Federal Ministry of Education and Research

# Climate Risk Profile: Malawi*

## Summary


This profile provides **an overview of projected climate parameters and related impacts** on different sectors in Malawi until 2080 **under different climate change scenarios** (so-called Representative Concentration Pathways, RCPs). RCP2.6 represents a low emissions scenario that aims to keep global warming likely 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 socio-economic impacts unless indicated otherwise.**

Agriculture, health, infrastructure and water are highly vulnerable to climate change. The **need for adaptation in these sectors should be represented in the German development cooperation portfolio** of the country.

Depending on the scenario, **mean temperature** in Malawi is projected to rise **between 2 °C and 3.3 °C** until 2080 compared to pre-industrial levels. The **number of very hot days** with maximum temperature exceeding 35 °C **is projected to increase**. By 2080, **32 more very hot days** are projected for Malawi and up to 60 additional very hot days for the south of the country under the medium to high emissions scenario. Up to **5 %** of Malawi's **GDP** is projected to be **exposed to impacts from heatwaves by 2080** under RCP6.0.

Precipitation trends in Malawi are subject to **high uncertainty** and high natural variability. Best estimates indicate a potential **decrease in precipitation in the long run**. The number of **heavy precipitation days** is, however, projected to **slightly increase** by 2080. Partly caused by heavy precipitation, Malawi has suffered from several **major flood events** in 2015 and 2019, impacting about 1 million people each.

Major floods caused immense damages to Malawi's infrastructure in the past, including roads, bridges, the power grid, water and sanitation infrastructure and housing. **Future projections show large uncertainty ranges with no significant change in flood impact.** The likely range of projections indicates that the share of major roads exposed to river floods could almost double by 2080, compared to the year 2000 under the medium to high emissions scenario.

Climate projections predict drought risk to further increase. In particular, **potential evapotranspiration** could **increase by up to 11 % by 2080** and **soil moisture** could **decrease by up to 5 % in 2080**, compared to 2000 (RCP 6.0). The share of **drought-exposed crop land area** is expected to reach **1–2 %** of the national total by 2080 (compared to 0.13 % in 2000), but projections are highly **uncertain** with likely ranges going **up to 15 % for RCP 6.0 in 2080**. Furthermore, climate change is projected to impact the **yields of important crop types** for Malawi, with declines for maize (−4 %), millet and sorghum (−12 %) and groundnuts (−4 %).

The overall **availability of water from precipitation** is projected to **decrease** in certain parts of Malawi by up to **15 % by 2080**. Best estimates project a reduction in per capita availability of water from precipitation of 11 % (RCP2.6) and of 6 % (RCP6.0) by 2080, compared to 2000 for current population levels. When projected population changes are taken into account, best estimates predict **a drop in per capita fresh water availability by 82 % by 2080** under both emissions scenarios.

Water scarcity, drought- or flood-induced food insecurity and temperature extremes can all impact human health. **Over 5 % of the population** is projected to be **exposed to heatwaves in 2080** (RCP 6.0). Similarly, **heat related mortality** is projected to reach up to 14 deaths per 100 000 inhabitants, **a more than threefold increase** (RCP6.0).


* This Climate Risk Profile was implemented by Climate Analytics and ifo Institute as part of a collaboration with the Potsdam Institute for Climate Impact Research (PIK) and is based on the Climate Risk Profiles developed within the AGRICA project. This Climate Risk Profile is up to date as of February 2022.

## Context

Malawi is a **least developed country (LDC)** country located in **South-Eastern Africa** bordered by Mozambique, Tanzania, and Zambia. With a GDP per capita of about 395 USD (constant 2015), it remains among the poorest countries in the world [1], ranking 174 out of 189 countries in the UNDP Human Development Index (2019, HDI) [2]. As of 2020, **approximately 83 % of the 19 million inhabitants live in rural areas** [1] and are **predominantly involved in small-scale subsistence farming**. High population density and rapid population growth is projected to increase pressure on the country's natural resources and reinforce present challenges to meet basic socio-economic needs of the population. While Malawi saw economic growth in previous years, the COVID-19 crisis hit Malawi hard. A study by IFPRI from April 2021 estimates that Malawi's GDP declined by about 16.5 % in April/May 2020 and between 8.3 and 11.3 % over the whole calendar year 2020. Moreover, the study estimates **that COVID-19 has likely pushed over 1.6 million Malawians into poverty**, at least temporarily [3].

## Quality of life indicators [1], [2], [4], [5]

| Human Development Index (HDI) 2019 [2] | ND-GAIN Country Index 2019 [4] | Gini Index[1] 2016 [1] | Real GDP per capita 2020 [1] | Poverty headcount ratio 2016 [1] | | Prevalence of undernourishment 2017–2019 [5] |
|---|---|---|---|---|---|---|
| **0.483** **174 out of 189** (0 = low, 1 = high) | **36.5** **163 out of 182** (0 = low, 100 = high) | **44.7** (0–100; 100 = perfect inequality) | **395.1 USD** (constant 2015 USD) | **69.2 %** (at 1.9 USD per day, 2011 PPP)[2] | **96.6 %** (at 5.5 USD per day, 2011 PPP) | **18.8 %** (of total population) |

## Regional development

Figure 1 shows the variation of the **Subnational Human Development Index** (SHDI) across Malawi's different regions, both aggregated and for each of the three dimensions health, education and income. Overall, the **highest development level is observed in the northern regions and around the two major urban centres Lilongwe** (Central Region) **and Blantyre** (Southern Region). The **educational status**, measured by mean years of schooling of adults and the expected years of schooling of children aged 6, **shows a similar pattern**, with lower levels in some of the eastern districts. **Low standard of living, proxied by an income index, is the main driver of the overall low HDI**, whereas the **population's health status**, based on life expectancy at birth, **contributes positively to the overall HDI**.

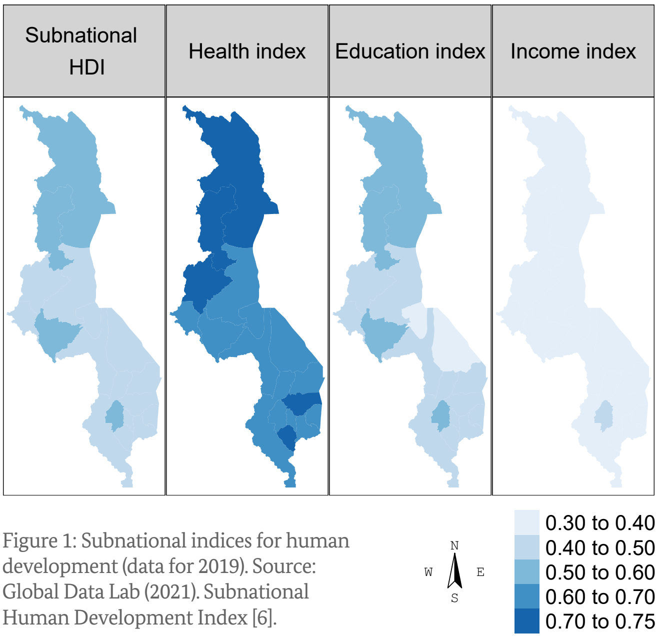


Figure 1: Subnational indices for human development (data for 2019). Source: Global Data Lab (2021). Subnational Human Development Index [6].

