Climate Risk Profile Jordan*

Summary

In Jordan, concerns are rising about the effects of climate change. In the last decades, the country has experienced recurring droughts, flash floods, and landslides. Most concerning, however, is the already highly critical water shortage: **Jordan currently is the fifth-highest ranking country in terms of water stress** [1]. Climate change-induced increases in temperature, decreases in precipitation and heightened evapotranspiration will continue to reduce water supply and further exacerbate water scarcity in the future, posing a substantial risk to the country's people, natural resources and economy [2].

This climate risk profile provides an **overview of projected climate parameters and related impacts** on different sectors in Jordan until 2080, **under different climate change scenarios provided** (called Representative Concentration Pathways, RCPs). RCP2.6 represents a low emissions scenario that aims to keep global warming below 2 °C above pre-industrial temperatures; RCP6.0 represents a medium to high emissions scenario. **Model projections do not account for effects of future socioeconomic impacts.**

Infrastructure: Throughout all time frames (2000–2080), the **exposure of major roads and urban land area to river floods is projected to hardly change** under either RCP. Even under RCP6.0, the annual exposure of major roads to flooding will amount to between 0 and 0.41 % by 2080 (very likely range), while flooding exposure of urban land area is very likely to remain below 0.15 % under both emissions scenarios.

Temperature: Depending on the climate change scenario, temperature in Jordan is projected to very likely **rise by between 1.4 and 2.5 °C by 2030, 1.7 and 3.1 °C by 2050, and 1.7 and 4.5 °C by 2080,** compared to pre-industrial levels. Rising air temperatures will affect the whole country, but will be comparatively higher in the already dry northeast and south. Furthermore, the **annual number of days with a maximum temperature above 35 °C is projected to augment with high certainty all over Jordan.** Until 2030, depending on the scenario and region, the number of very hot days will rise by between around 15 and 26 days, compared to 2000. In the long term, the **increase will be highest in the more populated northwest and west of Jordan,** with an increase by up to 71 very hot days by 2080, compared to the year 2000.

Precipitation: Higher greenhouse gas emissions will lead to a **drier future for Jordan**. All models project a **clear decrease in mean annual precipitation** over Jordan. The decline will be comparatively higher on the eastern border and in the southwest. Still, the magnitude of decrease is uncertain and natural rainfall variabilities will persist. Under RCP6.0, precipitation will decrease stronger, but also with higher uncertainties: Until 2030, annual rainfall will decrease by between 2 and 20 mm, by 13 to 23 mm until 2050, and 13 to 26 mm annually by 2080. **Heavy precipitation events can be expected to some degree decrease** under both scenarios, with slightly stronger declines in the very south and northeast of Jordan. However, uncertainties regarding the magnitude of the decrease are high.

Health: Rising temperatures and the increase in very hot days will very likely result in **more heat-related mortalities.** According to the best estimates, heat-related fatalities will go from 1 death per 100,000 people and year in 2000 to 1.7 and 1.8 deaths per 100,000 people and year until 2030 under RCP6.0 and RCP2.6 respectively.[1] By **2080, heat-related deaths will grow to 2.2 (RCP2.6) and 4.2 (RCP6.0) deaths per 100, 000 people annually.** Under a high emissions scenario (RCP8.5), temperature extremes are projected to **exceed a threshold for human habitability in many cities in the MENA region towards the end of the century [3].**

Water availability: Water availability in Jordan **is already highly insufficient today** [1]. **When accounting for population growth, per capita water availability for Jordan will decline to very low levels.** However, model disagreement remains very high. Projections for 2030 range between 46 and 385 m³ (multi-model median of 94 m³) per person and year under RCP2.6, and between only 32 and 301 (multi-model median of 80 m³) under RCP6.0. This decline will continue: By 2080, per capita water availability is projected to very likely range between 22 and 230 m³ (multi-model median of 60 m³) per person annually under RCP2.6, and between 15 and 206 m³ (multi-model median of 44 m³) under RCP6.0. In light of the **threshold for absolute water scarcity, which is below 500 m³ per person and year [4], these projections are a serious warning sign.**

* This climate risk profile is the product of a collaboration between Weathering Risk and the AGRICA project from PIK. It draws on the methodology developed within the AGRICA project.

Agricultural yields: The uncertainty of the projections regarding water availability translates into a **high uncertainty of crop exposure to drought,** with some models projecting a significant increase, and some no change. Potential evapotranspiration, an important indicator for drought conditions and thus agricultural productivity [5], is projected to intensify, though the magnitude of increase is highly uncertain. **Projections of future wheat and maize yields are also highly uncertain** due to different models projecting different directions of change. Consequently, no trend for future yields can be derived.

GDP exposure to heatwaves: Under RCP2.6, GDP exposure to heatwaves will remain low over the period 2000 to 2080, ranging between 0.1 and 4.5 % (very likely range). **Under RCP6.0,** GDP exposure will remain similarly small until 2045. From this point the models assume **a sharp increase, with between 2.2 and 18.3 % of the GDP to be exposed to heatwaves by 2080** (very likely range). However, modelling uncertainty about the magnitude of increase rises, too.

Exposure to heatwaves: Rising temperatures and the increasing number of very hot days will result in a heightened **exposure to heatwaves,** in comparison to the year 2000. While the population exposed to heatwaves under RCP2.6 will be comparatively low, **exposure to heatwaves will augment sharply between 2030 and 2080 under RCP6.0.** However, modelling uncertainty about the magnitude strongly augments, too: Between 1.7 and 20.5 % of the population will be exposed to heatwaves annually by 2080 (very likely range).

Ecosystems: The **Uncertainty regarding projections of species richness is high,** particularly under the low emissions scenario RCP2.6. Wherever data are available, medium (2050) and long-term (2080) projections under RCP6.0 suggest declines by up to 14 % (2050) and 19 % (2080) for the northwest and west of Jordan. **Model agreement on the direction of change in tree cover is low** and consequently, no reliable conclusions can be drawn under either RCP.

1 The differences between the RCPs by 2030 are often very small, and impacts by 2030 may even be slightly higher under RCP2.6 than under RCP6.0. The reason for this is that the climate system responds relatively slowly to changes in the concentration of greenhouse gases.
2 The symbol displayed here indicates the projections which are subject to high levels of uncertainty. These projections must be interpreted cautiously. For further explanations on uncertainties and how to deal with them, please see the text box “Uncertainties in climate change projections” on page 7.

Context

Jordan, officially referred to as the Hashemite Kingdom of Jordan, is located in the Middle East, bordering Israel, Syria, Iraq and Saudi Arabia. The country covers an area of 89,319 km² [2]. With a **shoreline of only 26 km along the Gulf of Aqaba in the south of the country, Jordan is an almost landlocked nation** [6]. The estimated total population is 10.2 million (as of 2020) [7]. Jordan's population is unevenly distributed across the country, with over 90 % residing in urban areas. Most people **live in the mountainous north-western region,** where rainfall amounts and water accessibility are highest [2]. The World Bank reports a decrease in population growth from 2.4 % in 2017 to 1 % in 2020 [7]. However, actual population growth has been substantially higher, as **the wars in Iraq and Syria have triggered an unprecedented influx of refugees** into the country: as of October 2022, a total of 676,621 Syrian refugees alone were officially registered with the United Nations High Commissioner for Refugees (UNHCR) in Jordan [8]. According to the Jordanian government, however, the number of Syrians seeking refuge in Jordan is significantly higher, amounting to more than twice the number provided by UNHCR [2]. This influx of refugees heightens **pressure on already limited natural resources,** as well as on Jordan's economy and public services [2].

Jordan is an **upper middle-income country** [7]. Unlike other countries in the Middle East, Jordan lacks rich oil and gas deposits to provide government revenues. The country is heavily dependent on foreign aid, loans and remittances [9]. Other economic challenges include chronically high unemployment rates[3] and high public debt [6]. In 2017, the service sector accounted for the largest share of GDP (67%), followed by the industrial sector (29 %), and the agricultural sector (5 %).[4] Potassic fertilizer, knit garments and packaged medicaments are Jordan's key export products [11].

The availability of water and other natural resources in Jordan is highly insufficient. Water scarcity and limited arable land are among the key constraints to agricultural production, making Jordan a **highly food-deficient country.** Around 80 % of food requirements are imported [12]. Nevertheless, 20 to 25 % of households depend on the agricultural and food sector for their livelihoods [10] [12].

Of the total agricultural land comprising 11.4 % of the country, permanent pastures take up 8.4 %, while only 2 % is arable land [6]. Livestock, primarily sheep, represent around 55 % of agricultural production [10] [12]. Though some field crops are grown in the Jordanian highlands, agricultural production mainly takes place in the Jordan Valley, whose warm, temperate climate allows for the **cultivation of fruit and vegetables,** including tomatoes, olives and other fruit and legumes [13] [14]. More than half of Jordan's agricultural land is rainfed [14]. In 2018, 32 % of Jordan's cultivated areas were equipped for irrigation, 93 % of which were actually irrigated [15]. According to the World Resources Institute (WRI), Jordan currently ranks fifth in nations facing the greatest water stress [1]. Despite the very small sectoral contribution to the national GDP (5 %), **over 50 %[5] of Jordan's freshwater resources are consumed by the agricultural sector,** mainly due to largely inefficient irrigation systems [2].

