows and tackle rising salinity and untreated wastewater discharge have largely failed, and so have reforms to make governance systems more inclusive and participatory. Instead, a supply-side approach is widespread, for the sake of expanding agriculture. However, this incites inefficient and wasteful flood irrigation.

Freshwater ecosystems and services: Around two-third of the participants deemed ecosystems to be in a poor state and expected a further deterioration of ecosystem services in the next 30 years. In terms of its importance for the resilience of the basin, this factor was ranked 7th (out of nine key factors). Healthy freshwater ecosystems and the services they provide, such as clean water, fish, or fodder, are critical for the basin's millions of ecosystem-dependent livelihoods. By ensuring a continuous income, health, well-being, and various natural resource needs, healthy ecosystems increase the resilience of rural livelihoods towards climate change.

In a worst-case scenario for the year 2050, poor water quality could be the greatest environmental challenge in Iraq and in parts of Syria, driven by the failure to provide adequate environmental flows and tackle rising salinity and untreated wastewater discharge. In drought years, the Euphrates and Tigris may stop flowing before they converge in southern Iraq. In Iraq, salinity levels in the two rivers are too high, which no longer permits irrigation in large parts of the country.

In a more optimistic scenario, water releases made from upstream dams partly mimic the rivers' original flood pulse, benefiting freshwater ecosystems, especially the Marshes. Through cooperation with the Turkish public and private sectors, Iraq has ramped up wastewater treatment facilities, built desalination plants, and promoted wastewater reuse for agriculture around urban centres, achieving some improvements for the rivers' water quality.

Rural livelihoods support and service delivery: The majority of experts believed that rural livelihoods support and service delivery provided through governments could evolve either into a negative or positive direction in the next 30 years. The importance of this factor was ranked 8th (out of nine key factors). Many farmers in the basin have difficulties making ends meet under normal conditions. Governmental support (such as in the form of subsidies or emergency payments) is critical for many households in the basin to deal with both incremental and sudden environmental changes.

In a worst-case scenario, ever scarcer natural resources have spiked prices for food, water, and other essential commodities. For the basin's population, of which an unprecedented part lives below the poverty line, poor access to natural resources and food insecurity have made it ever harder to eke out a living. The widening wealth gap in the region has been accentuated by technological progress, which

has mainly benefited the rich and left the poor behind, without serious intentions by politics to counter these trends.

In an optimistic scenario, economic development has created better employment opportunities and living standards, in particular for lower income households. An increasing number of local communities can provide for themselves through local income opportunities. While governmental support has decreased gradually, international support to sponsor community-led initiatives has played an important part in these developments; for example, by building capacities for decentralised water and energy systems.

Moreover, **water pollution** through untreated wastewater and salinisation is an acute problem. Experts consulted during our scenario planning exercise even expect that water quality, rather than quantity, will be the key limiting factor in the future. Historically, periodic floods have mitigated salinity by flushing salts from soils and renewing the top soil with silt and clay. However, upstream dam-building and diversions have reduced floods, which gradually exacerbates salinity problems. Meanwhile, 74% of Iraq's croplands are affected to some extent by soil salinity (Alwash et al., 2018). Future increases of river salinity due to sea-level rise could be aggravated by additional salt influxes from irrigated agriculture, especially if we assume reduced levels of discharge and hence higher concentration of salt loads in the rivers (Abdullah et al., 2016).

The severity of climate change-related water scarcity in Iraq and Syria will also strongly depend on future **upstream water resource development**. Turkish and Iranian projects, in particular, have had a strong influence on stream flows in the past (Rodell et al., 2018). Water demand in both Iran and Turkey is predicted to grow further, as ongoing and planned dams and irrigation projects indicate (Keynoush, 2019). Generally, water demand will increase due to higher evapotranspiration rates and increased water requirements for crops (Haddeland et al., 2013). However, growing water demand will not be the only issue. The management of dam reservoirs, built for example to cope with increasing variability in available water, will have significant effects on water availability downstream and the **health of freshwater ecosystems**. This would depend on whether water resources are managed in a coordinated fashion by all riparians, or unilaterally and in an uncoordinated manner. Likewise, the state of essential **water infrastructures** will be an important variable to consider for the future resilience of the Euphrates-Tigris basin to climate-related water stress. Scenarios for the future development of this factor are presented in Box 2 in section 3.3.

Land use and agricultural policies affect the viability of farming in the wake of climatic changes (including access to land, tenure rights, subsidies, etc.), and on whether agriculture, and especially smallholding farming, can sustain livelihoods in rural areas (see De Châtel, 2014; Selby et al., 2017a). In important ways, they also affect water availability. Aimed at increasing national food self-sufficiency, agricultural policies in Syria and Iran, for example, have encouraged over-exploitation of water resources over decades (Gleick et al., 2020). In particular, excessive groundwater depletion has, in turn, increasingly compounded agricultural production and reduced the drought-resilience of farmers, lowering incomes and exacerbating poverty among rural populations (Daoudy, 2021). The high prevalence of poverty among rural farming communities, for example, has been a key factor in defining vulnerability in the face of recent droughts (see e.g. Gleick, 2014; Werrell et al., 2015).

Demographic changes will influence future dynamics of water demand and consumption. Population growth, changing lifestyles, and cultural factors will drive absolute quantities. Together with population movements, they will determine where climate change-related water stress will become more or less acute in the future. While population is only one factor among others that drive water demand, it is an important one. The MENA region experienced the highest rate of population growth in the world over the past century. In all riparian countries, the population has increased three- to five-fold between 1940 and today. In Iraq and Syria, the population is likely to double again until 2025 (Kibaroglu, forthcoming). However, while fertility rates are still high in Syria and Iraq, large parts of the MENA region are currently in demographic transition, including Iran and Turkey (World Bank, 2018). Possible future scenarios for demographic change in the Euphrates-Tigris basin are presented in Box 2 in section 3.3.

Whether drought or flood-induced crop failures translate into food insecurity will also be determined by the riparian countries' ability to **import food** to make up for internal production shortfalls. Importing food can reduce the vulnerability to local water stress while simultaneously alleviating inter-state conflicts, especially if the imported crops entail a high water consumption (i.e. virtual water) (Allan, 1997). At the same time, volatile markets and global food price spikes can impair food security for countries that overly rely on food imports (see Werrell & Femia, 2013; Maystadt et al., 2014). Food security and rural livelihoods in the region are further linked to the governments' ability to subsidise agriculture and pastoralism, as well as prices of food- and feedstuff. This makes regional economies particularly vulnerable to **inflation** and sudden shifts in **subsidies** and **economic policies** (see also Selby et al., 2017a; Sowers et al., 2013). Possible future scenarios for the economic situation in the riparian countries are presented in Box 2 in section 3.3.

Moreover, future developments of **conflicts and violence** within or outside the basin will have significant impacts on water security and the ability of riparian countries to cope with adverse climate change. At its height, ISIS controlled a large number of dams in Iraq and Syria and in several instances manipulated flows of the Euphrates and Tigris, affecting the water supply for entire cities (von Lossow, 2016). A more frequent occurrence of water weaponisation, as suggested in chapter 3.3, will be a critical factor in influencing water security. A hoped-for end to the war in Syria and a subsequent development of the country's water resources, including through the development of currently abandoned agriculture, could have impacts on the Euphrates' flows and the water users that depend on it. Similarly, an escalation of tensions between the regional government of Kurdistan and the central government of Iraq could have significant impacts for water availability and ability to cope with water stress in southern Iraq. Possible future scenarios for the political stability and conflict propensity of the basin countries are presented in Box 3 in section 3.4.

In Iraq and Syria, possibilities to treat drinking- and wastewater and hence counteract the increase in climate change-related water stress, will also depend on **sufficient electrical power**. Frequent power outages and the need to transition away from fossil fuels will be important challenges to address. Yet, conversely, electricity generation that comes from hydropower is partially dependent on the rivers themselves and their management.

3.3 Possible consequences for political stability and conflict

There are concerns that climate impacts on water resources and subsequent disruptions to rural livelihoods, food and water security, as well as displacements and shifts in migration patterns in the Euphrates-Tigris basin could undermine the **region's stability** and increase the risks of **violent conflicts**. The 2007-2011 drought in Syria has frequently been cited as an example for the destabilising potential of extreme weather events. If we assume that such events will occur more frequently in the future due to climate change (see e.g. Kelley et al., 2015), this is likely to further aggravate the conflict propensity of the region, which has been high historically.

On the other hand, there is a debate over the extent to which climate impacts like droughts, and in particular the drought of 2007-2011, can be considered important drivers of conflict in the region. Some have argued that they must indeed be considered as serious threats (e.g. Gleick, 2014; 2017; Kelley et al., 2015; Werrell et al., 2015), whereas others tend to downplay their importance in relation to other factors, such as poor resource and water governance, political and religious tensions, social inequalities and political marginalisation of minority groups, as well as strained state-citizen relations and difficult economic conditions more generally (e.g. Selby et al., 2017a, 2017b; and to some extent De Châtel, 2014).

We do not believe that this debate will be resolved any time soon, and we also consider it somewhat misleading. As climate impacts affect security issues precisely through their interaction with other socio-economic and political factors, their contribution to a specific conflict is inherently difficult to isolate and contrast with the effects of other factors. It is also questionable to what extent such an exercise would yield useful insights for addressing interconnected climate security risks (which require integrated solutions rather than interventions that single out particular factors). From the above debate, we conclude that climate impacts on security in the Euphrates-Tigris basin must be studied and understood in the broader socio-economic and political context of the region.

That said, there are different ways in which the region's security and political stability could be affected by the impacts described in previous sections. First, climate change risks disrupting rural livelihoods and local economies, thus putting an additional burden on the region's social and state-citizen relations, especially if these have already been strained by years of corruption, mismanagement, social exclusion and violent repression (see Gleick, 2014; Werrell & Femia, 2013).

In such a situation, climate shocks like droughts or extreme temperatures (both low and high) could act like the proverbial "straw that breaks the camel's back" and as a painful reminder of past political shortcomings. Different experts have highlighted the vulnerable situation of the basin's countries, in particular Iraq and Syria, which have been plagued by conflict, mismanagement, and ineffective agricultural and water sector policies (see Sowers et al., 2013; De Châtel, 2014; Gleick, 2014; Kool et al., 2020). While these factors are valid sources of grievances in their own right, they may yet be too pervasive to really trigger the punctual and concerted public outrage and energy necessary for mass mobilisation. Extreme events like droughts are different in this regard as they are more punctual, highly visible, and may thus also serve as better anchors for quick mobilisation and widespread revolt. But it is precisely the

combination and interaction of unfavourable climatic and political conditions that is relevant here.