[1] The Gini coefficient measures the extent to which the distribution of income within an economy deviates from a perfectly equal distribution. A Gini index of 0 represents perfect equality, while an index of 100 represents perfect inequality.

[2] Poverty headcount ratio for the year 2018 adjusted to 2011 levels of Purchasing Power Parity (PPP). PPP is used to compare different currencies by taking national differences in cost of living and inflation into account.

# Topography and environment

Malawi is a **landlocked country** with a land area of 94 280 km² [1], [7]. **Lake Malawi** (also known as Lake Nyasa or Lake Niassa), which forms the eastern border with Tanzania and Mozambique, **occupies more than a fifth of the total area** [8]. 60 % of the land area is agricultural land, while 25 % is classified as forest land [9]. Malawi has a **varied topographical landscape** dominated by the East African Rift Valley, which traverses from north to south. Around the valley, the landscape is predominantly formed by large plateaus at an elevation of 800 to 1 200 meters with highland peaks up to 3 000 meters [7]. Malawi has a sub-tropical continental climate, which is relatively dry and strongly seasonal. The rainy season extends from November to April and the dry season from May to October. The great variation in Malawi's topography translates into differences in temperature patterns. **Temperatures are higher in the south and along the shore of Lake Malawi** and **decrease with increasing elevation** [10]. Annual average precipitation varies from 725 mm to over 2 500 mm, with a mean annual precipitation of 1 071 mm [11]. **Precipitation patterns are strongly influenced by the topography** and Lake Malawi, with the **highest precipitation levels experienced along the shore of Lake Malawi as well as in the southern and parts of the northern highlands** [12]. **Inter-annual variability in precipitation in Malawi is high**, due to its strong dependence on oscillations of the Inter-Tropical Convergence Zone (ITCZ) and the El Niño Southern Oscillation [13].

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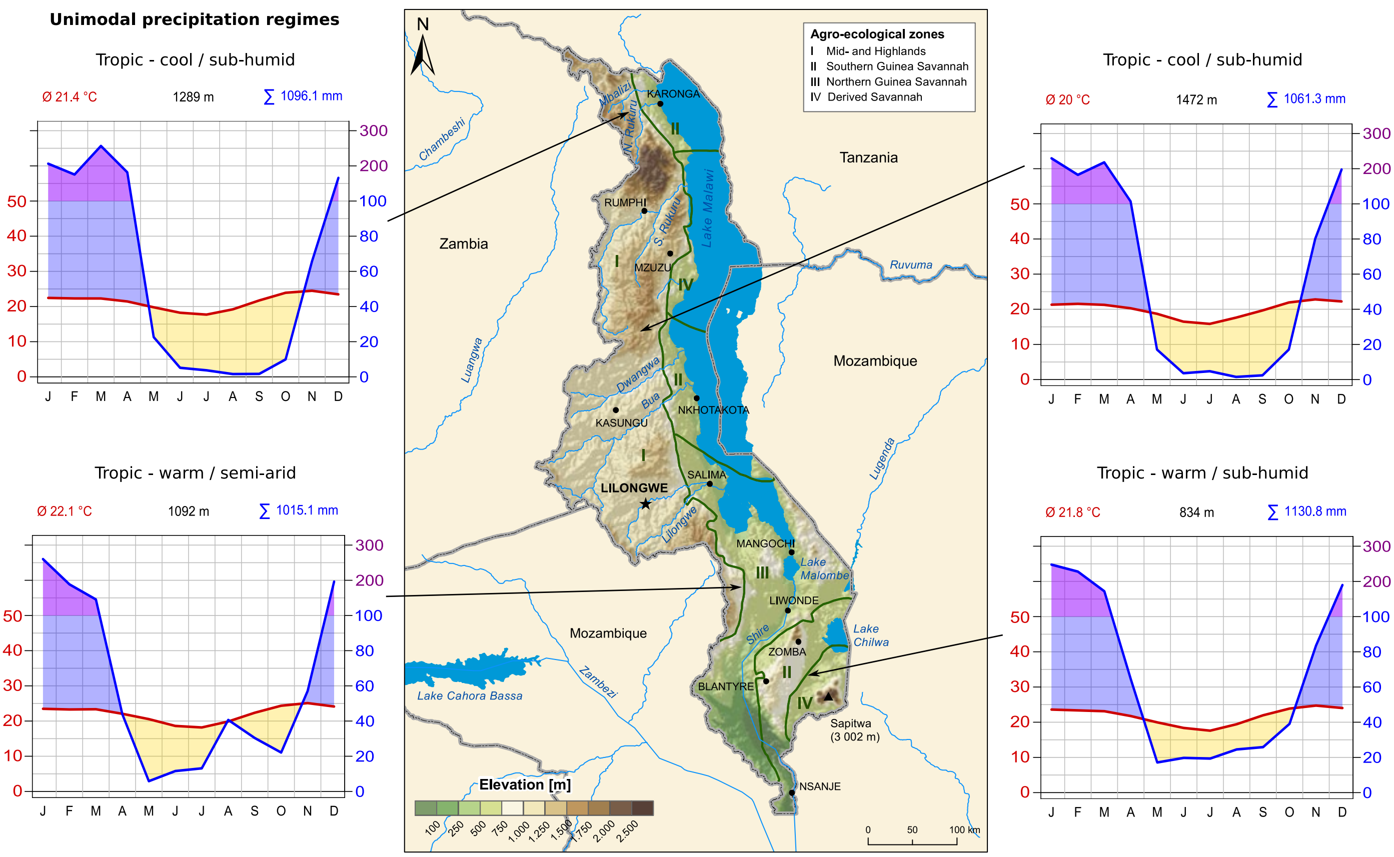



Figure 2: Topographical map of Malawi with existing precipitation regimes.[3]

[3] The climate graphs display temperature and precipitation values which are averaged over an area of approximately 50 km × 50 km. Especially in areas with larger differences in elevation, the climate within this grid might vary.