Concerns are also rising about the **effects of climate change.** In the last decades, Jordan has recurrently experienced droughts, flash floods and landslides, which caused multiple deaths and severely destroyed agricultural land and infrastructure [1] [16] [17]. Furthermore, as previously mentioned, water stress already poses a significant risk to Jordan's population [1]. **Climate change-induced rises in temperature, decreases in precipitation, and increases in evaporation will continue to reduce water supply and further exacerbate water scarcity in the future** [2] [17].

Quality of life indicators

Human Development Index (HDI) (2019)	ND-GAIN Vulnerability Index 2018	GINI Coefficient (2010)	GDP per capita 2020	Poverty headcount ratio (2018)	Prevalence of undernourishment (2019)
0.729 (0 = low, 100 = high) (102 out of 189)	**51.4** rank 75 of 182 countries (the higher, the more vulnerable)	**33.7**	**2,900** (constant 2015 USD)	**8.6 %** (at 1.90 USD per day, 2011 PPP)	**9.5 %**

[7] [18] [19]

3 Youth unemployment is particularly high: 37.3 % of the youth aged 17-24 were unemployed, as of 2019 [6].
4 However, when accounting for its indirect contributions (the entire food sector) agriculture contributes to 25-30 % of the GDP [10].
5 46 % are derived from groundwater sources [14].

Topography and environment

Jordan can be divided into **three major landscapes** (from west to east): the Jordan Rift Valley (or the Ghor), the Mountain Heights Plateau, and the Eastern Desert (or the Badia Region). The Jordan Rift Valley expands from north to south, reaching the lowest dry point on the Earth's surface at the Dead Sea (431 m below sea level). It continues south to the Gulf of Aqaba, where Jordan has small access to the Red Sea.[6] The Mountain Heights Plateau is rising east of the Jordan Rift Valley. With a height of 1,854 m, the Jabal Umm ad-Dami peak near the coastal city of Aqaba is the highest point of the country [6]. The Eastern Desert (Badia) adjoining the mountainous region covers around 75 % of the country [2]. These three landscapes also define Jordan's **agro-ecological zones** (subtropic-moderately cool/semiarid, subtropic-warm/semiarid, and desert arid (see Figure 1)). Each of these zones is characterised by specific temperature and moisture regimes and, consequently, specific patterns of crop production and pastoral activities.

Water demand in Jordan by far exceeds the supply from the available aquifers and surface rivers. The combined effects of declining rainfall, recurring droughts, excessive water consumption and population growth related to the refugee influx have resulted in a strong decrease in per capita water availability, **putting the country at dangerously low water levels.** Groundwater resources, contributing to around 61 % of the total water supply, are extracted at twice the rate as they are being replenished [21]. Most of Jordan's **freshwater resources stem from the Jordan River and its tributaries, the Yarmouk and Zarga rivers** (see Figure 1). The Jordan River forms the border between Jordan to the east, and Israel and the West Bank (Palestinian Territory) to the west. It rises at the Lebanese-Syrian border in the north of Jordan, and flows downstream through the Sea of Galilee before discharging into the Dead Sea. The Yarmouk River, originating in Syria and joining the Jordan River further downstream, is Jordan's largest tributary. It provides much of the freshwater for agricultural production in the Jordan Valley and to the capital Amman.

Declining freshwater supplies affect the entire region. Despite existing water sharing agreements with both Syria and Israel, **water withdrawals continue to cause tensions between the riparian states.** Jordan is adversely affected by unilateral water development projects by Israel in the Upper Jordan River and the Golan Heights [21]. Furthermore, since the 1960s, Yarmouk River flows have declined by over 85 %, which is mostly ascribed to dam building activities for agricultural irrigation [21].[7]

In addition to the challenges posed by limited water availability, an estimated **41 % of Jordan's total land area is degraded in consequence of unsustainable land use.** For example, substantial overgrazing reduced the value of the carrying capacity of rangeland areas by up to 70 % [23]. Unsustainable groundwater extraction, recurring droughts and climate change add to the deterioration of land [23]. Furthermore, Jordan is heavily exposed to the occurrence of **dust storms,** which are most prominent between February and May [24].[8] Dust storms remove topsoil and destroy crops and grassland, thereby further driving land degradation and desertification. At the same time, the expansion of desert areas favours the development of sand storms. Increased dust concentrations also cause respiratory and cardiovascular illnesses [25]. **Drier conditions are expected to intensify in the context of climate change,**[9] highlighting the need for adaptation strategies in order to protect biodiversity and maintain fragile ecosystems and their services [26] [27].

6 The Jordanian coastline along the Gulf of Aqaba is only about 26 km long. Our global climate models used for the projections are not sufficiently downscaled to allow for scientifically sound sea level rise projections which is why they are not provided in this climate risk profile.

7 For decades, Syria built dams for agricultural irrigation, limiting downstream water availability in Jordan [21]. The Syrian civil war led to a sharp decline in agricultural productivity in southern Syria, resulting in more water flowing into the Yarmouk River and reaching Jordan [22].

8 Between 1980 and 2018, dust storms have increased in frequency and intensity in southern and eastern Jordan as a consequence of drought, poor vegetation cover and reduced precipitation amounts [24].

9 As the IPCC Assessment Report 2021 finds, droughts in the Mediterranean region will become more severe, frequent and prolonged under moderate emissions scenarios and will rise sharply under higher emissions scenarios [26].

Present climate

There are two main seasons in Jordan. The rainy season lasts from October to May, with the months from December to March characterized by heavy rainfall. These are followed by hot and dry summers from April to November. Being a primarily arid to semi-arid country, annual precipitation is very low, amounting to only 110 mm on average. The average air temperature amounts to 19 °C [28]. However, temperature and precipitation levels vary significantly across the landscapes and between the seasons:

In the Jordan Rift Valley, average annual rainfall ranges between around 100 and 300 mm, reaching a maximum of nearly 400 mm in the very northeast of the country. The average temperature amounts to between 17 and 21 °C, with hot summer temperatures rising to between 38 and 39 °C. In the most populated Mountain Heights Plateau, temperatures range between around 17 and 19.5 °C, while precipitation varies from around 350 mm in the northern to only around 50 mm in the very southern highlands. The Eastern Desert (Badia Region) experiences average temperatures of between 18.5 and 21 °C, with relatively mild winters and hot summers (26–29 °C). Average annual rainfall levels remain mostly below 100 mm, partially as low as 60 mm [28] [29].