Furthermore, a lot will depend on how political elites react to the extreme event or climatic stressor. It is worth noting here that the Assad government's reaction to the 2007-2011 drought was widely perceived as insufficient and a source of anger for many affected Syrians. Several observers even made him responsible for the deplorable state of the Syrian agriculture and its high vulnerability to drought. This contributed to flaring resentment against the Syrian president (see De Châtel, 2014; Nafeez, 2013a; Werrell & Femia, 2013; Saleeby, 2012).

Finally, reduced rainfalls and increased water stress could also **benefit armed groups** in the Euphrates-Tigris basin. As water becomes scarcer, the weaponisation of water and targeting of water infrastructures also become more effective means of harming opponents and coercing populations. Water weaponisation is already quite harmful in the Euphrates-Tigris basin owing to high levels of water stress, and it has also limited the means of governments to protect critical infrastructures. It could become even more so in the future (see von Lossow, 2016).

Similarly, disruptions to rural livelihoods and food and water security can create **opportunities for armed groups** to more easily recruit and garner support among impoverished communities (Nett & Rüttinger, 2016; King, 2016). There is indicative evidence of such a conjuncture in Syria. The 2007-2011 drought particularly affected rural populations in a region called Jazeera in north-eastern Syria, which is among the country's least developed, featuring high poverty rates, poor access to healthcare, high illiteracy, and few alternative income sources besides agriculture. (De Châtel, 2014). King (2016) argues that the stronghold of ISIS was also located in Jazeera, where it was able to recruit 60-70% of its fighters among impoverished and desperate farmers (see also Schwartzstein, 2017).

Drought conditions and hardship in the wake of major climatic disruption also create opportunities for armed groups to help where governments fail to do so, thus gaining support from affected populations. Until 2016, for example, ISIS could extend its influence in Iraq by providing water services and electricity to areas where responsible authorities were struggling to do so (von Lossow, 2016).

Future vulnerability and resilience

A variety of factors determine how susceptible countries are to experience political instability and violence in the wake of climate change (Rüttinger et al., 2015; Mach et al., 2019). In the case of the Euphrates-Tigris basin, we focus on:

- General economic conditions (including economic diversity and climate-sensitivity)
- The effectiveness and inclusivity of institutions and means to prepare for and respond to climate-induced pressures
- State-citizen relations more generally

Economic conditions in the riparian countries are a key determinant of their resilience to climate change impacts and whether they may become an influential factor in contributing to political instability and violence. Whether (rural) populations in the basin can eke out a living is influenced by the general economic situation and economic opportunities in the riparian countries, economic and agricultural policies (including subsidies for commodities such as diesel used for pumping groundwater), or by

possibilities to receive remittances from relatives living in other places in case of emergency.

Box 2: Possible future trends of key vulnerability and resilience factors based on results from the scenario planning exercise

Economic conditions: The future evolution of economic conditions in the region was deemed uncertain by the majority of experts consulted during our scenario planning exercise, while some experts expected a negative development over the next 30 years. Economic conditions were considered the 4th most important factor for the region's vulnerability or resilience to climate impacts on livelihoods, human security, and riparian relations (out of nine key factors).

In an optimistic scenario for the year 2050, the riparian countries could shift away from an oil-dependent economy and towards more diverse activities and revenues. Green energies and community-led development play an important part in this scenario, including the promotion of biogas production from sewage sludge and solar and wind energy. Trade is increasing between the riparian states in this scenario. Strong economies often mean larger government budgets to tackle climate-related challenges, they also offer better job opportunities that can compensate for climate induced loss of livelihoods.

In a more pessimistic scenario, some basin countries, in particular Syria and Iraq are trapped in chronic economic depression, especially as revenues from oil have plummeted. Economies have failed to diversify and educated younger generations have left the region to seek better opportunities elsewhere. Ever scarcer natural resources are driving up prices for food, water, and other essential commodities, with disadvantages for poorer segments of society.

Population growth, rural-to-urban migration, and urban growth: the majority of consulted experts believed that population growth, rural-to-urban migration, and urban growth will remain at high levels over the next 30 years. However, they admitted that they could take different trajectories and also be dealt with in different ways. The importance of this factor was ranked 6th (out of nine key factors). In the absence of good systems to manage water resources, growing populations can easily drive up water demand and pollution beyond levels that are sustainable, thus increasing the vulnerability of households toward future climate-related water risks.

In an optimistic scenario, the growing youth segment of the basin's population is emerging as a critical driver of change in governing natural resources. Cheap and easily accessible information technology has helped them to essentially empower themselves. Social media is their primary tool. They promote decentralised systems as the best way to ensure their future. Interconnected civil society initiatives take on functions that central governments failed to perform in the past.

In a pessimistic scenario, without substantial advances in reducing water use and pollution, a growing basin population will put significantly more pressure on water resources, with larger numbers of people experiencing high levels of water stress. The frustration of younger generations in the absence of economic opportunities and a generally declining quality of life is a serious threat to political stability. Displacements and accelerating rural-to-urban migration overwhelm the capacities of cities, and lead to tensions between different ethnic and religious groups.

Quality of water infrastructures: Half of the consulted experts deemed that the quality of water infrastructures could either worsen or improve, while one-third believed it would improve over the next 30 years. The importance of this factor was ranked 5th (out of nine key factors). The quality of water infrastructures, such as those for treating wastewater or for storing and supplying clean drinking water, is fundamental in bolstering water systems against climate change.

In an optimistic scenario, water and energy systems have become more decentralised and with more technological improvements. As such, they make energy supply more robust, enabling smarter high-

tech agriculture and better management of water facilities, thereby leading to more efficient resource use and higher agricultural productivity. Treatment of wastewater and reuse of it in agriculture has been expanded, especially in close proximity to major cities, which contributes to food security and resilience of cities.

In a worst-case scenario, water infrastructures experience considerable system losses, while the modernisation of agriculture fails and with it also efforts to reduce high and inefficient water use. Because infrastructures for drinking water supply and sanitation exist only in some parts of the basin, and are frequently being weaponised by conflict actors, water delivery services remain poor, and the prevalence of waterborne diseases is high. Insufficient maintenance puts some of the basin's major dams at risk of collapsing, especially due to failed structures (e.g. Mosul Dam) and natural disasters (earthquakes).

Moreover, economic performance influences the **capacities** of riparian countries **to respond to climate-related challenges**. Already today, government budgets face a considerable constraint to shoulder water sector reforms and climate adaptation measures or to respond to security threats, such as attacks on infrastructures (von Lossow, 2018). Another decisive factor for future economic resilience in the region is the ability of the riparian countries to **diversify their economies**. In Iraq, for example, revenues from oil account for 90% of the national budget (Kool et al., 2021). Shifting towards renewable energies would be a good way to reduce oil dependence and build a more diverse and resilient economy, as highlighted in Box 2. The availability of economic opportunities beyond climate-sensitive sectors like agriculture will also have a bearing on the region's future resilience to droughts and similar shocks.

Effective and inclusive institutions are another important factor for resilience. Examples such as the 2007-2011 drought in Syria show that the long-term mismanagement of natural resources can not only exacerbate the climate vulnerability of populations but also fuel discontent with their political leaders, which, in an opportune moment, can trigger protests and lead to civil unrest. Similarly, a failed emergency response in the wake of adverse climatic shocks can further deteriorate state-citizen relations. Especially in Syria and Iraq, future vulnerability of political stability to climate impacts will depend on the ability to overcome corruption and funding gaps in public administrations, and to build more effective and inclusive institutions.

More generally, **state-citizen relations** are crucial in determining the riparian countries' susceptibility to political instability and violence, regardless if they are climate-related. As previously explained, poor basic water service delivery, failure to protect citizens from water-related disasters or the mismanagement of water resources influence how positively people perceive their leaders, with implications for state legitimacy and political stability (World Bank, 2014). Experts consulted during our scenario planning exercise repeatedly highlighted the extent to which the state-citizen relationship is broken in Syria and Iraq. This makes these countries more vulnerable to climate-related security challenges. In particular, trust in political leaders seems to be lower among younger generations, a high percentage of which are unemployed and frustrated with political elites. While this may become a driver of future instability, regional experts also envisioned a more optimistic scenario in which younger generations could act as a force for positive political change. Possible future scenarios for the political stability and state-citizen relations in the riparian countries are presented in Box 3 in the section 3.4.

3.4 Possible effects on transboundary water cooperation

Growing climate-related water risks will **increase the demand for climate change adaptation**. It will also make transboundary water cooperation generally more complex. Increased water stress will further widen the supply-demand gap (e.g. through decreasing flows and poorer water quality). High dependency on freshwater resources originating outside each country's respective territory increases the vulnerability towards water insecurity in Syria and Iraq. In the face of increasing demand and scarcity, the incentives of upstream states for exploiting water resources to their full potential also increases with water stress (Pohl et al., 2014).

Increasing water risks may further **weaken existing governance structures and water-sharing institutions** and their general effectiveness and adaptive capacity. Growing freshwater variability could render institutional arrangements and agreements unfit, for example, to deal with water shortages during droughts. It may equally lower the ability of existing institutions to deal with conflicts (Rüttinger et al., 2015).

The effects of climate change on water security could raise **the potential for transboundary conflict.** Droughts in the past led to repeated tensions between the riparian countries. During the 1980s and 2000s, for example, downstream governments were routinely engaged in threats to and complaints about the Southeastern Anatolia Project (GAP) in Turkey (Warner, 2011). Tensions usually rose during filling periods of major dams or droughts, both of which drastically reduced river flows. Several studies find that the combination of water stress, climate change, and socio-economic developments puts the Euphrates-Tigris basin at a relatively high risk of cross-border conflict (Bernauer & Böhmelt, 2014; Rüttinger et al., 2015; Farinosi et al., 2018).

Climate change may thus add more stress on water resources in the Euphrates-Tigris basin, thereby increasing cross-border conflicting interests, aggravating tensions, and exacerbating relations. However, several studies claim that the risk of climate-related military inter-state conflict remains very low (Erickson & Lorenz, 2013). There are several reasons for this. As the economic costs for waging war are very high, it is more rational for states to import food (i.e. virtual water) than to fight (Zeitoun et al., 2019). Moreover, the riparian countries (Iraq with Turkey and Iran) have strong economic relations, the benefits of which should outweigh any attempts to secure water through violent inter-state conflict (Badawi, 2020). Finally, Syria and Iraq would currently be too weak to coerce their upstream neighbours Iran and Turkey to stop their water resource development (Zeitoun et al., 2017).