## Present climate and related extremes

Over the period from 1960 to 2006, a **warming trend has been observed in Malawi**. Mean annual temperature has increased by 0.9 °C, corresponding to an average rate of 0.21 °C per decade [9]. Temperature increases have been most prominent in the wet months from December to February and slowest from September to November. In line with temperature increases, **evaporation has also increased**.

Malawi is **very vulnerable to floods, droughts, hailstorms and strong winds, with floods and droughts having the most severe impacts on the country** [14]. Since 1967, Malawi has experienced 20 major floods, which affected at least 20 000 people each [15]. **Both frequency and intensity of floods have increased** [15]. Due to the country's topography, the southern regions and, to a lesser extent, the Central Region are most prone to floods. Causes of floods are diverse as both riverine and flash floods occur regularly as a consequence of heavy precipitation [15]. Heavy preciptiation events adversely impact infrastructure, soil quality and agricultural productivity, which is of particular concern given that the majority of Malawi's population depends on agriculture for their livelihoods. In January 2015, extreme precipitation amounts caused the country's worst flooding in 50 years [14], predominantly in the Southern Region, with more than 1.1 million people affected, 230 000 displaced and an estimated damage of more than 335 million USD [16]. Also, heavy precipitation associated with tropical cyclones has caused severe flooding. In 2019, Malawi experienced one of the worst floods associated with tropical cyclone Idai, which affected more than 975 000 people and resulted in an estimated damage of 220.2 million USD [14].

Malawi is also exposed to regularly occurring droughts. Over the past four decades, the country has experienced eight major droughts [15]. Within the same period, the **impact, frequency and spread of drought has intensified**. Droughts usually coincide with El Niño years, during which the country commonly experiences erratic precipitation and prolonged dry spells [13]. The southern part of Malawi and, to a lesser extent, the central regions of the country are particularly exposed to droughts. In 2016, Malawi experienced a major drought due to strong El Niño conditions, which resulted in erratic precipitation across most parts of the country [13]. More than 6.5 million people (39 % of the population) were affected and economic losses were estimated at between 329 million [13] and 500 million USD [14]. This succession of climate shocks of this severe drought directly following the 2015 major flood had a cumulative negative impact on Malawi and its people. [14].

**Temperature-related extremes have also increased over the last decades**. Between 1960 and 2003, the number of hot days[4] and nights has increased by 30.5 days (an additional 8.3 % of days per year) and 41 nights (an additional 11.1 % of nights per year), respectively, particularly in the months from December to February. At the same time, the average number of cold days[5] and nights has decreased [17, 18].

[4] Hot days/nights are defined as days/nights in which the temperature exceeded the 90th percentile of days/nights in the current local climate of the region and season.

[5] Cold days/nights are defined as the mirror-image below the 10th percentile of days/nights in the current local climate. Note that this definition used by McSweeney et al. differs from the definition used for the projections of very hot days in this Climate Risk Profile (cf. Figure 4).

## Projected climate changes

### How to ...

#### ... read the line plots

| | | | |
|---|---|---|---|
| — | historical | — | best estimate |
| — | RCP2.6 | ▬ | likely range |
| — | RCP6.0 | ▬ | very likely range |

Lines and shaded areas show multi-model percentiles of 31-year running mean values under two different climate change scenarios called Representative Concentration Pathways (RCPs). RCP2.6 (blue) represents a low emissions scenario which would be a 'likely below 2°C' scenario[6]. RCP6.0 (red) shows a medium to high emissions scenario. Lines represent the best estimate (multi-model median) and shaded areas the likely range (central 66 %) and the very likely range (central 90 %) of all model projections. Projections do not account for effects of future socio-economic changes (e.g. population growth). Note that the presented indicators apply thresholds for defining extreme events that in pre-industrial time would have been considered very rare events[7]. When interpreting these projections, it should be considered that climate-related events that remain below these thresholds can also have devastating impacts which may not be reflected by these indicators.

#### ... read the map plots for projections

Colours show multi-model medians of 31-year mean values under the low emissions scenario RCP2.6 (top row) and medium to high emissions scenario RCP6.0 (bottom row) for different 31-year periods (the central year is indicated above each column). Colours in the leftmost column represent values for a baseline period (colour bar on the left). Colours in the other columns show differences relative to this baseline period (colour bar on the right). The presence of a dot in the other columns indicates that at least 75 % of all models agree on the sign of the difference, absence of a dot mean less than 75 % agreement.

#### ... learn more on the sources, methodology and interpretation

For further guidance and background information about the figures, maps and analyses presented in this profile kindly refer to the supplemental information provided by the Potsdam Institute for Climate Impact Research (PIK) [19], which developed the underlying format of the Climate Risk Profiles (see also 'Acknowledgements' at the end of this Climate Risk Profile).

[6] Note that RCP2.6 is, however, not consistent with the more ambitious goal of the Paris Agreement to limit global warming to 1.5 °C above pre-industrial levels.

[7] A flood event is for example defined to occur when daily discharge exceeds pre-industrial 100-year return levels, while a drought event is defined as the monthly soil moisture dropping to be below the 2.5th percentile of the pre-industrial baseline for at least seven months in a row (see Table 1 of the underlying publication describing the indicators[29]).

# Temperature change and heat risk indicators

## Temperature

**Mean air temperature in Malawi is projected to rise substantially** relative to the baseline of 1876 due to increasing greenhouse gas (GHG) concentrations (Figure 3). Under the lower emissions scenario (RCP2.6), the multi-model median air temperature amounts to an increase of around 2.0 °C by both 2050 and 2080.

Under the medium / high emissions scenario (RCP 6.0), temperatures are projected to rise by 2.3 °C in 2050 and 3.3 °C in 2080, according to the best estimate, with likely ranges going up to almost 4 °C temperature increase in 2080. **Both scenarios project mean temperature to increase by 1.9 °C by 2030.**

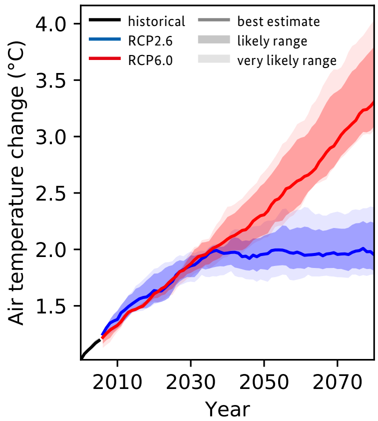



Figure 3: Projected changes in air temperature relative to 1876 for Malawi for different GHG emissions scenarios.