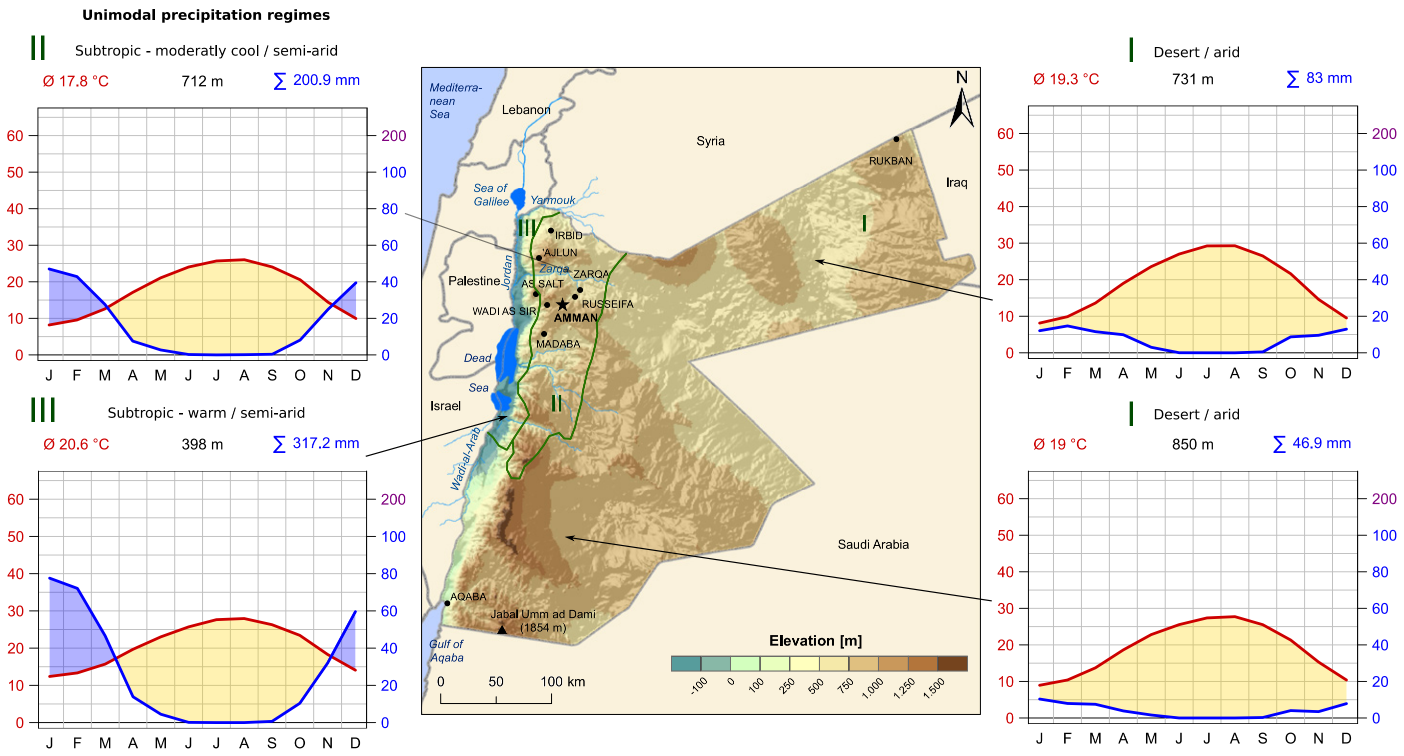

Figure 1: Topographical map of Jordan with existing temperature and precipitation regimes.[10]

10 The climate graphs display temperature and precipitation values which are averaged over an area of approximately 50x50 km. Especially in areas with larger differences in elevation, the climate within this grid size may vary.

How to read the plots

The maps and plots included in this section provide an overview of projected climate change parameters and related sector-specific impacts in Jordan until 2080 under two different climate change scenarios (RCPs): RCP2.6 represents a low emissions scenario that aims to keep global warming below 2 °C above pre-industrial temperatures, and RCP6.0 represents a medium to high emissions scenario. Projections are provided until the year 2080, with each year showing the mean value of a 31-year period.[11]

The **line plots** show climate impact projections averaged over the whole country, with the blue colour representing the RCP2.6 scenario, and the red colour representing the RCP6.0 scenario. While the lines depict the best estimate (representing the multi-model median of 10 climate models), the shaded areas represent the likely range (strongly shaded area) and the very likely range (lightly shaded area), indicating the range of model agreement of at least 66 and 90 % of all model projections, respectively.

How to read the line plots

historical RCP2.6 RCP6.0

best estimate likely range (central 66 %) very likely range (central 90 %)

The **map plots** display regionally explicit climate information under RCP2.6 and RCP6.0, in a spatial resolution of approximately 50 x 50 km. While the leftmost column represents the baseline period as found in the model data, the other three columns represent future projections in comparison to that baseline period. The colour values depict the multi-model median of the underlying models at each grid cell. The presence of a dot means that at least 75 % of the models agree on the sign of change depicted for the specific grid cell and scenario (i.e. whether an increase or a decrease can be expected). Conversely, the absence of a dot represents the lack of model agreement on the predicted change.

Uncertainties in climate change projections

It is important to acknowledge that uncertainties are always part of climate change projections. Uncertainties arise from a variety of factors, including natural variabilities, uncertainties in GHG emissions scenarios and differences in the models used [30]. Consequently, no future (climate change) projection comes without some level of uncertainty. The levels of (un)certainties, however, differ. We present the results of ten different global models. To indicate the (un)certainty of the projections we consider model agreement. The more these models agree the higher the certainty, the more they disagree the lower the certainty. For example, if different models project a similar result under the same scenario, the projected changes demonstrate low levels of uncertainty, however, if they project very different changes (in terms of range and also direction) under the same scenario, then the projections are uncertain.

Line plots and map plots depict uncertainty differently and cannot be compared: The line plots indicate the level of certainty through the shaded areas, depicting the likely (central 66 %) and very likely (central 90 %) range of all model projections (see section “How to read the plots”). Generally, the smaller the shaded areas, the more certain the projections (for an example of a relatively certain projection, see Figure 24, while for an example of a highly uncertain projection, see Figure 16). The map plots depict the level of certainty through the presence or absence of dots (see section “How to read the plots”). If dots are present, at least 75 % of all models agree on the direction of change or in other words an increasing or a decreasing trend (for an example, see Figure 3). If the dots are absent in a specific region or scenario, then model agreement within this specific region and scenario is below 75 % (for an example, see Figure 22).

To simplify the interpretation of the projections, all line plots and map plots that are subject to high levels of uncertainty are marked with a symbol ( ). This does not imply that these plots have no informational value, but rather draws attention to the limitations of such projections for future planning. Consequently, they should be carefully interpreted when they are used for planning measures. In the case of high uncertainty, additional information will be provided on how to interpret the data.

11 To generate clear and consistent long-term projections which balance interannual variabilities and extremes, we use a period of 31 years.

Part I: Projected climatic changes

Temperature

As a result of increasing greenhouse gas (GHG) concentrations, the **air temperature over Jordan is very likely to rise by between 1.7 and 4.5 °C by 2080, relative to the year 1876** and depending on the future GHG emissions scenario (Figure 2).

Compared to pre-industrial levels, the projected air temperature increase will very likely range between around 1.4 and 2.5 °C by 2030, 1.7 and 2.7 °C by 2050, and 1.7 and 2.9 °C by 2080 under RCP2.6. The median climate model temperature projects an increase of approximately 1.8 °C by 2030, and 2.2 °C by 2050 and 2080. Under the medium to high emissions scenario RCP6.0, air temperature will increase by 1.5 to 2.4 °C by 2030, 2.0 to 3.1 °C by 2050, and 2.9 to 4.5 °C by 2080 (very likely range). The median climate model temperature projects a rise of 1.8 °C by 2030, 2.4 °C by 2050 and 3.6 °C by 2080.

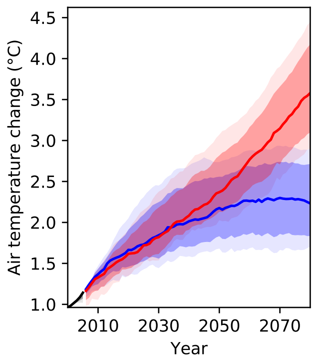

Figure 2: Air temperature projections for Jordan for different GHG emissions scenarios, relative to the year 1876.[12]

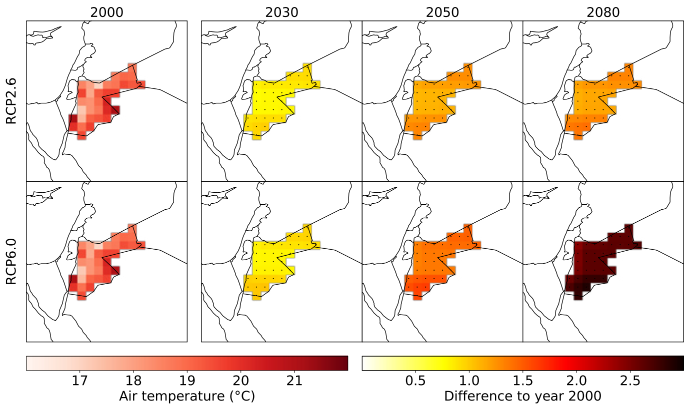

Figure 3: Air temperature projections for Jordan for different GHG emissions scenarios, relative to the year 2000 (regional variations).[13]

The increase in air temperature will affect the entire country with high certainty (Figure 3). Under the lower emissions scenario RCP2.6, the **incline in temperature will be slightly stronger in southern and northeastern Jordan.** By 2030, temperatures will augment by between 0.77 °C in central Jordan and by up to 0.97 °C in the south, compared to the year 2000. Temperature gains between 2030 and 2080 will be small. By 2080, models project a rise by up to 1.3 and 1.4 °C for northeastern and southern Jordan, respectively, and by up to 1.1 to 1.2 °C for the rest of the country. Under the medium to high emissions scenario RCP6.0, temperature changes by 2030 will develop very similarly to those under RCP2.6 (increasing by between 0.8 °C in central Jordan and 1 °C in the northeast and the south). In the long term, however, RPC6.0 projects a temperature increase of 2.4 to 2.9 °C by 2080, compared to 2000. Again, **the arid south will be most affected, with an increase of up to 2.9 °C.** Temperatures will climb by about 2.6 °C in the northeastern desert and by around 2.4 °C in the more densely populated semi-arid northwest of the country.

12 Changes are expressed relative to year 1876 temperature levels using the multi-model median temperature change from 1876 to 2000 as a proxy for the observed historical warming over that time period.
13 While the line plot on air temperature change (Figure 2) compares future projections with temperature changes between 1876 to 2000, this map plot (Figure 3) provides projected air temperature changes relative to the year 2000. Hence, projections of those plots are not comparable.