Conversely, drought-induced water stress and other climate-related water risks can also **prompt riparian states to cooperate**. Globally, water-related interactions between states in transboundary river basins have resulted in more cooperation than conflict. Even in the face of disputes over other issues, sharing rivers has motivated riparian states to cooperate and engage in dialogue (Wolf, 2007). Because of the impacts of climate change in lowering river flows, increasing their variability, and causing extreme floods, the need to manage these risks may stimulate high-level policy dialogue and actions to strengthen existing agreements and encourage cooperation (Rüttinger et al., 2016). This has been observed in the Euphrates-Tigris basin in several instances. For example, following tensions around the filling of the Ataturk Dam in 1989, and subsequent interruptions of the Euphrates' flows, Iraq took the initiative to

set up a permanent joint technical body (Kibaroglu, 2015). Turkey also postponed the filling of the Ilisu Dam in 2018 after Iraq voiced complaints about downstream effects on flows (Aboulenein & Karadeniz, 2018).

The greatest risk may not be an overt conflict between the riparian countries, but **progressively growing fragility in Iraq and Syria** as a result of the failure to significantly advance cross-border water cooperation. Despite some advances, especially between Turkey and Iraq (Kibaroglu, 2019), transboundary water cooperation has remained largely technical and focused on non-contentious issues. Cooperation takes place largely bilaterally, with limited improvements over recent years. Permanent, institutionalised cross-border cooperation seems unrealistic in the near future (von Lossow, 2018). Under such a scenario, water availability in Iraq, and partly in Syria, would gradually decline, increasing the reliance on and overuse of groundwater (Voss et al., 2013). This could increase the chances of the knock-on effects described above. The costs of non-cooperation can therefore be extremely high. Yet, the benefits from cooperation can also be comparably high (Pohl et al., 2017), some of which are discussed in chapter 4.3.

Future vulnerability and resilience

There are many factors that drive conflict and cooperation in transboundary river basins (Bernauer & Böhmelt, 2020). According to a study by Farinosi and colleagues (2018), a critical determinant in the Euphrates-Tigris basin is precipitation stress. Key non-climatic factors determining future inter-state interactions in the basin are high economic dependency on agriculture and population density. As for the other risks described above, water availability itself is an important factor. Driven by population dynamics, future policies, and management practices, both upstream use and downstream water scarcity may influence interactions between the riparian states. This includes the upstream states' approach to water development and, for example, how well they communicate decisions on operating dams. In consultation with regional experts, we identify the following key factors that influence the basin countries' susceptibility to either conflict or cooperation in the wake of major climatic stresses:

- Internal political situation and stability of the riparian countries
- Geopolitical ambitions and inter-state relations more generally
- Involvement of extra-regional third parties

The **domestic political situation** is a key factor in the dynamics of cross-border water conflict and cooperation in the basin. For example, the Syrian Civil War has led to a breakdown of bilateral political relations between Syria and Turkey, hampering any further transboundary water cooperation (Kibaroglu & Scheumann, 2013). An end to the conflict itself would not only affect the Euphrates' hydrology as aforementioned (e.g. the recultivation of abandoned agricultural fields, which would increase water demands and abstractions). It would enable new possibilities for cross-border water cooperation, both between Turkey and Syria and between Syria and Iraq.

Box 3: Possible future trends of key vulnerability and resilience factors based on results from the scenario planning exercise

Political stability: Experts consulted during our scenario planning exercise attached high uncertainty to the future development of political stability, with 17 out of 20 voting for an uncertain development over the next 30 years. Political stability ranked as the 3rd most important factor for the region's vulnerability or resilience to climate impacts on livelihoods, human security, and riparian relations (out of nine key factors). Political stability in the riparian countries is a precondition for managing their water resources sustainably and for bringing adaptation efforts under way, both at the national and transboundary level.

In a pessimistic scenario for the year 2050, Syria and Iraq have not recovered from the wars that ravaged both countries in the beginning of the 21st century. Politics remain volatile, with heads of states changing more swiftly than ever before. State-citizen relations are complicated. Iraq and Syria still face enormous structural challenges, including corruption, cronyism, and financial debt. Governments remain at risk of being overwhelmed by political crises, as popular grievances loom.

In an optimistic scenario, improved water delivery services and considerable reduction of waterborne diseases, coupled with greater food security, have contributed to greater political support in Iraq and Syria. Governments allow a free press to re-emerge, while also fostering rights and education for women. State-citizen relations have improved, while growing economies offer better employment opportunities and living standards, particularly for lower income households. Consequently, both Iraqis and Syrians from all parts of the world are returning to their home countries.

Interactions and relations between riparian states: Of all consulted experts, seven considered that interactions and relations between riparian states could go either way. Another seven believed that they would become more peaceful with cooperative interactions dominating. Five experts believed that riparian states' relations could become more tense and conflictive. The importance of this factor was ranked 2nd (out of nine key factors). In sections 2.3 and 3.4, we provide examples that emphasise how conflictive political relations between the riparian countries can undermine water cooperation and thus transboundary interventions necessary to increase the climate resilience of water resources in the basin.

In a more optimistic scenario for the year 2050, the establishment of a river basin commission is in close reach, while various transboundary arrangements are under way, including an internationally applauded cross-border adaptation strategy. Particularly, the relations between Iraq and Turkey have significantly improved. There is regular dialogue and transparent data-sharing, and the two countries are working on an adaptive allocation arrangement, which includes environmental flows. The two countries operate all their dams in coordination (including projects on joint dam building).

In contrast, in a pessimistic scenario, cross-border tensions reach an all-time high in the face of exacerbated nationalist rhetoric. The riparian governments incessantly blame each other for their own failure to ensure water and food security for their populations. Aggressive nationalist rhetoric dominates political discourses, not least to divert public attention away from the failures of political elites. Existing technical cooperation, which provided a margin for water cooperation in the beginning of the 21st century, is at a very low level.

Impact from the involvement of extra-regional actors: The future evolution of the involvement of extra-regional actors was considered as highly uncertain, with 15 out of 18 participants deeming that it could go either way. The involvement of extra-regional actors, which was described to include both beneficial and harmful actions, was ranked the lowest among all vulnerability and resilience factors. Mediation attempts to resolve water conflicts between the riparian states or development assistance

to introduce water sector reforms will be important for the ability of riparian countries to address future climate-related challenges to water security and diplomatic relations in the basin.

In an optimistic scenario, geopolitical power struggles in the region, especially between Turkey and Iran, have decreased. While the riparian countries themselves were largely responsible for ramping up cross-border cooperation, donor countries and the international community have been helpful in providing more effective support (especially through climate finance) that is driven by new approaches to development cooperation.

In a pessimistic scenario, international support for regional cooperation has dwindled, leaving the riparian countries to deal with their conflictual relations on their own. The failure of the international community beyond Agenda 2030, as well as weakened UN institutions, has reduced international aid to the basin, the dependence on which, however, remains high. Moreover, support by the EU and others has been withdrawn because they have lost faith in the Iraqi and Syrian governments' willingness to make effective use of the support that they have been offered.

Moreover, **geopolitics and inter-state relations** play a key role for future water-related conflict and cooperation. For example, during the Cold War, tensions were aggravated by Turkey's NATO membership, while Syria and Iraq drew closer to the USSR (Kibaroglu, 2015). Relations with the Kurdistan Workers Party (PKK) was a major bone of contention between Turkey and Syria until the 2000s (Erickson and Lorenz, 2013). Another relevant aspect in this regard has been Turkey's adjustments in its water legislation to comply with the EU Water Framework Directive (WFD), after having been declared an EU membership candidate in 1999 (Kibaroglu, 2014). Looking forward, workshop participants considered the power struggle between Iran and Turkey to be one of the largest impediments to future success of cross-border water cooperation, as the basin's two heavyweights compete for influence. The power struggles that are taking place in both Syria and Iraq are another important impediment to extend both bilateral and multilateral water cooperation. One example mentioned by regional experts consulted for this report is that Iran may attempt to prevent Turkey and Iraq from achieving closer cooperation on joint water and energy projects. While economic dependencies have been considered important for inter-state relations, they have also been deemed as a critical factor in driving future cooperation (see ideas on regional economic integration in chapter 4.3).

International assistance plays an important role in the basin. Chances are low that Syria and Iraq can improve their domestic water challenges (as well as other structural issues) by themselves. Financially, the costs to rebuild water infrastructures in Syria and Iraq largely surpass the budgets of the respective ministries. As argued above, the domestic water situation directly affects transboundary water interactions. Beyond its role as a donor, the international community could be an important force in driving diplomatic efforts such as in strengthening cross-border cooperation initiatives and mediating future inter-state conflicts. This is especially true in the absence of transboundary institutions and mechanisms that could mediate conflicts. In the past, other countries have stepped up to the occasion as mediators when tensions were building up during low-flow events. For example, Saudi Arabia intervened in the case of a conflict surrounding the Keban dam (Turkey) and Tabqa dam (Syria). Global organisations also have equal importance in this regard. The Strategic Foresight Group (SFG), a Mumbai-based think tank, hosted dialogue events between Turkey and Iraq between 2013 and 2014, which were joined by stakeholders from both countries.

4. Existing measures and potential for adaptation

This section assesses the most important options to reduce risks and vulnerabilities presented in section 3, as well as the progress that has been made in implementing them by the riparian countries. Identifying implementation gaps and challenges for adaptation measures in the Euphrates-Tigris basin, we formulate recommendations for the riparian countries for addressing future climate-related challenges to water resources, livelihoods, political stability and riparian relations in the region.

4.1 Water management

A sustainable management approaches

The preceding chapters of this report demonstrated that the approach to water management is gradually deteriorating the basin's water resources and ecosystems. Growing water challenges, intensified through climate change, necessitate a more sustainable water management for ensuring water security in the future. Such an approach needs to balance both human needs and environmental use. It also needs to deploy more decentralised, soft-path solutions, while fixing largely broken water systems. Demand-side approaches should be prioritised over augmenting supply through expensive water-supply infrastructures, because they are more cost-effective and sustainable.

Demand management

The growing water deficit emphasises the need to reduce water demands in the future. Demand management measures must focus on improving water use in the agricultural sector, which is by far the largest water consumer. One challenge is that water demands in the basin are highly inflexible, for example, because many cultivated crops are perennial. This limits adaptive responses in the face of water shortages, and hence increases vulnerability towards climate change (Qin et al., 2019). In agriculture, it will therefore be key to not only save water, but to move away from inflexible uses. This could, for example, include limiting areas of perennial crops. In urban supply systems, large improvements could be achieved by fixing leakages. By way of example, water system losses are as high as 70% in Iraq (Gleick et al., 2020). The application of water-saving techniques in irrigation could help to save 20–30% of irrigation demand. However, the use of water-saving innovations requires higher investments and necessitates educating farmers, which may take years to progress. Nevertheless, once the full use of water is reached, water-saving techniques will become compulsory as part of a scarcity regime (Food and Agriculture Organization, 2008).