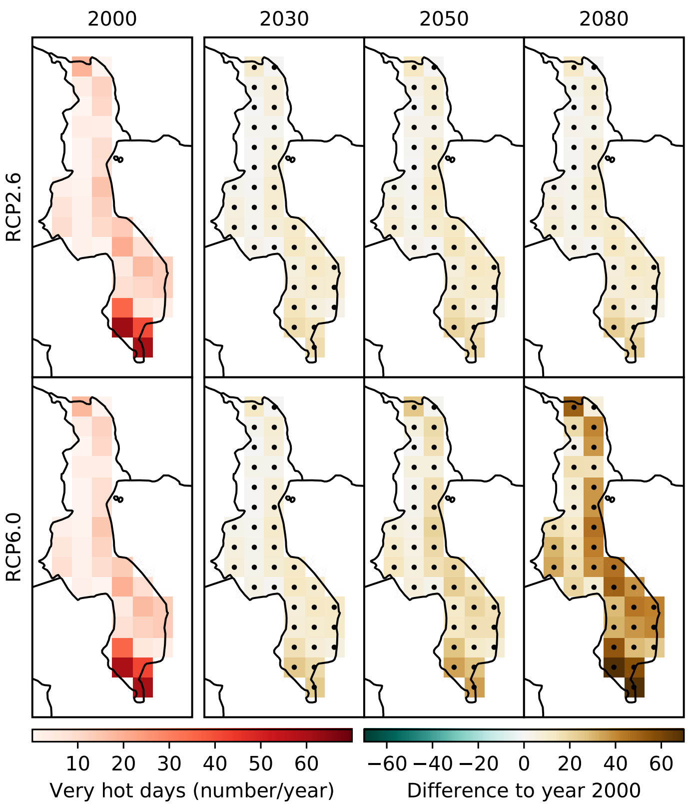



Figure 4: Projections of the number of very hot days (days with a maximum temperature >35 °C) per year for Malawi. The left-most column displays historical values for the year 2000, the other columns display projections for the years 2030, 2050 and 2080. The upper row shows projections under RCP2.6, the lower row those under RCP6.0. A dot in a grid cell indicates high agreement between the models and thus low uncertainty.

## Very hot days

The **number of very hot days** – defined as days on which the maximum temperature exceeds 35 °C – in a year is also **expected to rise** due to increasing GHG concentrations (Figure 4), mirroring the projected increases in mean air temperature (Figure 3). Even under the lower emissions scenario, best estimates project 7 more very hot days by 2030, 9 more by 2050 and 8 more by 2080. Under the medium/high emissions scenario, an average of 32 more very hot days are projected by 2080. The **southern part of the country** is expected to be **particularly affected with a projected number of over 60 additional very hot days per year by 2080**. Adding these to the historical values of already over 60 very hot days per year in 2000, southern Malawi is expected to face more than 120 very hot days per year by 2080 under the medium/high emissions scenario. The agreement between models is high leading to relatively low uncertainty for these estimates.

# Precipitation, flood and drought risk indicators

## Precipitation

With high natural variability, precipitation projections are less certain than projections of temperature change, as the **wide spread of possible future precipitation outcomes** indicates (Figure 5). Compared to the year 2000, precipitation changes could decrease by more than 110 mm per year or increase by about 70 mm per year in 2080, according to the very likely range of RCP6.0. According to the RCP6.0 best estimate, precipitation projections show initial decadal variability up to the year 2050 before decreasing to about 50 mm less annual precipitation by 2080 compared to the year 2000. The best estimate under RCP2.6 follows a more linear trend and projects annual precipitation decreases by 30 mm in 2030, 35 mm in 2050 and 67 mm in 2080. Uncertainty ranges under RCP2.6 also seem lower than those under RCP6.0 with a very likely range of annual precipitation decreases between 76 mm and 6 mm by 2080.

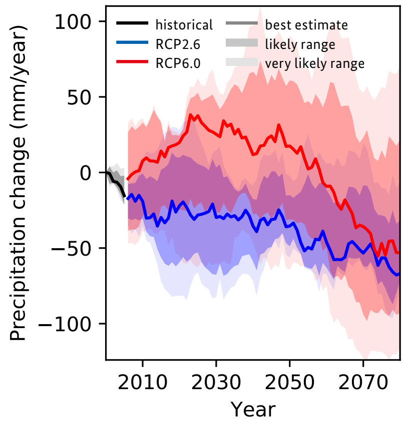



Figure 5: Projected changes in precipitation for Malawi in mm per year relative to the year 2000 for different GHG emissions scenarios.

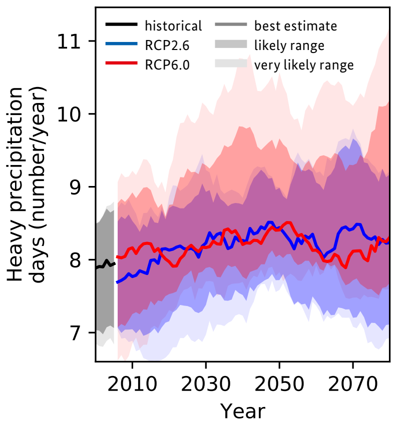


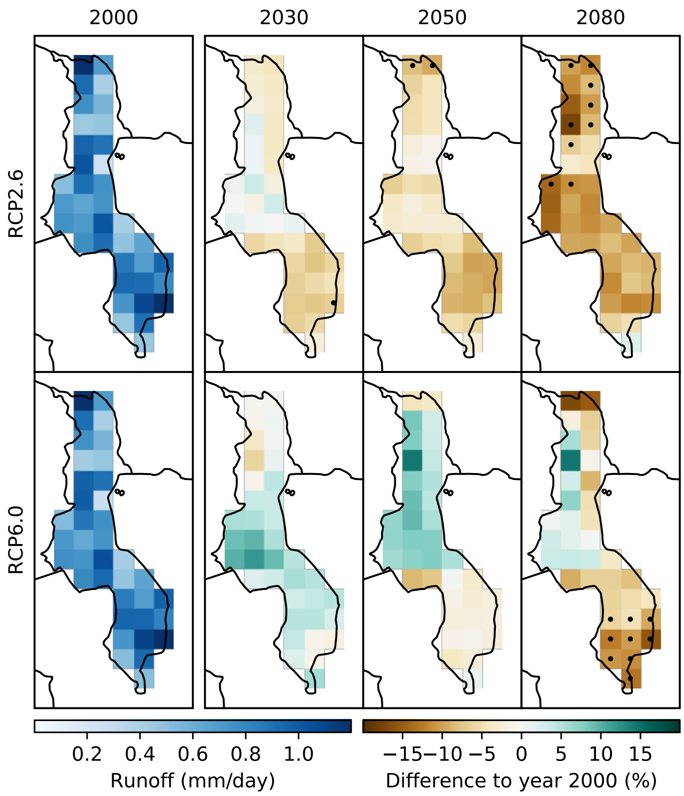

Figure 6: Projections of the number of days with heavy precipitation in Malawi under different GHG emissions scenarios, relative to the year 2000.