Very hot days

As our models show (Figure 4), the average number of very hot days, which we define as days with temperatures above 35 °C, amounted to approximately 76 days in 2000 (multi-model median). The highest recorded numbers were up to 111 days annually (multi-model median) in the eastern desert (Badia), while there were significantly less very hot days in the Mountain Heights Plateau.

Concurrent with rising annual mean temperatures (Figures 2 and 3), **the annual number of very hot days is projected to rise with high certainty all over Jordan, with the highest long-term increases in the west, including Jordan's populated northwest** under RCP6.0. Under RCP2.6, the number of very hot days will augment by between 20 and 26 days in most parts of Jordan, with a maximum of 28 more very hot days per year until 2030 in the southeast, compared to 2000. Thereafter, the number of days surpassing the 35 °C threshold will continue to grow steadily: In 2050, there will be between 23 and 32 additional very hot days annually, while the increase will range between 25 and 35 days annually by 2080, as compared to the year 2000.

Under RCP6.0, very hot days are projected to augment by 2030 in a relatively similar manner as under RCP2.6, between 15 and 25 additional very hot days. Until 2080, however, the incline will be stronger: comparatively smaller increases in hot days are projected for the northeast, amounting to around 45 additional days per year, while northwestern and central Jordan will experience a rise of up to 71 very hot days annually by 2080.

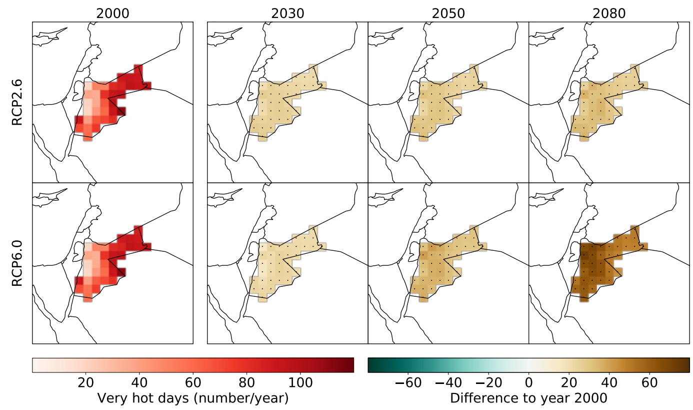

Figure 4: Projections of the annual number of very hot days (daily maximum temperature above 35 °C) for Jordan for different GHG emissions scenarios, relative to the year 2000 (regional variations).

Higher heat stress poses a risk to the population's ability to work and live [31].[14] For example, under a business-as-usual scenario, wet-bulb temperature extremes in many cities in the MENA region, particularly along the Persian Gulf, will exceed a threshold for human habitability towards the end of the century [3]. The projections of the population's exposure to heatwaves and heat-related mortality (Figures 23 and 24) illustrate possible consequences of projected temperature changes in Jordan.

14 Physical labor becomes difficult to impossible when wet-bulb temperatures exceed 31 °C, and heat stress can be fatal to humans when wet-bulb temperatures exceed 35 °C for six hours or more. Wet-bulb temperatures are air temperatures under conditions of 100 % humidity [31].

Precipitation

Higher greenhouse gas emissions will lead to a **drier future for Jordan.** All models project **a clear decrease in mean annual precipitation over Jordan,** in comparison to the year 2000 (Figure 5). However, future decreases in precipitation projections are subject to **uncertainties and natural year-to-year variability.**

The mean model projections for RCP2.6 show a decrease until about mid-century, though this decrease is subject to high uncertainty. Annual precipitation will very likely drop by between 1.6 and 14.2 mm (best estimate of -3 mm) by 2030, and by between 7.2 and 13.9 mm (best estimate of -10.8 mm) by 2050, compared to 2000. Despite interannual variability, long-term median precipitation stabilizes from 2050 onward. Under RCP6.0, precipitation will decrease more strongly than under RCP2.6. Annual precipitation will very likely go down by between 2 and 20.3 mm until 2030 (best estimate of -12.5 mm), and by between 12.8 and 23.22 mm by 2050 (best estimate of -17.1 mm). By 2080, precipitation is expected to decline by 12.5 to 26.1 mm annually (best estimate of -20 mm), compared to the year 2000 (very likely range). **In light of limited freshwater availability, any future decrease in precipitation is a reason for concern.**

There is uncertainty in geographically explicit mean annual precipitation projections under RCP2.6 (Figure 6). The absence of dots in the plots in 2030 and 2080 shows where the underlying models disagree about whether precipitation will increase or decrease. Wherever the models agree, precipitation will decrease slightly, with greater declines along the eastern border and in the southwest. By 2080, decreases in precipitation range between 2 and 4 % in the northwest, and between 8 and 12 % in the already dry northeast and south, compared to 2000.

Under RCP6.0, model agreement around annual precipitation changes is high, with models projecting **decreases for the entire country across all time periods. Compared to 2000, precipitation will decline by between 5 % and 20 % by 2030.** This decline will be comparatively stronger in the east, where a desert climate already prevails. **By 2050, annual precipitation amounts will decrease by between 20 and 28 % in southern and northeastern Jordan, and by between 10 and 16 % in northwestern and central Jordan.** Overall changes between 2050 and 2080 will be small, although further reduction in precipitation is projected in the northwest.

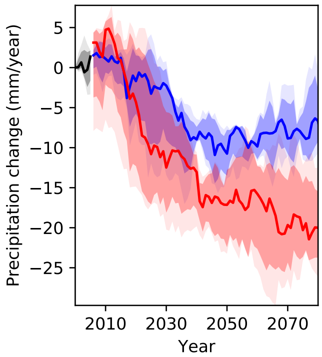

Figure 5: Annual mean precipitation projections for Jordan for different GHG emissions scenarios, relative to the year 2000.

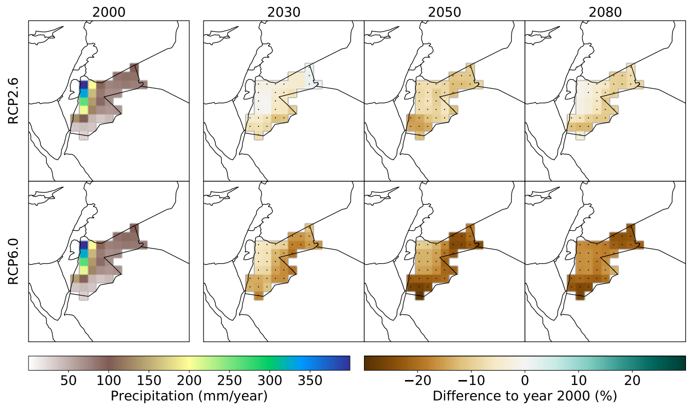

Figure 6: Annual mean precipitation projections for Jordan for different GHG emissions scenarios, relative to the year 2000 (regional variations).[15]

15 Please note that the line plots and the map plots represent uncertainty differently and cannot be compared (see section "Uncertainties in climate change projections" on page 7).

Heavy precipitation events

In response to global warming, **heavy precipitation events are expected to become more intense and frequent** in many parts of the world due to the enhanced water vapour holding capacity of a warmer atmosphere [32]. In the case of Jordan, **the trend towards more frequent extreme precipitation events cannot be confirmed (Figure 7). All models agree on a declining trend in heavy precipitation,** though the projected decline is much higher in one model than in the others. Under RCP2.6, heavy precipitation days will slightly decrease from between 5.2 to 7 days in 2000 to between 5.1 to 6.6 days by 2030, and between 4.5 to 6.3 days by 2050. Under RCP6.0, heavy precipitation frequency will decline comparatively stronger. Heavy rainfall events are projected to go down to between 5 and 5.9 days a year by 2030. Due to a growing discrepancy between the models, modelling uncertainty strongly increases from 2030 onwards. Hence, while the best estimate projects 5.5 heavy precipitation days per year by 2050, the very likely range projects between 3.9 and 5.7 days. Projections for the year 2080 are similar (3.8 to 5.6 days/year).

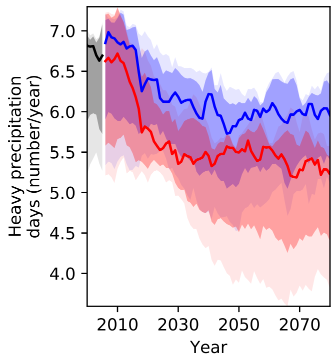

Figure 7: Projections of the number of days with heavy precipitation over Jordan for different GHG emissions scenarios, relative to the year 2000.

Particularly under RCP2.6, geographically explicit projections of heavy precipitation events (Figure 8) are uncertain in many regions. Overall, regional variations will be rather small. Certainty is much higher under RCP6.0, with heavy precipitation events projected to decline across the entire country. The **strongest decrease can be expected for the arid east throughout all time frames, and for the very south of Jordan in the long term.** By 2080, the projected median decrease will be around 1.1 to 1.4 days in the populated Mountain Heights Plateau, 1.6 days in the northeast, and up to 2.2 days in the very south, in comparison to the year 2000.