The price of irrigation water is still based on operation and maintenance costs of irrigation schemes across the basin, and it is charged on a per hectare basis, differentiated according to crop. The recovery of capital costs has been low. There is almost no volumetric pricing system in irrigation. Agriculture will bear the burden of

adjustment to water scarcity. Fast implementation of the necessary policy measures at all levels will encourage a more efficient use of public resources and water. More resources can be allocated to restrict water losses from irrigation infrastructure, especially in regions experiencing high evaporation. To illustrate this, in Turkey, through government subsidies, there have been improvements in adopting more efficient water application technologies such as closed pipe systems (in which loans are given to farmers to shift to pressurised irrigation), as well as drip and sprinkler irrigation. The uptake of these technologies by irrigators can be further increased by shifting towards volumetric pricing practices. The determination of irrigation fees proportional to the actual amount used will increase the efficiency of irrigation water use (Cakmak, 2010).

Water and climate adaptation strategies developed by the riparian countries recognise the issue of inefficient water use. An analysis by the Economist Intelligence Unit (2020) (Appendix 5) shows that national water quantity monitoring and water efficiency programmes exist to some extent. Turkey has developed an Action Plan for the Program on Enhancing Efficiency of Water Use in Agriculture (MoEU, 2018). Moreover, it intends to implement modern agricultural practices and to control the use of fertilisers (Republic of Turkey, 2015). Additionally, the riparian countries have indicated in their National Communications that they intend to pursue various other water efficiency measures, some of which are mentioned in this study.

However, widespread occurrence of inefficient water resource use in large parts of the basin suggests that much greater efforts are needed for lowering demands. Generally, while the figures above indicate that water savings can contribute significantly to closing the basin's supply-demand gap, the implementation of water efficiency measures is commonly subject to various practical challenges (Grafton et al., 2018). For example, workshop participants pointed out that the high share of small-scale farming complicates water-efficiency interventions, as they need to reach out to a very high number of small farms, which is a logistical and financial challenge. Moreover, the deployment of more efficient technologies (such as agricultural irrigation technologies) must come with improved monitoring of water use, robust water accounting, and regulations of abstractions, for both surface and groundwater (ibid.). This degree of technological development exists only in certain parts of the basin. Furthermore, measures to lower water utilisation by end users will not be enough. It will be necessary to reform agricultural and development policies, which have been driving the witnessed large-scale overexploitation of water resources (e.g. through incentives), as aforementioned.

Supply augmentation

In addition to saving water, it will be necessary to augment supply in some instances simultaneously, ideally through non-conventional resources. To this end, expanding wastewater treatment and reuse should be prioritised, given the positive effects on water quality. As the volume of treated wastewater is currently low, the potential for wastewater reuse is large, especially in supplying agriculture in urban peripheries. In cases where water use cannot be reduced, the deployment of desalination in some parts of the basin may be necessary for addressing residential water supply shortages. Workshop participants suggested that the technology could become particularly useful in the southern parts of Iraq. However, agricultural water needs are large, rendering current desalination technologies uneconomical for farming. Desalination also comes with significant drawbacks. The process is energy-intensive and produces considerable

amounts of brine as waste material, which is often channelled back into the sea, thereby causing environmental harm.

Water pollution and quality

Improving water quality in the future would mainly entail tackling salinisation and reducing pesticide and fertiliser application, as well as limiting untreated wastewater discharge. For this, it will be necessary to transform the way farming is done (for example, by using different irrigation techniques), while installing additional wastewater treatment plants in key locations and repairing those that have been destroyed or have become dysfunctional. While the agricultural sources of water pollution are an issue across the basin, low wastewater treatment is mostly an issue in Iraq and Syria.

There are interventions under way to mitigate these sources of pollution, but these seem insufficient. Although the share of the population with access to sanitation is increasing (see Appendix 2), large amounts of untreated sewage are still discharged into rivers. High salinity levels in water systems remain a grave problem (Abdullah et al., 2016; Bachmann et al., 2019). Appendix 5 shows that essential pollution control measures, including water quality monitoring systems and national water pollution programmes, exist only to some extent in Iran and Turkey. The lack of an effective water monitoring network makes it difficult to take measures addressing water quality and pollution, as it is impossible to identify the causes. Hence, rehabilitating and reconstructing the existing water monitoring network is an urgent task to ensure water security (UN-ESCWA & BGR, 2013).

Besides reducing the influx of pollutants into water systems, it will be critical to maintain or enhance river flow volumes. This is because predicted future decreases in discharge are likely to elevate the concentration of pollutants in the Euphrates and Tigris. In addition, mimicking certain flow dynamics, especially small-scale floods, can also help to mitigate the salinisation problem along the rivers' floodplains by flushing salts.

In a scenario where flows decrease while water pollution increases, it may be necessary to consider large-scale engineering solutions, such as discontinuing the use of the Lake Tharthar reservoir in Iraq, which is a major source of salinisation in both the Euphrates and Tigris rivers (International Organization for Migration Iraq, 2020). However, these types of large-scale engineering solutions may only be deployed as a last resort as they can result in impactful and unpredictable changes to freshwater ecosystems, possibly causing more harm than benefits. As noted by workshop participants, a barrage at the river mouth of Shatt al-Arab may be a necessary long-term solution to prevent further salt water intrusion into the system.

Conservation of freshwater ecosystems

The decline of freshwater ecosystems in many parts of the basin, as well as growing anthropogenic and climate change-related stressors, requires generally greater conservation efforts in the future. Increasing the resilience of freshwater ecosystems to cope with climate change does not demand entirely new measures. While there are additional needs (e.g. conducting climate vulnerability assessments for ecosystems), strengthening sustainable water management practices, such as those envisioned by the IWRM approach, will automatically benefit freshwater ecosystems (Le Quesne et al., 2010).

The riparian countries are carrying out several conservation projects. The most notable ones may focus on the rehabilitation of the Mesopotamian Marshes. However, additional measures to protect and restore ecosystems are needed, given their poor and declining state. As assessed by the survey during the workshop, most participants agreed that under current conditions, the basin's freshwater ecosystems will further decline, and that much greater efforts are needed to safeguard them.

Environmental flows are one of the most critical measures to sustain the integrity of freshwater ecosystems (Tickner et al., 2020), and the need to implement them at the basin scale is widely recommended, especially for safeguarding the Mesopotamian Marshes (see for example Gleick et al., 2020). As of now, only limited measures are under way to implement environmental flows, which usually encompass conducting baseline studies on the state of rivers, strengthening national policies, establishing procedures for implementation of environmental flow requirements, and, in the long-term, developing basin-wide environmental flow strategies (Speed et al., 2013).

The quantity and quality of water entering the Gulf is also an issue to be addressed, since fisheries are an important food source for the region. The impact of water management and changed flow regimes on migrating fish and terrestrial species, and on the viability of riverine and floodplain ecosystems throughout the basin are further environmental issues to consider (Food and Agriculture Organization, 2008).

Moreover, while being among the most essential conservation instruments, formal protection of freshwater ecosystems is extremely limited in the basin. Across the whole basin, only 1.4% of the rivers are located within protected areas, compared to a global average of 16% (Abell et al., 2016).

4.2 National climate adaptation efforts

Adaptation strategies

Managing water resources sustainably will not be sufficient to make ecosystems, and the human systems depending on them, more climate-resilient. Water strategies need to take climate change impacts into account and be designed in a flexible and adaptive way, in order to better address future uncertainties. Similarly, the adaptation strategies of water-dependent sectors must incorporate water issues. Moreover, national strategies for climate change adaptation and disaster risk management must be aligned with those existing at the transboundary level (Kerres et al., 2020).

Climate change affects the water security of various water-dependent sectors. One governance challenge in designing robust adaptation measures is to consider the cross-sectoral nature of climate vulnerabilities and adaptive responses. Overcoming this challenge could include applying the water-food-energy nexus, which can facilitate implementation of adaptation actions in all water-dependent sectors. The water-food-energy nexus approach, therefore, seeks to equally consider and weigh sectoral objectives with respect to water.

A national disaster risk management plan exists only to some degree in Turkey and Iraq, while only Turkey and Iran have developed national adaptation strategies (see Appendix 5). All countries except Turkey have ratified the Paris Agreement. Despite not ratifying it, Turkey did submit its NDC[17] to the Secretary of the UNFCCC on 30 September 2015.[18] Recent developments indicate that all countries have made advancements in developing climate adaptation policies and strategies. Iran has recently launched the process of developing a National Adaptation Plan (NAP)[19] in 2017 (GRI, 2017), and Iraq in 2020 (United Nations Environment Programme, 2020). It can be deduced from their National Communications[20] that all countries intend to pursue a broad range of adaptation measures, both with respect to improving agricultural productivity and water management in agriculture (see Appendix 1). It is, however, unclear to what extent these measures are implemented.

Infrastructures

Beyond ensuring the delivery of water services, investments in infrastructures also need to increase their resilience in order to buffer against climate variability and minimise risks. Generally, future investments must consider climate risks, trade-offs, and uncertainties associated with alternative investment pathways (Hall et al., 2014). Climate change projections, as outlined in chapter 3.1, may require an upgrade of the basin's water infrastructures in several ways. More variable flows, and especially more

[17] The Nationally Determined Contributions is a core component of the Paris Agreement, and reflects the ambitions undertaken by each country to reduce national emissions as well as to adapt to climate change impacts (UNFCCC, 2021a).

[18] For all NDCs submitted, see: http://www4.unfccc.int/submissions/indc/

Submission%20Pages/submissions.aspx.

[19] The National Adaptation Plan, established under the Cancun Adaptation Framework, is an approach that allows countries to identify its medium- and long-term climate adaptation needs as well as developing and implementing respective strategies to address them (UNFCCC, 2021b).

[20] Every Party to the Climate Convention is requested to prepare a National Communication every four years in order to report its implementation of the Convention, and to monitor its progress (UNFCCC, 2021c).

frequent flood events, may demand larger storage capacities to capture increasingly irregular flows. While additional dam-building can locally alleviate water shortages, it causes negative downstream effects for freshwater ecosystems and biodiversity (Moran et al., 2018). The benefits and trade-offs must be carefully evaluated. Considering the high levels of evaporation losses from surface waters, the rate of which is increasing, it may be more beneficial to store water upstream or underground.

Information systems

Climate change, particularly the uncertainty over precipitation, raises demands for collecting, analysing, and transferring information to operate institutions and infrastructures (Hall et al., 2014). This not only requires improving the currently low capacity for hydrological monitoring (such as on discharge and water quality of rivers), but also of various socio-economic indicators. Only in this way will it be possible to adequately model future climate change impacts on water and food security in the basin.