## Heavy precipitation events

**Heavy precipitation events[8] are expected to increase**. Projections regarding future heavy precipitation events are, however, subject to considerable modelling uncertainty, mirroring the uncertainties in the precipitation projections (see Figure 5). Best estimates under both RCP2.6 and RCP6.0 project no significant change in the number of heavy precipitation days per year by 2080, compared to the historical value of 7.9 days per year in 2000 (Figure 6). Yet, the **number of heavy precipitation days per year could be as low as 7 (very likely range RCP2.6) or as high as 11 by 2080 (very likely range RCP6.0)**, which would imply an increase of over 30 % in heavy precipitation events compared to current values.

[8] Heavy precipitation days are defined as days "on which the precipitation sum exceeds the 98th percentile of the daily precipitation sums of all wet days from 1861 to 1983, where a wet day is a day with a precipitation sum of at least 0.1 mm" [19].

## Surface runoff




**Surface runoff**, defined as the amount of water discharged through surface and subsurface streams, is **projected to decrease in several parts of the country** with increasing GHG concentrations (Figure 7). The low emissions scenario projects reductions in runoff by 10–15 % over the entire country by 2080, with agreement between the models being high only for the northern part of the country. Under the medium/high emissions scenario, the strongest decreases in runoff (10 and 15 %) are projected for the southern part as well as the northern-most point of Malawi by 2080, with high model agreement only in the south. Taken together, adverse trends in precipitation and water availability projections call for **urgent water conservation actions**, given that 96 % of current agricultural production is still rainfed (see also section on water resources).

Figure 7: Projections of surface runoff (water availability from precipitation) for Malawi as percent difference to values in the year 2000 in mm per day. The left-most column displays historical values for the year 2000, the other columns display projections for the years 2030, 2050 and 2080. The upper row shows projections under the lower emissions scenario RCP2.6, the lower row those obtained under high/medium emissions scenario RCP6.0. A dot in a grid cell indicates high agreement between the models and thus low uncertainty.

## Potential evapotranspiration

Potential evapotranspiration, the total amount of water that would be lost from the soil through evaporation and of water transpired from plant leaves, if enough water was available on and below the land surface, is also projected to increase with climate change due to higher air temperatures and rising air movements. **Projections for Malawi suggest a significant increase in the potential evapotranspiration under both RCP2.6 and RCP6.0** (Figure 8). In the low emissions scenario, the potential evapotranspiration is expected to increase by 4 % until 2030 (best estimate) and remain stagnant towards 2080. The medium / high emissions scenario (RCP6.0) projects the potential evapotranspiration to constantly increase over time becoming about 11 % higher by 2080 compared to the year 2000.

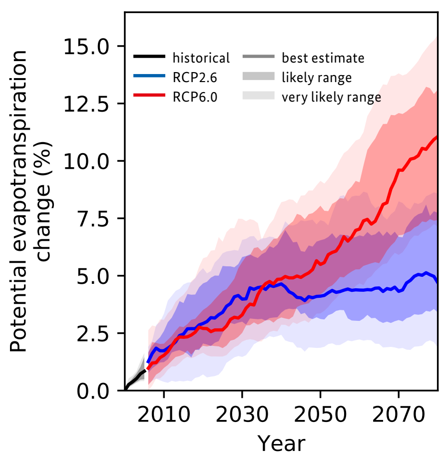



Figure 8: Projected changes in potential evapotranspiration for Malawi for different GHG emissions scenarios, relative to the year 2000.

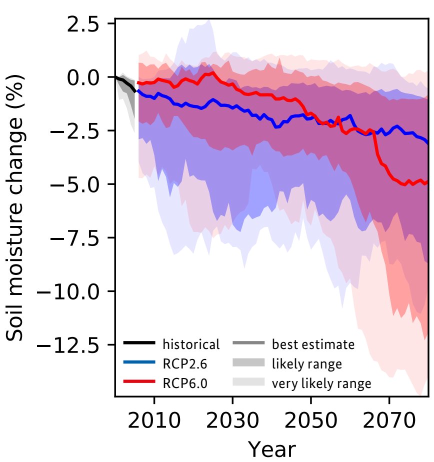



Figure 9: Projected changes in soil moisture for Malawi for different GHG emissions scenarios, relative to the year 2000.

## Soil moisture

Soil moisture, an important indicator of drought conditions, refers to the amount of water stored in the soil and is a function of temperature, precipitation and soil characteristics. In line with overall drought projections, **soil moisture is expected to decrease by 2080 compared to the year 2000 under both RCP2.6 (decrease of 3 %) and RCP6.0 (decrease of 5 %)** (Figure 9). Projections are, however, subject to substantial modelling uncertainty: Under RCP6.0, the very likely range in soil moisture changes ranges between a 14 % decrease and a 0.3 % increase by 2080 compared to the year 2000.

## Sector-specific climate change risk assessment

### a. Water resources

Water management and access to clean drinking water remain a challenge in Malawi. Reasons for this are droughts, the naturally high variability in precipitation as well as floods, which cause damages to infrastructures for drinking water, sanitation and irrigation [14].

The projected increases in air temperature (see Figure 3), precipitation-related uncertainty (see Figure 5) and changes in surface runoff (see Figure 7) can impact future water availability in Malawi. Water availability at the national level is projected using the Falkenmark Water Stress Indicator which provides a measurement of water availability per capita and year (Figure 10). It is computed by summing up runoff over the entire country and dividing it by the national population. Due to increased variability in precipitation and the increased intensity and frequency of extreme events, **water stress plays a critical role in determining food security**. Thresholds for water stress and water scarcity are defined at 1 700 and 1 000 m³ per person per year, respectively. Assuming constant population levels (Figure 10, Panel A), best estimates project a **decrease in per capita water availability** from precipitation of 11 % under RCP2.6 and of 6 % under RCP6.0 by 2080 compared to almost 3 000 m³ in 2000. In line with other precipitation-related projections, projections of future water availability are also subject to modelling uncertainty. By 2080, the very likely range includes decreases in water availability of 18 % as well as increases of 10 %, compared to 2000. **Taking into account projected population growth, water availability is projected to decrease by 82 % by 2080 under both emissions scenarios** with best estimates **crossing the threshold for water scarcity and coming close to the threshold for absolute water scarcity** (Figure 10, Panel B).