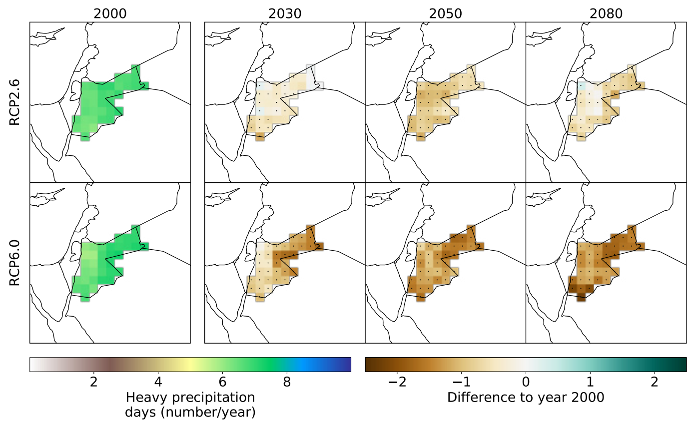

Figure 8: Projections of the number of days with heavy precipitation over Jordan for different GHG emissions, relative to the year 2000 (regional variations).

Soil moisture

Soil moisture is an important indicator for drought conditions. In addition to soil parameters, it depends on both precipitation and evapotranspiration and therefore also on temperature, as higher temperatures translate to higher potential evapotranspiration. The multi-model median projects a slight medium and long-term **decrease in annual mean top 1-m soil moisture** under RCP2.6, and a significantly larger decrease under RCP6.0, but the **uncertainty around future soil moisture changes is high and augments significantly over time** (Figure 9).

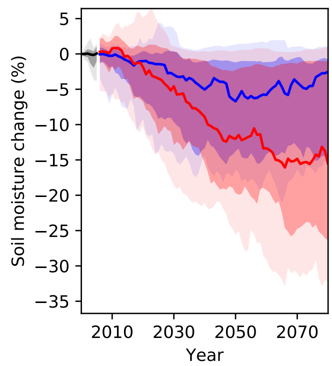

Figure 9: Soil moisture projections for Jordan for different GHG emissions scenarios, relative to the year 2000.

Under RCP2.6, soil moisture change will very likely range between -14 and + 3.5 % by 2030, and between -17 and +1 % by 2080, compared to the year 2000. Under RCP6.0, though the best estimate projects a decrease of around 5 % by 2030 and almost 16 % by 2080, high deviations between the underlying models translate into a high range of projected changes: soil moisture will very likely range between -19 to +1 % by 2030 and between -32 to +1 % by 2080.

Potential evapotranspiration[16]

Evapotranspiration contributes to the reduction of soil moisture and thus has important implications for agricultural production and the availability of fodder vegetation. It is therefore an important drought indicator [5].[17] All models indicate an overall **rise in potential evapotranspiration in comparison to the year 2000** (Figure 10), though with **growing uncertainty in terms of the magnitude of increase.**

Under RCP2.6, multi-model median projections show a consistent increase in evapotranspiration that weakens slightly, beginning around 2035. Compared to the year-2000 levels, potential evapotranspiration is projected to rise by between 1.1 to 7.3 % by 2030 and between 2.3 to 10.1 % by 2080 (very likely range).

The heightened potential evapotranspiration under RCP6.0 will be relatively similar to the RCP2.6 scenario until around 2035, but is expected to continue to become much stronger from then on. Modelling uncertainties under RCP6.0 are much higher than under RCP2.6. The projected increase in evapotranspiration ranges between 6.8 and 19.6 % by 2080 (very likely range). Long-term planning must consider the great uncertainty relating to future rises in potential evapotranspiration.

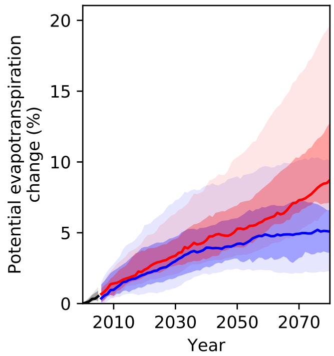

Figure 10: Potential evapotranspiration projections for Jordan for different GHG emissions scenarios, relative to the year 2000.

The geographically explicit projections (Figure 11) show an **increase in potential evapotranspiration throughout Jordan.** Model agreement on this increase is high under both scenarios. Under RCP2.6, relative to the year 2000 levels, potential evapotranspiration is projected to increase by between 2.5 to 3.6 % by 2030 and by between 4.4 to 5.9 % by 2080. While this will affect all regions equally by 2030, in the medium to long term, models project slightly larger evapotranspiration rates in the far north and a more moderate increase across the rest of the country.

Under RCP6.0, potential evapotranspiration increases until 2030 will be similar to the RCP2.6 scenario, rising between 2.9 and 3.9 %, compared to the year 2000. Potential evapotranspiration will intensify most strongly between 2050 and 2080. The long-term increase will affect the entire country, with a minimum rise of 7.9 % in Jordan's southeast, and a maximum rise of 10.5 % in the northwest.

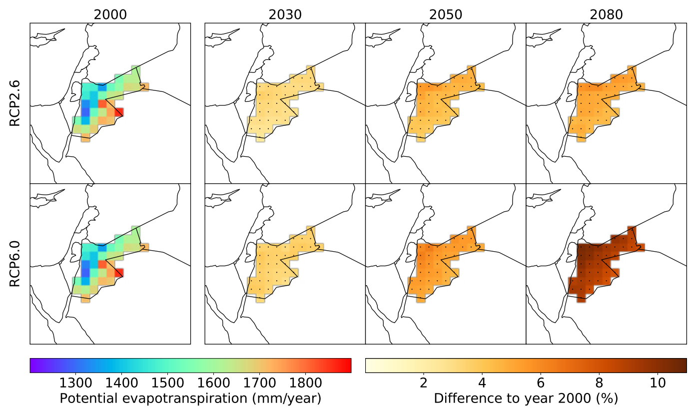

Figure 11: Potential evapotranspiration projections for Jordan for different GHG emissions scenarios, relative to the year 2000 (regional variations).

16 Potential evapotranspiration is the amount of water that would be evaporated and transpired if sufficient water was available at and below the land surface. Since warmer air can hold more water vapour, it is expected that global warming will heighten potential evapotranspiration in most regions of the world.
17 For example, the widely used Standardized Precipitation Evapotranspiration Index (SPEI) is a drought index that is based on the water balance. The water balance is defined as the difference between precipitation and potential evapotranspiration [33].

Part II: Sector-specific climate change risk assessment

Water resources

Water resources in Jordan are severely limited. **Renewable water supplies only meet around half of the total water consumption.** The overextraction is strongly driven by a combination of **declining rainfall, rapid population growth, poor water management and non-existent or low water pricing** [12]. Supply deficits have heightened the pressure on groundwater resources, which are currently being withdrawn twice as fast as they are replenished [21]. **Surface water resources are saline and threatened by withdrawals in upstream countries.** Flows in the lower Jordan River are estimated to have declined by nearly 90 %, due to Israel's water management further upstream [12]. At the same time, water development projects in Syria divert water resources from the Yarmouk River. In the event of the Syrian war ending and a subsequent recovery of its agriculture, Yarmouk River outflows to Jordan would likely decline further according to watershed projections [21].

To ensure the future availability of drinking water, Jordan and Israel jointly initiated the Red Sea-Dead Sea Water Conveyance Project in 2013. The aim was to build a canal to convey water from the Red Sea to the Dead Sea, which would generate enough energy to desalinate a considerable fraction of water resources. However, after a long period of delays, financial constraints and environmental concerns, Jordan cancelled the project in 2021 [12] [35]. In November 2021, Israel and Jordan signed an **agreement to exchange water for energy: Jordan is to set up a solar power plant** and provide a capacity of 600 megawatts to Israel. In exchange, Israel is to supply Jordan with 200 million cubic meters of **desalinated water.** The signing of the agreement was accompanied by massive opposition from the Jordanian population which fears a future dependence on Israel [36].

Water availability in Jordan has already reached alarmingly low levels. With an estimated per capita water availability of between around 110 and 800 m³ (multi-model median of 200 m³) (Figure 12), **water supply in Jordan was already well below the water scarcity threshold of less than 1,000 m³/cap/year in 2000 [4].** Global climate models project **further declines in water availability,** though with large uncertainties regarding the magnitude of the decrease under both emissions scenarios.

Assuming a constant population level (Figure 12A) under RCP2.6, the projected range of available water is very wide, from 67 to 683 m³ per year by 2080, although the best estimate predicts a very small decrease (multi-model median of 177 m³). Under RCP6.0, per capita water availability will decrease slightly, compared to 2000. The available water quantity is projected to range between 45 and 614 m³ per person and year (multi-model median of 130 m³) by 2080.