Moreover, the assessment and management of climate-related risks in the planning and design of water systems will be key to guarantee a continuous performance under unknown future conditions. Climate risk and vulnerability assessments will provide the basis for sound planning of climate resilience measures and strategies. The uncertainty of future climate conditions means that these need to consider a wide range of climate and non-climate scenarios (i.e. robust), and be easily adapted to changing conditions (i.e. flexible) (Kerres et al., 2020).

There are a range of ongoing efforts to improve weather monitoring and forecasting projects. As depicted in Annex B, all four countries either plan to develop such information systems or have them in place. For example, Iran’s Meteorological Organization (IRIMO) plans to set up additional monitoring networks and early warning systems to enhance climate observations and forecasts (DoE, 2017). Likewise, Syria plans to develop early warning systems to monitor extreme weather events (Department of Environment of Iran, 2015; Syrian Arab Republic, 2018).

However, several studies conclude that the systems to collect and manage data are currently insufficient, particularly in coping with future changes (Voss et al., 2013; Gleick et al., 2020). As Appendix 5 illustrates, monitoring programmes and systems for water quantity and quality, as well as systems for disaster risk management, exist only to some extent. The same applies to risk assessments. Referring to Turkey, Tanik and Tekten (2018) stress that there is a greater need to determine sectoral vulnerabilities and prioritise actions for different sectors, so as to increase the effectiveness of climate change adaptation measures. Turkey has recently introduced a risk management-oriented drought management system, which aims to inform a comprehensive national policy setting to provide a coordinated and integrated approach. A national drought monitoring system and a drought management plan for the part of the Euphrates-Tigris basin within Turkey's territory include a series of drought mitigation measures, including underground storage of water. Among the riparians of the basin, Turkey's economy is better positioned to alleviate drought impacts and compensate for the production and livelihood losses caused by the drought. A national level implementation guide for the farming sector, the Turkish Agricultural Drought Action Plan establishes the preparedness and drought mitigation measures (Food and Agriculture Organization, 2017).

4.3 Transboundary and regional cooperation

A transboundary approach

In the Euphrates-Tigris basin, cooperation between the riparian countries exists only to a limited extent, as we have outlined in previous chapters. Agreements are only bilateral, while unilateral action dominates water resources development, as is reflected, for example, in extensive dam-building projects over recent decades. Transboundary water cooperation has remained largely technical and focused on non-contentious issues, with limited improvements in recent years (von Lossow, 2018; Kibaroglu, 2019). Climate change will aggravate some of the water challenges that exist at the transboundary level today. It will also increase the requirements and complexity for institutional arrangements. As climate change enhances water risks, and thereby also competition over water resources between the riparian states, it will gradually become more challenging to reach agreements, especially between all riparian states (Gleick, 2014).

Avoiding conflict while establishing sustainable water management requires a basin-wide approach. The challenges that future changes entail (e.g. lower and more variable river flows in Iraq and Syria) require scaling up existing transboundary water governance mechanisms. The JTC, various MoUs, as well as informal track two initiatives such as the Euphrates Tigris Initiative for Cooperation (ETIC) and Blue Peace Initiative, can form a basis for such efforts. Fostering and initiating new dialogue and exchange could help to restore and improve trust among the riparian countries. To this end, workshop participants emphasised the critical need of including Iran in cooperative efforts, in order to make transboundary water management more effective. This needs to be done not only in multilateral efforts, but also on cross-border issues between Iran and Iraq (such as on water development projects on the Tigris tributaries).

Moreover, trust-building activities and transboundary water management will also benefit from improved basin-wide data on hydrology, water availability, and climate risks. Currently, basin-wide data monitoring on discharge and water quality, which is a key prerequisite for transboundary planning and management, does not currently exist. Improved satellite-based hydrological remote sensing can complement on-the-ground measurements (Voss et al., 2013). The Mekong Dam Monitor, which provides real-time data on various features of dam operations and hydrological parameters of the Mekong river through an online platform, is a good example to this end (Stimson Center, 2021).

Benefit-sharing and economic integration

So far, there has only been limited progress by riparian governments in embracing a transboundary management perspective. This may call for new and greater efforts in incentivising cross-border cooperation. One way of doing so, as pointed out by the workshop participants, concerns identifying new issues that could serve as entry points for enhancing transboundary water cooperation. Such new issues may include joint efforts to protect water infrastructures from water weaponisation, or to advance basin-wide climate adaptation. As such, the riparian states could map potential synergies for basin-wide adaptation planning, and harness adaptation projects to foster cross-border water cooperation (Blumstein, 2017). These issues could have more potential to unite interests and incentivise multilateral cooperation (also because

they might allow for attracting finance that may not otherwise be accessible), while they, in parallel, can function as vehicles for addressing water issues.

Moreover, following the same logic of cross-border benefit-sharing, regional economic integration activities that address water issues as an integral component can also incentivise cross-border cooperation. An example prominently discussed during the workshops relates to the joint management of water and energy resources between Turkey and Iraq. As Alwash (2016) proposes, Turkey could store water for Iraq in its territory, where evaporation losses are low and the topography is more suitable for building reservoirs, while Iraq offers Turkey cheap energy in exchange (including solar power and fossil gas). In an ideal case, the countries would manage dam infrastructure at a basin-wide scale, and align operations to maximise the benefits for water supply and energy generation, while ensuring environmental flows to maintain and restore freshwater ecosystems. Such trade deals offer economic benefits and can therefore be pursued more easily politically, while allowing to embed much-needed water-sector reforms. Regional economic integration can also enhance foreign and private sector investments (Verner, 2013).

While the potential for economic integration is large, actions to galvanise it have been limited, especially when it comes to topics concerning the water-food-energy nexus. Strong support from Turkey, in particular, will be essential in enabling greater regional economic integration, including in securing investments and climate finance. A key challenge will also be to find or establish organisations (such as private or public companies) for implementing and managing projects that focus on economic integration - a challenge that was pointed out during the workshops. Research can help to show the potential and feasibility of such projects, as was done, for example, in a recent study on the regional integration of hydropower, solar, and wind energy in the Nile basin (Sterl et al., 2021). In this way, the buy-in from political decision-makers and investments could be secured more easily.

Institutions

Although the basin features a range of institutions, these mostly comprise only Iraq and Turkey and are insufficient for dealing with future challenges. These institutions, of which the JTC between Turkey, Syria, and Iraq is the most important, tackle important water challenges, including water development and allocation. However, existing institutions are insufficient because they are non-permanent and they do not bring all riparians together. Furthermore, participation of different stakeholders is generally limited, an aspect that was highlighted by the workshop participants.

Compared with the current web of weak institutions, a transboundary river basin organisation (RBO) would have several advantages as a platform through which the riparian countries can establish sustainable water management at the basin level. This could spearhead adaptation efforts to future hydrological changes or resolve conflicts over water (Blumstein & Schmeier, 2017). The likelihood that the Euphrates-Tigris riparians make significant headway on establishing an RBO in the near future appears slim under the current state of cross-border relations. Until the political opportunity arises, it will be useful to support the preparation process for establishing a RBO or alternative multilateral platforms that the riparian countries can agree on, proposals of which exist (see for example Shamout & Lahn, 2015).

The chances for any form of permanent, institutionalised cross-border cooperation between all states are unrealistic in the near future (von Lossow, 2018). It will therefore

be necessary to support existing institutional structures (e.g. the JTC) that can perform similar functions to those of a RBO. Until a permanent multilateral platform exists, there is also the need for establishing new structures, such as working groups that monitor adaptation efforts and organise emergency responses.

Workshop participants also discussed the usefulness of other institutions as vehicles for propelling water cooperation. With respect to fostering economic integration, participants reflected on whether an organisation similar to the Southern African Development Community (SADC) could be beneficial for the Euphrates-Tigris basin. SADC functions as the main regional organisation to achieve development, peace and security, and economic growth in Southern Africa. Furthermore, Water User Associations or Irrigation Associations[21] were deemed important players and worth supporting to initiate water-relevant measures in agriculture. Such measures include raising awareness of water efficiency measures on farms, or supporting their implementation.

International law and agreements

Cross-border institutional arrangements are essential to managing transboundary rivers in a sustainable way and to ensure climate resilience of water systems and water-dependent ecosystems. Such arrangements also play a critical role in mitigating cross-border conflict and security in the riparian countries (Gleick & Iceland, 2018). Generally, climate-resilient, cross-border institutional arrangements should, among others, encompass a transboundary water management agreement, a joint management plan, a flexible water allocation agreement, and a dispute resolution mechanism (Cooley & Gleick, 2011). Furthermore, transboundary issue- or sector-specific strategies, such as for climate adaptation or environmental flow implementation, should be developed to guide water resources management at the basin scale (Speed et al., 2013).

All of these institutional arrangements are either weak or absent in the basin (see Appendix 5). The basin lacks a foundation for equitable and sustainable future allocation of water resources among the riparian states. It also lacks institutional arrangements for preventing inter-state conflicts, for coping with increased climate variability, or for mitigating against risks associated with water weaponisation (Gleick et al., 2020; Kibaroglu, 2019). Moreover, if Syria and Iraq were to move towards the peace and stability that most of its people yearn for, the expected increase in water demand would make a water-sharing agreement and a cross-border conflict prevention mechanism all the more urgent (European Intelligence Unit, 2020).

[21] Traditionally, central water authorities have been in charge of building, operating, and maintaining irrigation systems in the riparian countries. However, in Turkey, including the Euphrates-Tigris basin, operation and management responsibility of 98% of the irrigated area that is equipped with irrigation facilities by DSI has been transferred to the water users, namely the irrigation associations (IA). The Turkish experience of water user associations can be shared with other riparian countries to increase water use efficiency, to ramp up water revenue collection rates, and to save water. However, both good and bad experiences should be shared. Following the transfer of irrigation schemes to the user organisations, some improvements are recorded in irrigation ratios, irrigation water fee collection rates, and financial cost reduction in irrigation systems operated by the IAs. However, system performance remained almost at the same level. The participatory aspect of the transfers in particular has been questioned, owing to the exclusion of irrigators from IA general assemblies and boards. The top-down approach which was adopted, rather than a grassroots approach that is generated by farmer interest and involvement, has caused fierce debate over the characterisation of the associations as democratic. Critics also stress that maintenance, rehabilitation, and modernisation of the irrigation canals, some of which are 50 years old, cannot be accomplished due to technical, administrative, and legal capacity deficiencies of the IAs (Kibaroglu, 2020).

In order to reduce (potential) tensions, existing agreements should be extended to include provisions on water quality standards, flexible allocation during extreme events such as droughts and floods, coordinated management of dams, and data collection and sharing. In the Euphrates-Tigris basin in particular, there is also the need to set up security arrangements for protecting infrastructures against weaponisation. These arrangements would identify infrastructures that require prioritised protection, as well as establish strategies for protecting them during and after conflict, including early warning systems that notify authorities when non-state violent actors, for example, threaten to hijack infrastructures (Kibaroglu & Sayan, 2021). Workshop participants noted that existing agreements, such as the MoUs, can serve as a basis for developing more comprehensive ones. The process of developing them should draw on the knowledge and experiences of different stakeholders, including civil society organisations and private companies.