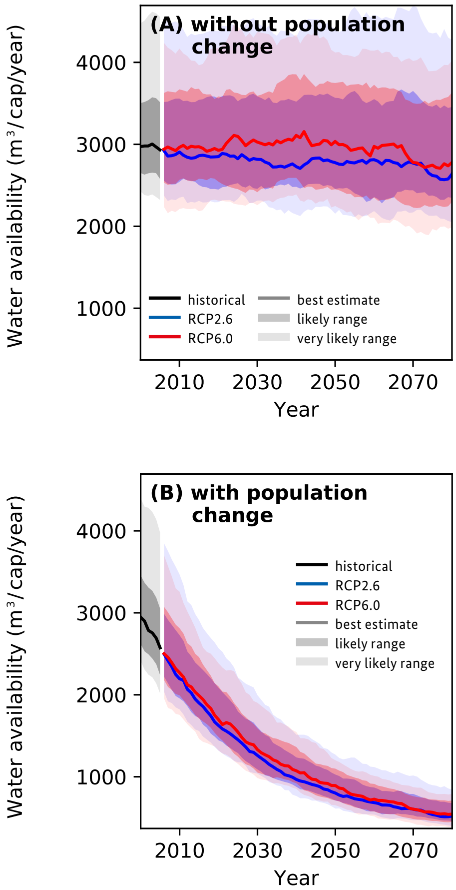



Figure 10: Projections of water availability for Malawi relative to the year 2000, measured in m³ of freshwater available per inhabitant per year. Panel A shows projections assuming a constant population, Panel B takes expected population changes into account (in line with SSP2). 1 000 – 1 700 m³ per capita year indicates water stress, 500 – 1 000 m³ per capita/year indicates water scarcity, and <500 m³ per capita/year indicates absolute water scarcity [20].

## b. Agriculture

**Malawi's economy is heavily dependent on agriculture, which accounts for up to a third of annual GDP**, more than 90 % of export earnings (mainly tobacco) and nearly 80 % of employment [21, 22]. The performance of the agricultural sector also has significant implications for the production and services sector due to its dependence on agricultural inputs and the importance of households' disposable income for consumer demand, respectively. With 96 % of agriculture being rainfed [13], crop yields are particularly vulnerable to droughts or erratic precipitation. It has been estimated that the 2016 drought has led to losses of up to 198.7 million USD in crop production for Malawi, with the majority of losses attributed to the loss of maize (145 million USD; 73 %). These losses led to a steep increase in food insecurity in the country, particularly for smallholder farmers in the south [13].

**Maize is considered Malawi's most important staple food crop** and of particular importance for the population's food security and is predominantly produced by smallholder farmers for their own consumption. Due to the high sensitivity of maize to droughts, other crops such as **cassava and sweet potatoes have slightly gained in importance over the last years** (Figure 11). **Major cash crops are tobacco, tea, groundnuts, cotton and sugar** [23].

Floods can also have a detrimental impact on agriculture due to damages to crops, livestock and infrastructure [16]. The two major floods in 2015 and 2019 accounted for agricultural losses of 13.6 million USD and 29.8 million USD, respectively [14, 16].

### Crop yield changes

Agricultural yields are projected to change due to increasing GHG concentrations. Projections show different patterns, with **both increases and decreases in yield, depending on the crop type**. Cassava, rice, cow peas and groundnuts, so-called C3 plants, follow a metabolic pathway, which allows them to benefit from higher $CO_2$ concentration levels. This is different for maize, millet and sorghum, C4 plants which are benefiting less from a $CO_2$ fertilisation effect compared to C3 plants. **Cassava yields are projected to increase by 12 % (RCP2.6) and 17 % (RCP6.0) up to 2050**, compared to 2000 values, and then to decrease by 2080 under the low emissions scenario, but continue rising to an overall 20 % change under the medium/high emissions scenario. Cassava has a high tolerance for both drought and temperature extremes. **Cow pea yields display a similar pattern with yield increases of 4 % up to 2050**, compared to 2000 values. By 2080, the low emissions scenario projects a decrease in yields of 0.5 %, compared to the year 2000, and the medium/high emissions scenario projects an increase by 8 %. **Best estimates for rice yields project a decrease of 0.3 % (RCP2.6) and an increase of 5 % (RCP6.0) by 2080** compared to the year 2000. **Millet and sorghum yields are expected to decrease significantly under both emissions scenarios**. Best estimates project yield decreases of 9 % (RCP2.6) and 12 % (RCP6.0) by 2080, compared to the year 2000. **Groundnuts yields are equally expected to decrease by 4 % (RCP2.6) and 3 % (RCP6.0) in 2080**, compared to yields in the year 2000, but projections are subject to considerable uncertainty. Similarly, expected future **maize yields are highly uncertain**. While **best estimates suggest yield drops by 2–4 % in 2080**, compared to the year 2000, **yield drops could be as large as 19 %** (very likely range) under the medium/high emissions scenario. This is of particular concern given the important role maize plays for Malawi's food security (Figure 11).

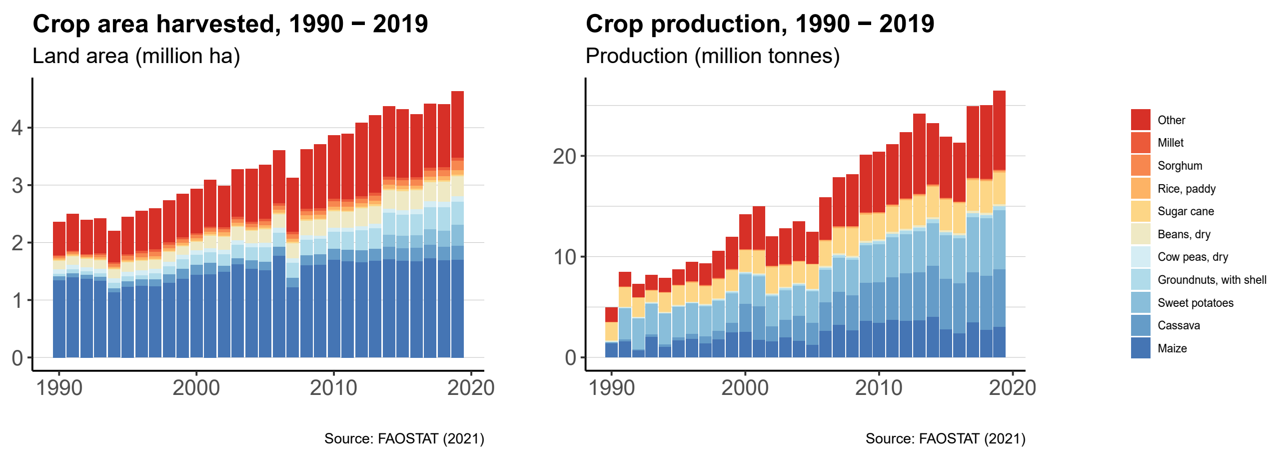



Figure 11: Historical development of selected crops in Malawi from 1990 to 2019. Crop production in million tonnes (left) and crop area harvested in million ha (right). Source: FAOSTAT (2021) [24]