When accounting for population growth according to SSP2 projections (Figure 12B),[18] **water availability will sharply decline under both scenarios,** but again with significant uncertainties. Under RCP2.6, models project a decrease between 46 and 385 m³ (multi-model median of 94 m³) per person and year by 2030, and between 22 and 230 m³ (multi-model median of 60 m³) per person and year by 2080. Under RCP6.0, per capita water availability will very likely range between 32 and 301 m³ (multi-model median of 80 m³) annually by 2030, and between 15 and 206 m³ (multi-model median of 44 m³) per person and year by 2080. The multi-model median decrease under RCP6.0 corresponds to a **reduction of 75 % by 2080, compared to the year 2000, when water shortages were already alarming.**

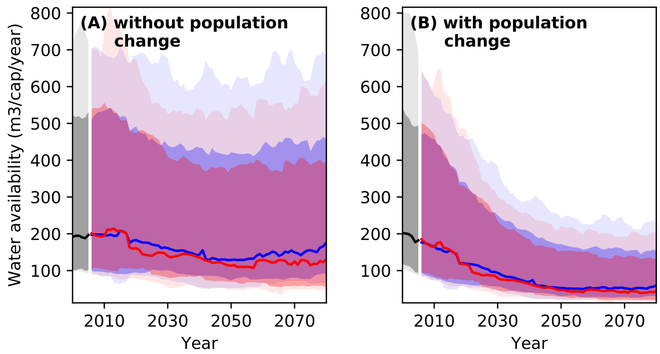

Figure 12: Projections of water availability from precipitation per capita and year with (A) national population held constant at year 2000 level and (B) changing population in line with SSP2 projections for different GHG emissions scenarios.

Even though **declining water availability is primarily driven by the expected population growth instead of climate change,** these projections highlight the **urgent need for a more sustainable management of water resources.** It is recommended that Jordan takes rapid action, including for example through improved water-management practices, transboundary water-sharing agreements and large-scale freshwater desalination efforts to secure its future water supply [21].

18 Shared Socio-economic Pathways (SSPs) outline a narrative of potential global futures, including estimates of broad characteristics such as country-level population, GDP growth or rates of urbanization. Five different SSPs outline future realities according to a combination of high and low future socio-economic challenges for mitigation and adaptation. SSP2 represents the "middle of the road" pathway.

Water availability from precipitation

Consistent with the precipitation change projections (Figure 5), projections of **water availability from precipitation** (Figure 13) suggest a **decline under both scenarios**. Further, both scenarios show interannual variability. However, models differ in the amount of projected change.

The mean model projections for **RCP2.6 show a decrease in water availability until around mid-century,** despite temporal variations in the uncertainties regarding the magnitude of the decrease. With one model projecting increased runoff rates in comparison to the year 2000 levels, precipitation runoff change will very likely range between -33 and +7 % by 2030. Runoff rates will continue to decrease by between 7 and 50 % in 2050 and slightly recover from 2050 onward. Under RCP6.0, the mean river runoff will decrease more strongly than under RCP2.6, but also with high uncertainties. Annual runoff change will very likely range between -53 and +7 % in 2030, and decrease by between 54 and 12 % by 2050. In the long term, runoff change is expected to range between -63 and +1 % annually, compared to the year 2000 (very likely range).

There is uncertainty in geographically explicit annual water availability from precipitation under RCP2.6 (Figure 14). The absence of dots in the plots, particularly in 2030 and 2080, depicts the model disagreement around the direction of change. Overall, however, **runoff rates can be expected to slightly decline, particularly along the western border and in the southeast** in the medium term.

Certainty is higher under RCP6.0, especially in the medium to long term. Consistent with decreasing annual precipitation projections (Figures 5 and 6), precipitation runoff will decline across the entire country. Compared to the year 2000, river runoff will decrease by up to 46 % in southern Jordan, and by up to 43 % in the northeast until 2050. Variations within the rest of the country are large. The decline will be smaller in the Mountain Heights Plateau (northwestern and western Jordan), where decreases will range between 20 and 28 %. By 2080, overall spatial variations in precipitation will decline slightly, although there will still be large differences. River runoff will decrease by between 42 % in the very southwest and 5 % in the very south.

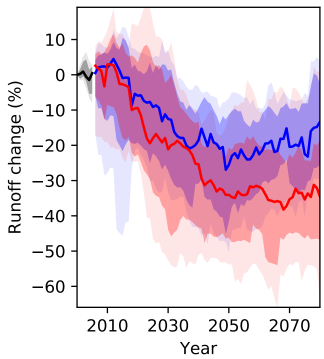

Figure 13: Water availability from precipitation (runoff) projections in Jordan for different GHG emissions scenarios, relative to the year 2000.

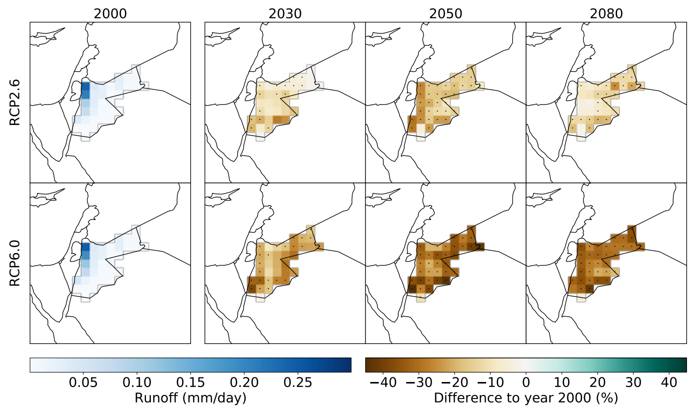

Figure 14: Water availability from precipitation (runoff) projections in Jordan for different GHG emissions scenarios relative to the year 2000 (regional variations).

Agriculture

Freshwater scarcity is already affecting the agricultural sector and severely limiting agricultural productivity. At the same time, agriculture is responsible for more than half of Jordan's freshwater consumption and a **major contributor to increasing water stress.** Given its small contribution to GDP (5 %) [6] relative to its huge water consumption, the sector has been declared "economically inefficient" [37]. However, agriculture is the **primary source of livelihoods especially for poor households in rural areas,** including for many refugees,[19] and employs about a quarter of the population [10] [12]. Compared to other countries in the MENA region, investments into the primary sector have been low, resulting in **highly inefficient and water-consuming irrigation techniques, poor agricultural technologies, and limited access to finance** [10]. At the same time, unsustainable land use practices and overgrazing, partly as a result of high population growth, are driving **wind and water erosion, rangeland and vegetation degradation and declining soil fertility.** Future climate change, including decreasing rainfall and increasing temperatures, as well as evapotranspiration, are likely to further exacerbate soil degradation [40] [41].

The last two decades have seen **decreases in rainfall and related adverse impacts on water resource availability, rainfed agriculture and livestock.** During the drought of 1999/2000, only 30 % of the long-term average precipitation fell, resulting in a 60 % decline in rainfed crop yields [41]. The **potential for drought in the country is high,** particularly in the north and northwest of Jordan. The governorates of Irbid, Jarash and Ajloun in the northwest, where rainfed agriculture is predominant, are particularly vulnerable to droughts due to limited water availability relative to the total population [41].

Currently, the very high uncertainty of projections regarding water availability (Figures 13 and 14) translate into a **high uncertainty of drought projections** (Figure 15). According to the median over all models employed for this analysis, **the national crop land area exposed to at least one drought per year will hardly change in response to global warming.**

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19 According to government estimates, around 70 % of all agricultural workers in Jordan are refugees [38].

However, there are models that project a strong incline in drought exposure, while others project no or only an extremely small rise. This translates into a large range of projected changes under both scenarios. For example, under RCP6.0, the projection of drought exposure of the national crop land area widens from 0 to 25 % in 2000 to 0.02 to 67 % by 2080. This means that **some models project up to a threefold increase in drought exposure over this time period, while others project no change.** This high discrepancy between different models does not allow for any conclusions regarding future impacts of droughts on crop land.

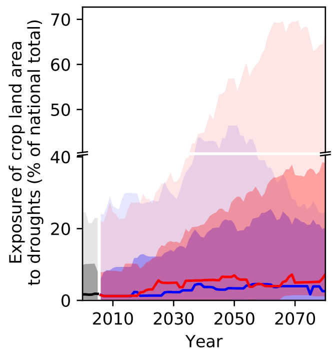
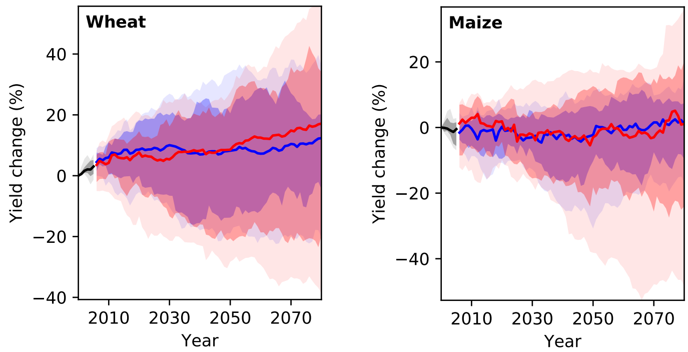


Figure 15: Projections of crop land area exposed to drought at least once a year for Jordan for different GHG emissions scenarios, relative to the year 2000.