Beyond reaching such agreements, the application and enforcement of international water law could strengthen transboundary water cooperation in the basin. International water law includes general principles for cooperation, equitable and reasonable utilisation, as well as "no-harm." These principles have been codified through the UN Watercourse Convention in 1997 and the 1992 UNECE Water Convention. With respect to the protection of infrastructures, there exist at least two international conventions that are of relevance (one being the Additional Protocol II of the Geneva Conventions relating to the Protection of Victims of Non-International Armed Conflicts). These laws stipulate the rules and standards for protecting civilians and infrastructures during military conflicts, and they classify the weaponisation of water as a war crime, thereby prohibiting it accordingly (King, 2016).

While both conventions are useful in defining rights and obligations of riparian states in the utilisation of transboundary rivers, different stances in the basin have meant that their invocation has become part of the problem rather than providing a solution. Turkey is one of three countries globally that voted against the UN Convention (1997), which eventually entered into force in 2014. Workshop participants stressed that not all the provisions of those international water conventions fit with the basin's contextual factors and the Middle East at large. They explained that each transboundary watercourse possesses sui generis technical, socio-economic, and political characteristics. Additionally, most of the Middle Eastern countries face frequent instabilities and hot conflicts, which complicate transboundary water cooperation.

Moreover, as King (2016) notes, international law has not been helpful in deterring non-state violent actors from weaponising water, or in effectively prosecuting them for capturing water resources and related infrastructure. Only in a few cases has the UN Security Council enacted these laws successfully (Sowers et al., 2017). One important reason for this shortfall is that the respective provisions in these war laws do not apply to subnational disputes or non-state violent actors. The international community can use its diplomatic leverage in the UN and other bodies to support the application and enforcement of these international laws. Another way is to create awareness among and provide training to national armed forces on the laws of war (King, 2016; Gleick, 2019).

4.4 National-level water governance

Successful climate adaptation of water systems depends on effective multi-level governance with vertical (i.e. across administrative units) and horizontal (i.e. across sectors) cooperation and coordination, from the local to the transboundary level. This requires sufficient capacity at all levels and in all processes and institutional structures. It also necessitates the involvement of various stakeholders, especially agriculture, as the sector is a major driver of land-use change and water consumption (Kerres et al., 2020).

Legislation and policies

Both Turkey and Iran have relatively robust environmental policy frameworks. Environmental laws in Syria and Iraq are incoherent, and their enforcement is insufficient (World Bank, 2018). For example, development projects are usually pursued without conducting environmental impact assessments (EIAs), while pollution control measures, such as a national wastewater discharge permitting system, are not in place. The government of Iran has been diluting the country's environmental policy regime for years, which used to be one of the most robust in the Middle East just a few decades ago (Schwartzstein, 2020).

Relating to water resources specifically, all riparian countries have established national water laws and policies. All countries have also issued a range of important water-relevant strategies. In 2015, Iraq, for example, developed a comprehensive national strategy for the management of water and land resources (not publicly available). In Turkey, a new action plan will come into force at the beginning of 2021, which makes important provisions for sustainable water management (Ateş, 2020).

Table 2: State of implementation of Integrated Water Resources Management in the ET basin[22]

	Turkey	Syria	Iraq	Iran
2017	70%	-	25%	59%
2020	72%	56%	38%	40%

According to an evaluation by the Blue Peace Index (European Intelligence Unit, 2021), water laws in the riparian countries have, however, considerable weaknesses. Table 2 illustrates that all countries have started to mainstream an Integrated Water Resources Management (IWRM) approach into respective policies, laws, and management practices. The implementation of this concept could indicate to what extent water resources are managed sustainably. This could be evident, for example, if an enabling legal and policy environment for sustainable water resources is in place. The state of implementation differs considerably between the countries. Turkey and Iraq have made progress over the recent period, which is quite significant in the case of the latter.

[22] Source: United Nations (2021a). The IWRM implementation has been assessed based on four key dimensions: (1) enabling environment (including policies); (2) institutions and participation; (3) management instruments; and (4) financing (see United Nations, 2021b).

A deterioration in Iran, from 59% in 2017 to 40% in 2020, may be related to changes in the country's environmental politics, which will be mentioned below.

An overhaul of environmental policies and laws in Iraq and Syria will be necessary, in view of the poor state of their respective environment and water systems, as well as growing anthropogenic pressures. Given their distinct policy situation, the riparian countries need to focus on different measures. For Turkey and Iran, strengthening checks and balances to reduce the cross-border impacts of domestic development projects will be important. This could entail, for example, making it mandatory to include such projects in Environmental Impact Assessments (EIAs). In all countries, especially in Syria, Iraq, and Iran, it will be critical to introduce policy provisions that effectively regulate over-exploitation of aquifers and rivers (Voss et al., 2013), as well to implement environmental flows (Jägermeyr et al., 2017), as already mentioned.

Institutions

The wide differences regarding the robustness of water governance systems between the countries are also prevalent when it comes to relevant institutions. All countries have water-related ministries and institutions in place (Appendix 4), including agencies responsible for water management. River Basin Organisations (RBOs), which are a key feature of IWRM and fundamental for managing water resources sustainably, exist only in Turkey. For example, the Basin Management Committees, which were established in 2013, started to act as horizontal and vertical coordination networks between ministries, local governments, and other concerned stakeholders, with a basic responsibility to prepare river basin protection and management plans. In Syria and Iraq, water-related institutions are considered to be generally ineffective and largely incapable.

Institutional designs and organisational features that are critical for effective governance are more advanced in Turkey and Iran, while these are principally subject to considerable weaknesses in Iraq and Syria (see Appendix). Common issues include insufficient capacity and resources, a lack of horizontal and vertical coordination between different ministries or agencies (including those responsible for water resources and climate adaptation), and poor data management and sharing between different ministries and with the public. Progress on solving growing water problems in Syria and Iraq hinges on transforming government institutions that are tasked with water management. However, these institutions are indebted and partly dysfunctional and corrupt, and they therefore face significant distrust and grievances from their respective populations (Cooke et al., 2020). The capacity deficit in government institutions is generally exacerbated by a "brain drain" from Iraq and Syria in particular. To that end, workshop participants noted that development assistance should focus on strengthening capacity building in national and local institutions, an element which has been insufficiently represented in past development projects.

Finance will be a serious bottleneck to climate adaptation, especially as the impacts of the COVID-19 pandemic will be felt over the coming years. The analysis by the Blue Peace Index shows that indicator values of national level investments in the water sector are rather inadequate, except for Turkey (see Appendix 5). The riparian countries will require external financial help. For example, the financial resources to rehabilitate the most critical water sector infrastructures in Iraq will require funding that exceeds the budget of the Ministry for Water Resources by ten times (in von Lossow, 2018: 9). Combining development assistance for rehabilitating infrastructure

and introducing water sector reforms together with the criteria for climate-resilient and sustainable water management provides a means for donor countries and organisations to enhance future water security in the basin (Lahn, 2020).

As shown in Appendix 5, except for Turkey, national stakeholder participation in water sector decision-making processes is limited, with Iraq lagging behind the most. This pertains to the involvement of regional and local stakeholders, as well as to the general public. Moreover, women are insufficiently represented in government institutions, and with notable differences between the four countries. Iraq has by the far the highest rate of women in the national parliament. Workshop participants confirm the analysis by the Blue Peace Index that there is also a need for improved engagement of stakeholders at the transboundary level.

The current institutional context makes bureaucratic and policy reforms challenging. It is necessary to not only strengthen the capacity and resources of central governments in the long-term, but to also tackle problems such as corruption. Because the radical institutional changes in Iraqi and Syrian water sector institutions are not easy to manifest, some experts highlight the need to increasingly work with non-governmental informal actors and establish more decentralised structures (Cooke et al., 2020). Moreover, workshop participants highlighted that the outcomes of development projects could benefit from additional support of and closer work with younger, entry-level staff in government institutions (if available) that may be less prone to corruption and cronyism.

Environmental awareness and societal support

To facilitate a change towards sustainable use of water resources, as well as to make water systems climate-resilient, it will be necessary to gain societal support. Achieving large-scale water savings or reducing pollution of water systems depends on water use practices by farmers and households, and their willingness to change habits. Such a paradigm shift will also depend on water-specific and environmental awareness-raising campaigns targeting topics such as water use, especially in agriculture. However, behaviour change will, at the same time, inevitably rely on overcoming larger structural challenges, such as low levels of education, poverty, and gender inequalities.

Politicians in the riparian countries are largely aware of the importance of environmental awareness-raising, and are addressing water-relevant issues, among others, in national water strategies. The National Communications indicate that some interventions are being pursued to improve the appreciation for environmental issues and water scarcity within society. For example, Turkey conducted local and nation-wide public awareness campaigns on the issue of climate change, which was supported by private institutions (MoEU, 2018). In its National Adaptation Process, Iraq too underlines that it will work on increasing awareness, conducting education via various media, working on capacity-building, and providing (technical) training (United Nations Environment Programme, 2019).

However, awareness on water scarcity within the societies of the basin countries is generally low, as is the case in most other MENA countries (De Châtel, 2007). In Iraq, besides low public awareness on environmental topics, there are only a few environmental NGOs, while activities by the media to report on environmental issues are rare (United Nations Environment Programme, 2007; Al-Maliki, 2021). In this regard, the workshop participants highlighted the political and cultural challenge of creating awareness among populations on water scarcity and the importance for using

water wisely, because the riparian countries had been historically used to abundant water resources.

Due to ineffective water-related government institutions, it is critical to strengthen civil society actors who are engaged in environmental issues (e.g. Nature Iraq, Save the Tigris, and BirdLife-Turkey). Where they exist, they function as an important force in driving awareness campaigns and putting pressure on governments to address environmental challenges. Some NGOs have also contributed to stimulate a more positive discourse on the value of transboundary water management. However, the limited number of environmental NGOs is not the only challenge: these NGOs are partially under high pressure from governments (Bachmann et al., 2019). For example, in Iran, environmentalists suffer from severe persecution and are often terrorised (Schwartzstein, 2020). Workshop participants pointed out that donor organisations often provide the only source of finance for NGOS. At the same time, given that the agendas between governments and donor organisations may differ, the dependence on donor organisations can lead to a situation where governments are suspicious of NGOS and may even impair their work.