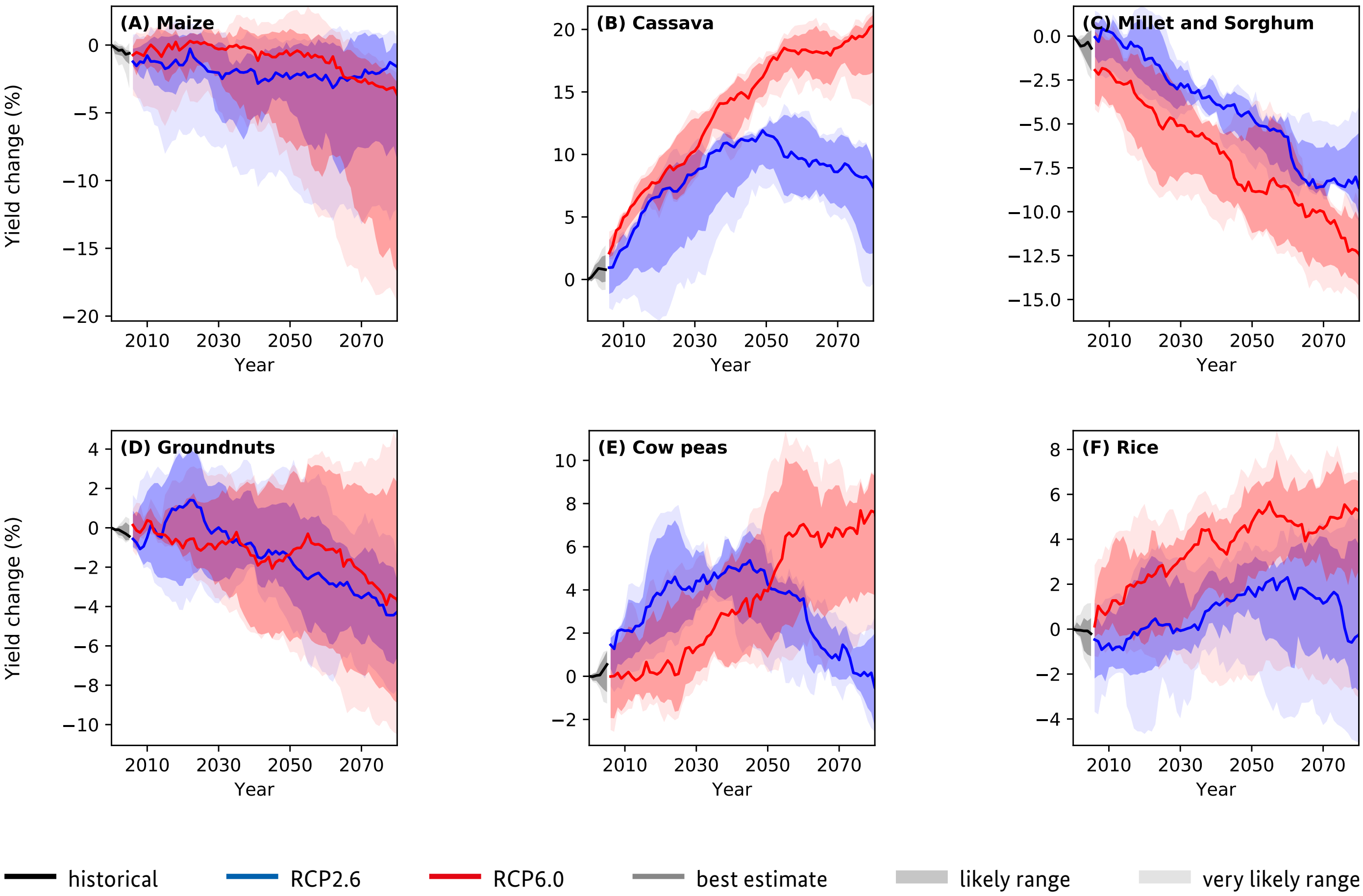



Figure 12: Projected changes in yields for selected crops in Malawi for different GHG emissions scenarios, assuming constant land use and agricultural management, relative to the year 2000.

## Exposure of crop land to droughts

According to the best estimate, the **share of drought-exposed crop land area in the national total crop land is expected to increase to 1–2 %, compared to 0.13 % in 2000** (Figure 13). Due to a high variability for precipitation trends (see Figure 5) uncertainty ranges are large. While the lower bounds of the very likely range of both RCP2.6 and RCP6.0 indicate little crop land area exposure to drought, the upper bounds project shares as high as 17 % (RCP2.6) or 24 % (RCP6.0). **This is of particular concern given Malawi's strong economic dependence on agriculture and almost all agriculture being rainfed.**

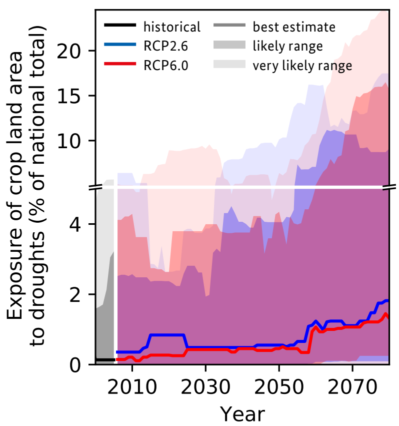



Figure 13: Projected exposure to droughts of crop land area for Malawi for different GHG emissions scenarios, relative to the year 2000.

## c. Infrastructure

Infrastructure is an important factor for economic as well as socio-economic development prospects. Already in the past, a **large infrastructure funding gap** has been identified for Malawi [25]. **Impacts from climate change additionally threaten already existing infrastructure**. For example, the 2019 floods in Malawi caused substantial damages to roads, bridges, the power supply grid, infrastructure for irrigation, water and sanitation infrastructure, schools and also housing with over 280 000 houses being partly or completely destroyed [14].