Despite these challenges, **overall agricultural outputs have increased**[20] over the last decades, which is primarily due to heightened labor and land productivity as well as a heightened use of fertilizer [10]. The World Bank sees further potential in the agricultural sector: according to their estimates, only 50 to 60 % of the export potential of fruit and vegetables is currently being achieved. Particularly the export of fresh tomatoes, peaches and nectarines could be scaled up [10].



Figures 16 and 17: Projections of crop yield changes for two of the major staple crops wheat (Figure 16) and maize (Figure 17) in Jordan for different GHG emissions scenarios assuming constant land use and agricultural management, relative to the year 2000.

Cereals are mostly grown in central and northern Jordan [42]. Despite their importance for food security, the estimated total cereal production in 2021 was only about 100,000 tons, of which barley accounted for 35,000 tons, wheat for 30,000 tons, and maize for 25,000 tons [43]. As a result, **Jordan imports 97 % of its cereal consumption.** In response, the government recently launched price subsidy programs to encourage local grain production and reduce food dependence [44].

Climate change will impact agricultural yields to different extents, depending on the crop types grown.[21] The different models underlying the projections for both wheat (Figure 16) and maize (Figure 17) yields project **very different directions of change, making it difficult to discern any viable future trends.**

Wheat yield projections are highly uncertain and uncertainty continues to rise over time. By 2030, wheat yield changes are projected to range between -10 and +27 % under RPC2.6, and by between -21 and +25 % under RCP6.0, as compared to 2000. The projected range widens steadily, amounting to between -20 and +36 % under RCP2.6, and to between -39 and +56 % under RCP6.0 by 2080. Multi-median projections for **maize yields,** despite year-to-year variabilities, show almost no changes in yields. However, similar to the wheat projections, there are **large differences among the models** in the direction of change, and those differences increase substantially over time: Under RCP6.0, maize yield projections widen from between -17 and +14 % in 2030 to between -50 and +36 % by 2080 (very likely range), compared to 2000.

As for the regionally explicit yield projections, **no reliable estimates on how climate change might affect future wheat and maize yields** can be derived. The reason is that the underlying models do not agree on the direction of change. Consequently, it is recommended to account for uncertainty in future crop yield changes across the country.[22]

20 The World Bank estimates that between 1995 and 2014 a nimal-based products have increased by 84 % and crop production by 71 % [10].
21 Modelling data is available for a selected number of crops only. Hence, projections for barley and fruit and vegetables could not be generated and the crops listed on page 3 differ.
22 Due to the low informative value, we do not provide any map plots on agricultural yields in this profile.

Infrastructure

Climate change is expected to adversely affect infrastructure including buildings, transport infrastructure and energy, especially through extreme weather events such as floods and heatwaves [45]. For example, high temperatures can cause **roads, bridges and protective structures to develop cracks and degrade more quickly.** This can result in substantial maintenance and replacement costs. Transport infrastructure is vulnerable to extreme weather events, yet essential for people's livelihoods. Roads serve communities to trade goods and to access healthcare, education, credit and other services. At the same time, extreme weather events can have devastating effects on human settlements and economic production sites, especially in urban areas with high population densities. Informal settlements and camps for internally displaced people (IDPs), both formal and informal, are particularly vulnerable to extreme weather events.

Flood hazard severity mapping suggests that **17.6 % of Jordan's land surface is at high risk of flash floods** [46]. For example, in October 2018, unusually heavy rains caused severe flash flooding along the Dead Sea, killing at least 21 passengers on a bus which was swept away by the flooding. The flooding also destroyed a bridge on the Dead Sea Cliffs. Heavy rain simultaneously occurred in the capital Amman, flooding roads and causing traffic problems [47] [48]. In February 2019, heavy rainfall caused buildings in the cities of Amman, Russeifa and Irbid to collapse [49] and major roads have repeatedly been damaged by flooding [50] [51]. **Land use change, associated with urbanization, heightens the risk of flash floods,** i.a. through removing soils and vegetation [46].

Despite the fact that risk of infrastructure damage is likely to increase due to climate change, precise predictions of the location and the extent of exposure to extreme events are difficult to make. For example, **projections of river flood events are subject to substantial modelling uncertainty,** largely due to the uncertainty of future projections of precipitation amounts and their spatial distribution, affecting flood occurrence (see Figures 5 and 6).

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In the case of Jordan, **projections for both RCP2.6 and RCP6.0 show almost no change in the exposure of major roads or urban areas to river floods** (Figure 18). According to our models, in 2000, only 0.11 % of major roads were exposed to river floods at least once a year.

Road exposure to river floods is projected to hardly change under either emissions scenario or time frame. Under RCP2.6, by 2080, only between 0 and 0.19 % of Jordan's major roads will be exposed to river floods (best estimate of 0.05 %), while the proportion of affected roads under RCP6.0 will very likely range between 0 and 0.41 % (best estimate of 0.11 %). Hence, according to our models, the flood risk to major roads will remain relatively small.

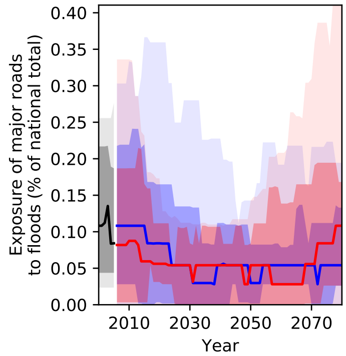

Figure 18: Projections of major roads exposed to river floods at least once a year for Jordan for different GHG emissions scenarios.

As with the exposure of major roads to river flooding, the exposure of urban land area to flooding is projected to hardly change under either RCP. As shown by Figure 19, all models underlying this projection agree that **flooding exposure of the urban land area is very likely to remain below 0.15%** under both emissions scenarios throughout the time periods shown.

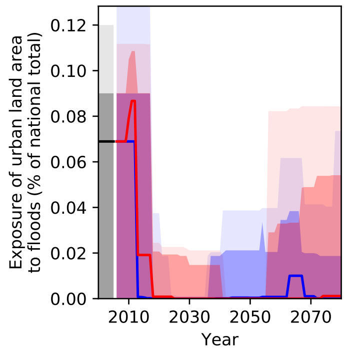

Figure 19: Projections of urban land area exposed to river floods at least once a year for Jordan for different GHG emissions scenarios.

Rising temperatures and very hot days (see Figures 3 and 4) will affect GDP exposure to heatwaves differently, depending on the scenario (Figure 20). Particularly under RCP6.0 the magnitude of increase is subject to increasing modelling uncertainty.

According to projections **under RCP2.6, GDP exposure to heatwaves will remain at relatively low levels throughout the time periods shown.** The exposure will very likely range between around 0.1 and 4.5 %, depending on the time frame. Median model projections show slight fluctuations from around 0.1 % in the year 2000 to 1.5 % in 2030, 0.6 % in 2035 and 2.2 % in 2080. Under RCP6.0, GDP exposure to heatwaves will only slightly augment until around 2045, similar to the RCP2.6 projections, with a very likely increase of between 0.1 and 2.7 % until 2030, and between 0.4 and 4 % until 2045. From then on, however, models project a strong rise in national GDP exposure to heatwaves. However, modelling uncertainty about the magnitude also rises significantly. Whereas two models project very strong increases, two other models project two weaker increases. Consequently, the **GDP exposure to heatwaves will be ranging between 2.2 and 18.3 %** (best estimate of 8.45 %) **in 2080.**

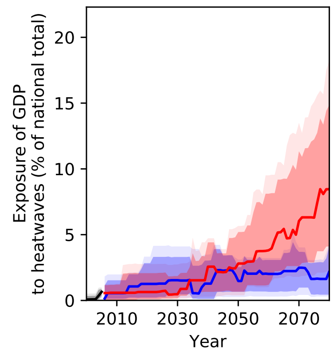

Figure 20: Projections of GDP exposure to heatwaves at least once a year for Jordan for different GHG emissions scenarios.

Ecosystems

Climate change is expected to have a significant impact on the ecology and distribution of tropical ecosystems, even though the magnitude and direction of these changes are uncertain. **Due to rising temperatures, a rising frequency and intensity of droughts and shorter growing periods, riverine systems are increasingly at risk of being converted to other ecosystems,** with plant populations being succeeded and animals losing their habitats. Rising temperatures and droughts can also influence succession in forest systems, while simultaneously increasing the risk of invasive species. In addition to the climate-related impacts, **population growth and reduced agricultural productivity might motivate further agricultural expansion, resulting in heightened deforestation, land degradation and forest fires,** all of which will impact animal and plant biodiversity [52].