Moreover, another major element is civil society organisations (CSOs), which played an important role in Syria during the civil war. As the conflict became protracted and created an overwhelming amount of needs, CSOs have become important actors, mainly by supporting humanitarian relief activities (Khalaf, 2015). The tremendous challenges during the war and in the foreseeable future would require concerted efforts from regional governments and the international community to extend their humanitarian aid and economic support to the region in more systematic and determined ways. A strategy could be adopted by the riparian states as well as by local and international funding agencies that focuses on strengthening civil society in Syria, supporting their actions in the water sector, and enhancing their ability to get funds for rehabilitation and reconstruction activities.

5. Summary and recommendations

This study examined the **impacts of climate change on water resources** and the ensuing economic and political challenges in the Euphrates-Tigris basin. In this section, we summarise its key findings and present recommendations for adaptation measures that will be essential in grappling with climate-related water risks in the future. These recommended actions will form the foundation for later work in the CASCADES project, which will reflect on the policy responses that the EU could take in supporting the riparian states in their adaptation efforts.

Compared to direct human interventions, climate change has so far played only a minor role in changing the basin's hydrology and freshwater ecosystems. However, these impacts will gradually become more significant and may eventually outweigh those caused by water infrastructure and use. Climate change will complicate and aggravate water-related challenges that are already significant in the region, especially in Iraq and Syria.

The main hydro-climatic impacts can be summarised as follows:

- Changes in rainfall volumes and timing, together with higher evapotranspiration, reduce river flows, groundwater recharge, and soil moisture;
- Reduced snow cover and more abrupt melting, driven by temperature change and flow dynamics (including flood incidences);
- Altered river flows and rising sea levels, causing saltwater intrusion into the Shatt al-Arab river system, aggravate water quality challenges;
- Increased frequency and severity of extreme climatic events like droughts, heatwaves, and flood-inducing heavy rains.

These effects of climate change, and their interactions with a number of socio-economic and political changes, will exacerbate several **risks** in the basin, but they might also entail **opportunities** for improving water security and development more broadly. We focused on how changes in water security might interact with the risk areas of (1) livelihoods and food security, (2) political stability and violence, and (3) interstate conflict and cooperation, which can be summarised as follows:

- **Livelihoods and food security:** Water stress is already high in the basin and will increase due to climate change. Many rural livelihoods that are dependent on farming are therefore vulnerable to the impacts of climate change. More severe water shortages and water quality problems will make it harder to sustain farming and livelihoods depending on ecosystems. These impacts will also compound the delivery of domestic water services in some parts of the basin, especially in southern Iraq. A failure to mitigate these water risks can contribute to poverty, food insecurity, and unemployment in rural farming communities, and eventually lead to displacement and internal migration at a larger scale than is seen today. Our work shows that the impacts of climate change are different but also significant in urban areas. Service delivery will be affected directly, for example, through deteriorating water quality in the rivers that source urban water supply, while demographic changes in rural areas could put additional pressure on urban water systems.
- **Political stability and violence:** This study examined several critical ways in which climate-related water risks could interact with political instability and violence. In rural areas, growing water scarcity is likely to increase competition over water and could lead to more local violence (e.g. between different communal groups). Growing water insecurity will lead to economic losses, which in turn reduces the government's resources for an adequate adaptation response. Rising poverty and unemployment caused by declining agricultural productivity and the loss of rural livelihoods are likely to raise discontent with political authorities and aggravate existing grievances with regard to poor service provision and resource management. As water becomes scarcer, water weaponisation could become a yet more widespread political tool.
- **Transboundary conflict and cooperation:** At the transboundary level, the main risk may not entail inter-state violence over water, the chances of which we deem relatively low. Yet climate change increases the need for cross-border action, because it renders existing allocation arrangements inefficient, for example. If the riparian states are not able to scale up efforts accordingly, climate change will intensify water insecurity in the future. This, in turn, may fuel social turmoil in Syria and Iraq where water-dependent livelihoods, communities, and economies will be increasingly affected, gradually contributing to regional destabilisation. By contrast, rethinking and scaling up cross-border cooperation could unlock significant opportunities, which could, for example, include deeper economic integration in the water and energy sectors.

The likelihood and severity of climate change impacts on livelihoods, (human) security, and riparian relations in the Euphrates-Tigris basin will largely depend on the future evolution of the region's socio-economic and political conditions. Together with regional experts consulted during our scenario planning exercise, we identify a number of factors that are critical for the **future vulnerability or resilience** of the region to climate change-related security and development challenges. These include the type of water management and pollution, demographic changes, the capability of governments, economic conditions, state-citizen relationship, and regional geopolitics and power struggles the type of water management and pollution, demographic

changes, the capability of governments, economic conditions, state-citizen relationship, and regional geopolitics and power struggles, among others.

Alongside the frequency and severity of climate hazards and the vulnerability/ resilience of riparian countries, we also assessed the **adaptive capacity** of human systems in the region by looking at the scope and quality of current adaptation measures undertaken.

As discussed in the previous section, there is limited awareness and understanding of the risks and opportunities that climate change poses. The riparian countries have started to bring adaptation efforts underway. The institutions, capacity, and policy frameworks across the Euphrates-Tigris basin are, however, currently insufficient to cope with the looming challenges of climate change. The domestic water and climate adaptation policies and infrastructure need a major overhaul that may be beyond the financial and political capacity of basin governments to deliver. The gap is even more pronounced when it comes to the regional cooperation that is necessary for addressing these challenges effectively and efficiently. As for many aspects in this study, Turkey's adaptive capacity is considerably greater than those of the other riparian states.

The **limited progress in climate adaptation** has not resulted from a shortage of approaches embraced by basin countries, although there is room for improvement when it comes to prioritisation, feasibility, or cost-benefit analysis (such as lacking feasibility and impact studies that assess, for example, the most suitable water efficiency measures at the basin scale). Many key adaptation measures that would increase the climate resilience of water-dependent sectors fall within the domain of sustainable water management (including management methods and technologies for using water more efficiently or curbing pollution). They are known and outlined in the water strategies and adaptation strategies developed by the riparian countries.

The key issue is that various economic, political, security, and institutional challenges undermine policy reforms and technical implementation. Barriers range from corruption to lack of finances and a broken state-citizen relationship, creating a "vicious cycle" that is hard to break. Our study also showed that the enabling conditions necessary for ushering in a more sustainable, climate-resilient water management are becoming less supportive (e.g. due to shrinking economies and budgets). As a consequence, the possibilities for mitigating growing water-related climate risks or taking advantage of the opportunities climate change entails are diminishing.

There is hence not only a need for **increasing adaptation efforts considerably**, but for improving the governance mechanisms that enable their effective implementation. The riparian states may not have the capacity to shoulder these interventions alone. Rather, this would require a targeted engagement by the international community. Because the EU has a particular interest in the basin's stability, it should consider how it could (best) support efforts to attenuate these risks and realise opportunities. Such considerations should include domestic and regional adaptation efforts in the water sector and other related sectors. This would help to minimise the negative impacts of climate change on livelihoods, and support national and regional efforts in devising effective and legitimate institutions that can prevent and manage potential conflicts and their impacts on livelihoods. To that end, this study recommends to:

1. **Help individual basin countries reform water management in water-intensive sectors.**

Given the uncertainty about (and low likelihood of) substantial advances in cross-border multilateral water cooperation in the near future, there is a particular need for Iraq and Syria to make the best use of available water by establishing a more sustainable water management approach, e.g. by improving demand management and reuse of wastewater. Given the distinct challenges they face, riparian countries will have to pursue different priorities. For Syria and Iraq, it will be critical to rebuild essential infrastructures for drinking water and wastewater treatment and infrastructures for conveyance, and to establish a more sustainable approach to water management. In their own interest in terms of regional stability and prosperity, Turkey and Iran should seek to reduce negative cross-border impacts (e.g. by conducting environmental impact assessments that explicitly study downstream effects).

2. **Help the region devise adaptation options that strengthen overall water security.**

Measures that should be prioritised include mutual learning, data-sharing, joint risk assessments, and exploration and identification of effective adaptation options. Advancing climate adaptation will require strengthening efforts for international policy processes (such as the NDCs) and for accelerating implementation. The international community can assist the riparian countries, for example, in accessing climate finance and ensuring that sustainable water resources management is adequately considered in climate adaptation strategies and projects. At the same time, it is critical to make sure that climate resilience is an integral part of water management. The international community can ensure this, for example, by making climate resilience conditional in the finance it provides for rebuilding water infrastructures or improving water management. Adaptation efforts should also support individual countries in their respective efforts to increase alternative livelihood options, manage internal friction over resource access, and prepare strategies for coping with larger numbers of internal and cross-border refugees.

3. **Support the conditions that enable advancements in institutionalised cross-border water cooperation.**

Improving knowledge will be important, not only to make water resources management more effective, but also to help the riparian countries build trust with one another and with cross-border water institutions. Knowledge creation will also be essential in the context of benefit-sharing and economic cooperation, for example, by promoting studies that map out mutually beneficial development pathways (such as on joint water and energy projects discussed in this study). Moreover, it will be crucial to strengthen the capacity of existing institutions (including those working in agriculture, irrigation, and other water-relevant sectors) to cope with future changes, as well as to support the process of establishing a future platform for multilateral cooperation. Interventions in this regard must also improve stakeholder participation, extending processes to a broader range of stakeholders from civil society and the private sector. The international community may play an increasingly important role in mediating inter-state conflicts, as water stress in the basin is increasing. This is especially true in the absence of transboundary institutions and mechanisms that could mediate conflicts.

4. **Help strengthen the water governance system in the riparian countries.**

Efforts should aim at making environmental and water legislation more robust, and ensuring more systematic enforcement of such legislation. While central water

agencies exist in all riparian countries, these tend to be largely incapable of implementing effective and sustainable water resources management (except in Turkey). Growing future challenges will widen the gap between resources and know-how. River basin organisations need to be established to allow for basin-level water management, but these only exist in Turkey. Without significantly larger interventions in capacity-building and resource provision, government institutions will not be able to accomplish major reforms of water management, given the range of discussed structural challenges. As experts are not in a position to overcome many of the structural challenges of governance systems, it will be critical for the international community to consider approaches that enable them to provide effective development assistance in contexts that may become yet more dysfunctional and ineffective. This could include support for decentralised governance, including irrigation associations, empowerment of civil society (e.g. for women), and trying to leverage private sector actors for positive change (e.g. in the realm of renewable energy).