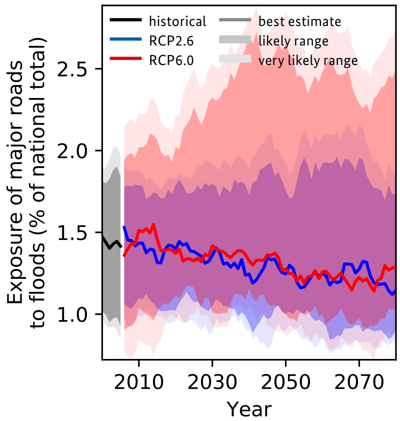



Figure 14: Projected exposure of major roads to river floods at least once per year for Malawi for different GHG emissions scenarios.

### Flood exposure of infrastructure

Floods can lead to substantial human and economic losses due to their adverse impacts on infrastructure, industry sites and settlements. **Flood projections for Malawi, however, show a high degree of uncertainty under both emissions scenarios** (Figure 14). Median values project a slight decrease of the share of major roads exposed to floods by 2080, compared to 1.5 % in 2000. At the same time, up to 2.7 % of major roads could be exposed to floods by 2080 (upper bound of the very likely range of RCP6.0). Infrastructure destructions induce substantial indirect costs as a functioning infrastructure is a prerequisite for almost all economic activities as well as further investments.

### Flood exposure of urban land areas

Under both RCP2.6 and RCP6.0, best estimates do not project a significant change in the urban land area exposed to floods, compared to 0.25 % in 2000 (Figure 15). However, given that 80 % of Malawi’s population live in rural areas, the **country’s exposure of urban land areas to floods might change with higher urbanization rates**. In addition, projections under RCP6.0 exhibit large uncertainty ranges towards 2080.

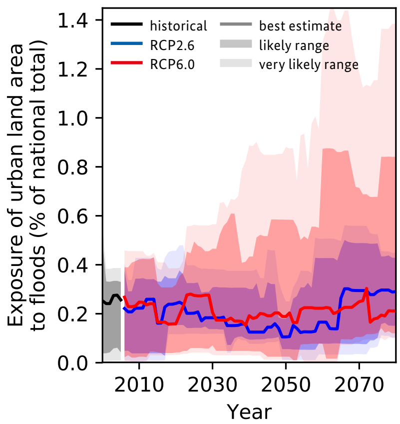



Figure 15: Projected exposure of urban land area to river floods at least once per year for Malawi for different GHG emissions scenarios.

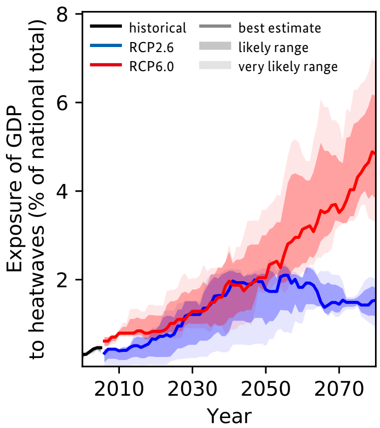



Figure 16: Projected exposure of GDP to heatwaves for Malawi for different GHG emissions scenarios.

### Exposure of GDP to heatwaves

Projected heatwave exposure of the GDP (Figure 16) mirrors trends in the heatwave-exposed population (see Figure 18). Compared to 0.3 % of the national GDP being exposed to heatwaves in 2000, the **GDP exposed to heatwaves to increase to 1.8 % by 2050** with no further increases up to 2080 **under RCP2.6**. **Under RCP6.0,** the best estimate projects about **5 % of Malawi's GDP to be exposed to heatwaves by 2080**.

## d. Human health

Climate change affects human health along different dimensions. Water scarcity and damages to water and sanitation infrastructure can have adverse health impacts. Droughts and floods affecting crop yields can **threaten food security**. A recent study found that the **most urgent climate-related health risks in Malawi included increases in climate-sensitive diseases (e.g. malaria and diarrhoea), increasing food insecurity and related health impacts from malnutrition** [26]. It is expected that the impacts of the 2019 flood will have medium- to long-term impacts on the nutritional status of Malawi's population, which exhibited relatively high rates of stunting among children already prior to the flood [14].

Furthermore, climate-driven temperature extremes have been shown to be linked to **increased heat-related mortality** [27]. Moreover, **labour productivity and economic production have been shown to be negatively impacted by heat extremes** [28].

### Heat-related mortality

For Malawi, **heat-related mortality** – measured by the number of deaths due to heat stress per 100 000 inhabitants per year – is **projected to increase**, particularly under the medium/high emissions scenario. Compared to less than 4 deaths per 100 000 inhabitants in 2000, heat-related mortality is projected to rise to 14 deaths per 100 000 inhabitants by 2080 according to RCP6.0, a more than threefold increase (Figure 17).

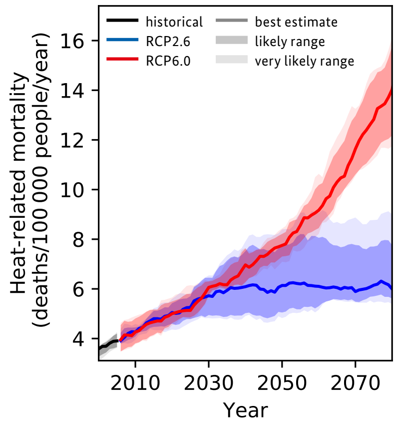



Figure 17: Projections of heat-related mortality for Malawi for different GHG emissions scenarios, assuming no adaptation to increased heat.

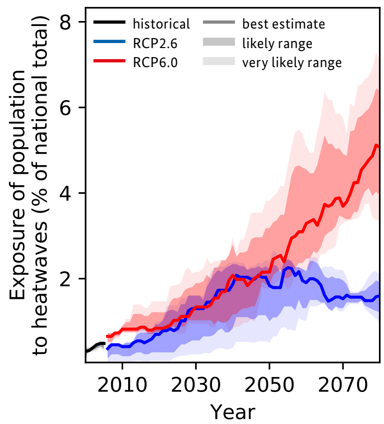



Figure 18: Projected share of the population exposed to humid heatwaves at least once per year for Malawi under different GHG emissions scenarios.

### Population exposed to humid heatwaves[9]

**Exposure to heatwaves is expected to increase**, in line with the projected increases of the mean annual air temperature (see Figure 3). Under RCP2.6, the share of the population exposed to heatwaves is projected to increase to 1.8 % in 2050 with no further increases until 2080 (Figure 18). Under the medium/high emissions scenario, the same share could increase to 5.1 % until 2080.

[9] A heatwave (as defined for the projections used in this profile) takes both relative humidity as well as mean and maximum air temperature into account. A grid cell is classified to be exposed to at least one heatwave per year if the Heat Wave Maximum Index daily (HWMId) of that year is in the top 2.5 % of the HWMId distribution under pre-industrial climate conditions and the humidex exceeds 45 on all days of the respective heatwave [19].

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