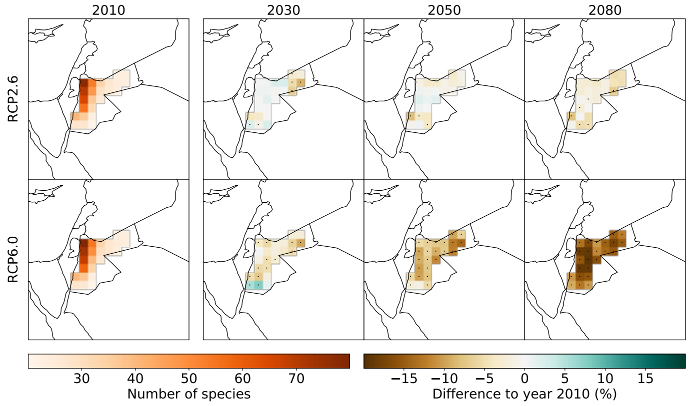

Figure 21: Projections of the aggregate number of amphibian, bird and mammal species for Jordan for different GHG emissions scenarios, compared to the year 2010 (regional variations).

Model projections of species richness (including amphibians, birds and mammals) and tree cover for Jordan are shown in Figures 21 and 22, respectively. **Projections of species richness are subject to high uncertainty under both scenarios** due to model disagreement on the direction of change. Consequently, reliable estimates are difficult to derive under RCP2.6. While the short-term projections under RCP6.0 are as uncertain as the projections under RCP2.6, the medium (2050) and long-term (2080) projections indicate declines in species richness wherever data are available. Compared to the baseline period of 2010, species richness is projected to **decline by up to 14 % by 2050, and 19 % by 2080. The greatest long-term decline will be in the northwest and west of the country.**

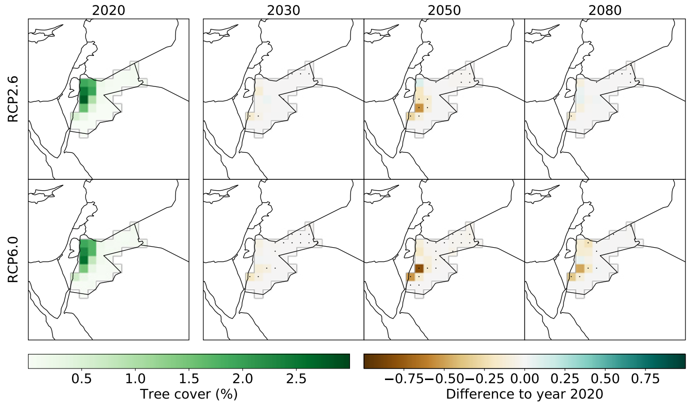

Figure 22: Tree cover projections for Jordan for different GHG emissions scenarios, compared to the year 2020 (regional variations).

The total forest area in Jordan is very small. According to government data, **only about 1 % of Jordan's total land area is classified as forested,** of which less than half is natural forest [38].[23] Projections of changes in tree cover (Figure 22) are very uncertain. For both scenarios, **reliable estimates of how climate change might affect tree cover cannot be derived** across all time periods shown, because the underlying models do not agree on the direction of change.

It is important to keep in mind that the model projections **exclude any impacts on biodiversity loss from human activities** such as land use, which have been responsible for significant losses of global biodiversity in the past and which are expected to remain its main driver in the future [54].

23 According to Global Forest Watch, the percentage of tree cover is even lower, amounting to less than 0.1 % of Jordan's land area [53].

Human health

Compared to other countries in the Middle East, Jordan has a modern health care system. High investments in the health sector in the last decades have led to enormous progress in reducing maternal and child mortality and expanding and improving health infrastructure. However, **the recent population growth including the influx of refugees and the COVID-19 pandemic increased the demand for medical treatment,** putting critical health facilities increasingly under pressure and threatening the quality of health services [55].

Climate change further threatens the health and sanitation sector in different ways. The National Ministry of Health identified the following **climate-sensitive health issues: air-borne and respiratory diseases, water-borne and food-borne diseases, nutrition, vector-borne diseases,**[24] **heatwaves, and occupational health** [56]. Limited access to freshwater resources is one of the biggest threats. The expected decrease in freshwater availability (Figure 12) may lead to the **consumption of contaminated water, which in turn can increase water and food-related diseases such as diarrhea.**[25] Future river flooding might equally contribute to the spread of gastrointestinal diseases [2]. Furthermore, declining agricultural production due to rising temperatures and precipitation **heightens the risk of malnutrition and food security.**[26] Jordan already imports about 80 % of its domestic food needs [38] and rising food prices could make access to affordable and nutritious food even more difficult for the most vulnerable populations [9]. **Air pollution as well as dust particles increase the risk of airborne and respiratory diseases.** The dispersion of air pollutants is influenced by climate and weather factors such as temperature, droughts and storms. These include rising ground-level ozone in urban areas, more particulate matter from higher frequencies of forest fires, and the increased presence of airborne particles from dust storms due to desertification [56]. According to the World Bank, 700 deaths annually can be attributed to increased dust concentrations in Jordan [25].

Heat stress due to heightened temperatures and longer lasting heatwaves will adversely impact people in the entire MENA region. Children and elderly people, as well as the chronically ill and at-risk occupational groups are among the most vulnerable. In the absence of air conditioning systems, refugees and IDPs in emergency shelters are also strongly exposed to extreme heat. Already today, temperatures in the refugee camps in Azraq and Zaatari repeatedly reach up to 40 degrees. Heat stress can cause several disorders, ranging i.a. from sunburn to cutaneous malignant melanoma, fatigue, heat exhaustion and heat stroke [2].

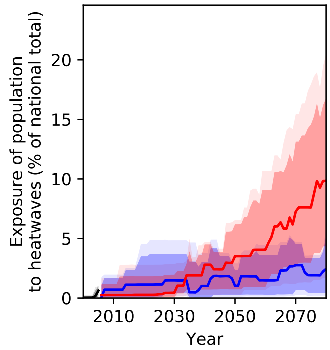

Figure 23: Projections of population exposure to heatwaves at least once a year for Jordan for different GHG emissions scenarios.

Depending on the scenario, the projected rise in temperature (Figures 2 and 3) will result in **more frequent and intensive heatwaves in Jordan.** The magnitude of increase in future heatwave exposure of the population depends on the emissions scenario and is subject to increasing modelling uncertainty, particularly under RCP6.0. As shown in Figure 23, under RCP2.6, the population affected by at least one heatwave per year will remain comparatively small throughout the time periods shown (very likely to range between 0.1 and 6 % from 2000 to 2080). The median model projections show slight variations, ranging from about 1.5 % in 2030 to 0.5 % in 2035, 1 % in 2050 and 2.5 % in 2080. In contrast, **under RCP6.0, the median exposure to heatwaves** remains at almost 0 % until 2030 **but rises sharply from then on, reaching nearly 10 % in 2080.** However, modelling uncertainty also increases along the rise, with exposure of population to heatwaves to rise to between 0.3 and 6.6 % by 2050, and between 1.7 and 20.5 % by 2080.

24 Including malaria and schistosomiasis (ilharzia). Reported incidences are, however, very low and Jordan is considered a malaria-free country. The construction of water-related infrastructure, including dams and irrigation schemes, might adversely impact the transmission of vector-borne diseases, but projections for the case of Jordan are not available [56].

25 Diarrhea-related mortality decreased significantly since the 1970s. Nevertheless, diarrheal diseases continue to pose high risks to the health of children under the age of 5 [56].

26 In Jordan, the prevalence of undernourishment was 10 % in 2019. The stunting rate in children under age 5 was 7.8 % in 2012 [7].

Heat-related mortality will very likely increase following the projected increase in the number of very hot days (Figure 4). Under RCP2.6, heat-related casualties are projected to rise from 1 death per 100,000 people annually in 2000 to between 1.6 and 2.4 deaths per 100,000 people (best estimate of 1.8) and year until 2030 (very likely range) (see Figure 24). The increase will slow down after 2030, with models projecting between 2 and 2.8 heat-related deaths (best estimate of 2.2) by 2080 (multi-model median).

The projections make clear that both rapid reductions in greenhouse gas emissions and climate change adaptation measures are urgently needed to reduce future exposure of people to climate risks in Jordan.

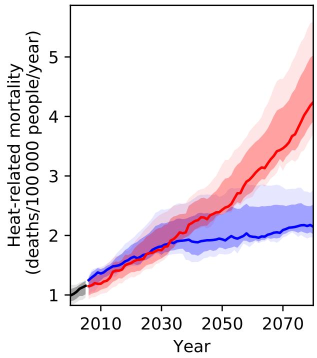

Figure 24: Projections of heat-related mortality for Jordan for different GHG emissions scenarios assuming no adaptation to increased heat.

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