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7. Annexes

Annex A: Employment in agriculture and contribution of agriculture to GDP[23]

Year	Turkey	Syria	Iraq	Iran
Employment in agriculture (% of total employment)				
2000	41.43	32.89	26.24	24.52
2010	23.70	14.53	21.89	19.22
2017	18.02	10.50	17.79	17.82
Contribution of agriculture to GDP (%)				
2000	10	24.1	4.6	9.1
2010	9	/	5.2	6.5
2017	6.4	/	1.5	12.2

Annex B: Key indicators determining water security at household level[24]

	Turkey	Syria	Iraq	Iran
Renewable internal freshwater resources per capita (cubic metres)				
2017	2,799	418	937	1,593
Access to water (% of population)				
2000			50.0	91.1
2010			55.2	91.5
2017			58.8	91.8
Access to sanitation (% of population)				
2000	52.8		31.7	
2010	60.6		36.3	
2017	65.2		41.1	

[23] World Bank (2021a; 2021c). World Development Indicators | DataBank (worldbank.org)

[24] World Bank (2018; 2021b); United Nations (2021a)

Annex E: Continued

Children Deaths under five due to diarrhea (%)				
2015		14.4	5	4.2
Mortality attributed to poor water and sanitation access (deaths per 100,000)				
2016	0.3		3.0	1.0

Note: Some data are estimated or comprise estimates based on projected values.

Annex C: Key indicators regarding food security in the ET basin[25]

	Turkey	Syria	Iraq	Iran
Number of undernourished people (in millions)				
2001			5.5	3.2
2010			6.5	3.6
2018			9.1	3.9
Prevalence of undernourishment (%)				
2001	<2.5		22.6	4.8
2010	<2.5		21.9	4.9
2018	<2.5		23.7	4.7
Prevalence of moderate or severe food insecurity in the adult population				
2015				48.0
2018				39.7

Note: Some data are estimated or comprise estimates based on projected values.

Annex D: Volume of crop production, demand for food, and net trade[26]

	Turkey	Syria	Iraq	Iran
Volume of crop production (million tons)	82.50	13.3	9.65	56.8
Food Demand (million tons)	38.20	8.09	6.17	33.90
Net trade (million tons)	2.02	-3.74	0.68	-5.49

[25] United Nations (2021a)

[26] Source: World Resource Institute (2019)

Annex E: Main governmental institutions for environment, agriculture, and water resources as outlined in official documents[27]

Country	Name of the Institution	Responsibilities and Characteristics
Iran	Department of Environment	Climate change adaptation and mitigation Coordinating the NCCC, working groups, and external organizations like the UN
	National Climate Change Committee	Is part of the DoE Comprises all relevant ministries Implementing strategies and action plans
Iraq	Ministry of Environment	Protect and preserve the environment Plan, observe, and enforce environmental standards, policies studies, strategies, and interventions
	Ministry of Agriculture	Develop policies on food security and supply Support investments in agriculture Develop and increase water resources and canals
	Ministry of Water Resources	Water management, including maintenance of irrigation canals and dams, or marsh restorations
Syria	Ministry of State for Environment Affairs	Leads environmental programs and initiatives Prepares plans, regulations and laws Establishes necessary environmental institutions
	Ministry of Local Administration and Environment	Monitoring and controlling water quality Issuing national standards for the protection of water resources and tracks pollution Involved in the drafting process of Syria's NDC
	General Commission of Environmental Affairs	Under the administration of the MLAE National focal point of the climate change convention and executing the INC Coordinates relevant ministries, provincial departments, and other governmental sectors
	Environment Protection Council	Comprises all relevant ministries Developing national policy and coordinating environmental activities Legislation
	Ministry of Agriculture and Agrarian Reform	Rational use of water for agricultural purposes
	Ministry of Irrigation	Managing policies and investments related to water Water protection and allocation between various sectors

[27] Sources: DoE, 2017; Food and Agriculture Organization, 2008a; MoE, 2016; MoEU, 2018; Veilleux, 2018.

Annex E: Continued

Turkey	Ministry of Environment and Urbanization	Preparing legislation, permits and other documents related to environmental protection Formation and implementation of environmental policies Planning, monitoring and coordinating studies and interventions
	Ministry of Agriculture and Forestry	Issuing laws and legislation with regard to food, water, agriculture and livestock Water resources development, management and allocation for domestic, irrigation, industrial and energy uses Developing and executing river basin protection and management plans Providing funding Carrying out research
	Agriculture and Rural Development Support Institution	Managing rural development programs by accepting, controlling, evaluating, and funding them
	Climate Change and Air Management Coordination Board	Coordinated by the MoEU Determines and executes climate change policies Comprises representatives of all relevant ministries and institutions

Note that finding up-to-date information about the relevant institutions is difficult, especially for Syria. Administrative changes may have occurred since the publication of the consulted documents.

Annex F: Evaluation of management of shared water resources across five pillars based on a score (0 being low; 100 being high)[28]

		Turkey	Syria	Iraq	Iran
Policy and Legal Frameworks					
	National Water Policy				
	National water law/policy	50	50	50	50
	IWRM	100	0	0	50
	Transboundary impact provisions	0	0	0	0
	National environmental policy				
	National wastewater discharge permitting system	100	0	0	100
	Polluter pays principle	100	0	50	100
	Transboundary environmental impact assessment (EIA)	50	0	0	0
	Environment impact assessment (EIA) public consultation	100	0	0	50
	International Water Conventions				
	International Water Conventions	0	100	100	0
	Basin water policy framework				
	Transboundary water management (TBWM) agreement	33.3	33.3	66.7	33.3
	Joint management plan	0	0	0	0
	Water allocation mechanism		0	0	0
	Transboundary water management (TBWM) sectoral score	0	0	0	0
	Dispute resolution mechanism	0	0	0	0

[28] Sources: EIU (2021)

Annex F: Continued

Institutional arrangements & participation					
	National water agency				
	National water agency	100	100	50	50
	National water capacity building	100	50	0	50
	National stakeholder engagement				
	Inter-ministerial stakeholder engagement	100	50	0	100
	Regional and local stakeholder engagement	100	50	0	0
	Broader public stakeholder engagement	50	0	0	0
	National data sharing				
	Inter-ministerial data sharing	50	0	0	100
	National public data sharing	100	0	0	0
	Basin level body				
	Joint River basin Organisation (RBO) operational body	0	0	0	0
	River basin Organisation (RBO) secretariat	50	0	0	0
	Joint water capacity building	50	0	50	0
	Basin stakeholder engagement				
	Inter-governmental stakeholder engagement	0	0	0	0
	Basin public stakeholder engagement	0	0	0	0
	Basin data sharing				
	Inter-governmental data sharing	0	0	0	0
	Public data sharing	0	0	0	0

Annex F: Continued

Water management instruments					
	Water availability management				
	National water quantity monitoring	100	0	50	50
	National water efficiency programme	50	50	0	50
	Pollution control				
	National water quality monitoring	50	0	0	50
	National water pollution reduction programme	100	0	0	100
	National disaster management				
	National disaster risk management plan	50	0	50	0
	National climate change adaptation strategy	100	0	0	100
	Basin water availability management				
	Joint monitoring programme	0	0	0	0
	Joint assessment programme	0	0	0	0
	Basin pollution control				
	Joint water quality standards	0	0	0	0
	Joint water pollution reduction programme	0	0	0	0
	Basin disaster management				
	Joint alarm system	0	0	0	0
	Joint mutual assistance system	0	0	0	0

Annex F: Continued

Infrastructure & Financing					
	National-level investment				
	Infrastructure quality	57.5	19.3	40.2	31
	National water budget	100	0	50	50
	National source of revenue allocated to water development	100	0	0	0
	Watershed protecting funding	0	0	0	0
	Sovereign debt risk	59.6	13.4	45	65.4
	Private sector investment				
	Water-related PPP projects	0	0	0	0
	Overall number of PPP projects	66.7	6.3	4.7	1.7
	Currency risk	64.5	25.6	57.5	60.6
	Green finance	0	0	0	0
	Investment climate				
	Registering property (incl. land)	82.2	15.6	40	53.3
	Getting credit	75	15	0	50
	Dealing with construction permits	73	0	68	69
	Financial and regulatory risk	83.9	4	12.5	25
	RBO operational financing				
	National River basin (RBO) funding	0	0	0	0
	Joint investment programmes	0	0	0	0
	Basin infrastructure financing				
	Private sector investment	0	0	0	0
	Innovative River Basin Organisation (RBO) funding	0	0	0	0

Note: More information on the indicator framework underlying the evaluation can be found in the methodology document developed by the Economist Intelligence Unit:
https://bluepeaceindex.eiu.com/pdf/Blue%20Peace%20Index%202019_methodology%20note.pdf

Annex G: National communications on adaptation measures. Sources: The latest National Communication of each country[29]

		Iran	Iraq	Syria	Turkey
	Adaptation for water resources				
	Promote research and data collection		X		X
	Increase internal data exchange and coordination			X	
	Enforce water protection laws and regulations	X	X	X	X
	Enhance water collection	X	X	X	X
	Promote and improve dam operations	X	X	X	X
	Optimize water use and increase water saving	X	X	X	X
	Strengthen observation networks	X	X	X	X
	Establish early warning systems	X	X		X
	Sector-specific water adoption plans	X		X	X
	Facilitate collaboration with neighboring states	X	X		
	Enable inter-basin water transfer	X	X		
	Ensure training and capacity building		X	X	
	Strengthen public awareness and participation	X	X		X
	Adaptation in agriculture				
	Review and improve policies and strategies	X	X	X	X
	Develop drought information forecast and other information systems	X	X	X	X
	Changing crop practices	X	X	X	X
	Control and prevent soil erosion	X			X
	Developing research		X	X	X
	Improving irrigation methods and management	X	X	X	X
	Apply water harvesting and storing	X	X	X	
	Modification of pesticide, herbicide, and fertilizer use	X	X		X
	Implement regulation and laws	X	X		X
	Expand insurances	X			X
	Income stabilization and financial assistance	X			X
	Establish rewards and subsidies	X			X
	Ensure training and education	X			X
	Increase public awareness	X	X		X

[29] (DoE, 2017; MSAA, 2010; MoEU, 2018; MoHE, 2016)

Annex G: Continued

	Adaptation in public health				
	Control and prevent water pollution	X	X	X	X
	Establish wastewater treatment plants		X	X	X
	Develop monitoring and/or warning systems	X	X		X
	Food and nutrition interventions	X			X
	Promote health education and awareness	X	X	X	X
	Monitoring and/or evaluating health information		X	X	X
	Develop health strategies and plans	X	X	X	X
	Capacity building for institutions and staff		X	X	

Note: X means they are considered and listed in the National Communications. This is not a complete list of all planned adaptation measures for each country. It only includes the explicitly listed actions for adaptation and the national adaptation measures listed may be influenced by the time the document was written (e.g. 2010 in the case of Syria and 2018 in the case of Turkey). Hence, this table only serves the purpose of comparison.

The project has been funded by the European Union's Horizon 2020 research and innovation programme under grant agreement No. 821010

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