Federal Ministry
for Economic Cooperation
and Development

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Climate Risk Profile: Zambia*

Summary

This profile provides an **overview of the projected climate parameters and related impacts** on different sectors in Zambia until 2080 **under different climate change scenarios** (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 that is likely to exceed 2 °C. **Model projections do not account for effects of future socio-economic impacts unless indicated otherwise.**

Agro-ecological zones might shift, **affecting ecosystems, biodiversity** and **crop production**. Models project decreases in species richness, while projections of tree cover show the opposite trend, with moderate increases particularly in western Zambia. However, these projections exclude any impacts from human activities, such as charcoal production, smallholder farming and timber extraction, among other factors, which have been major drivers of deforestation in the past.

Agriculture, biodiversity, health, infrastructure and water are highly vulnerable to climate change. The **need for adaptation in these sectors has been stressed in Zambia's Nationally Determined Contributions (NDC) targets and should be addressed by cooperating partners.**

Climate change impacts on water availability show strong variations within Zambia. While projections indicate a tendency towards higher runoff in the northern regions, the southern and south-western regions are projected to have declines in runoff in the second half of the century. Furthermore, it is likely that climate change will increasingly lead to temporal variability within the year through **more extreme dry and wet periods**.

Depending on the scenario, **temperature** in Zambia is projected to **rise by between 1.8 and 2.0 °C by 2030 and up to 4.3 °C by 2080**, compared to pre-industrial levels. Higher temperatures and more temperature extremes are projected for the western part of the country.

The share of the **population affected** by at least one **heatwave** per year is projected to **rise marginally**, due to the absence of humid heatwaves in Zambia. Nevertheless, **heat-related mortality** is estimated to **increase from 5.2 deaths per 100 000 people in the year 2000 to 18.1 deaths by 2080, which is a factor of almost 3.5**. This trend will already be felt early in the century, with an increase to 9.0 deaths by the year 2030.

Precipitation trends are uncertain and characterised by high inter-annual variability: Under RCP 2.6, precipitation is projected to rise earlier in the century, reaching a peak around the year 2030 and slowly declining afterwards. Projections under RCP2.6, however, point to an overall decreasing trend towards the end of the century, indicating **no clear trend in precipitation**. Nevertheless, future dry and wet periods are likely to become **more extreme**.

Climate change is likely to cause **damage to the infrastructure sector** in Zambia including roads and bridges. Roads are the backbone of the country's transportation network and essential in linking farmers and markets. Investments will need to be made into building climate-resilient roads and other infrastructure to maintain agricultural supply chains and foster economic growth.

The models project an **increase in crop land exposure to drought**. Yields of maize are likely to decrease, while yields of cassava, soybeans and groundnuts are projected to benefit from CO_2 fertilisation. To counteract the currently high degree of food insecurity in Zambia, farmers will need to adapt to these changing climatic conditions.

* Further in-depth information on climate impacts and selected adaptation strategies in the agricultural sector can be found in a complimentary climate risk analysis for Zambia, which will be finalised in spring 2023.

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Context

Zambia is a landlocked country, located in **Southern Africa** and bordered by the Democratic Republic of the Congo, Tanzania, Malawi, Mozambique, Zimbabwe, Botswana, Namibia and Angola. The country had a **population of 18.4 million** in 2020 with an annual demographic **growth rate of 2.9 %** [1]. The **majority of the population lives in the central area**, particularly around the capital Lusaka, in addition to the cities of Ndola, Kitwe and Mufulira [2]. With a 44.6 % urban population, Zambia has one of the highest urbanisation rates in Africa [1]. With a real GDP per capita of 1 274 USD in 2020 [1], the country is a **lower-middle-income country**. Zambia is furthermore characterized by high rates of poverty, malnutrition and wealth inequality (see also quality of life indicators). Zambia's economy is dominated by the services sector, contributing 53.6 % to the country's GDP in 2020, followed by the industrial sector with 40.3 % and the agricultural sector with 3.0 % [3]. Although the agricultural sector contributes a marginal share to the national GDP, an estimated 50 % of the working population are officially employed in this sector, with many more being employed on an informal basis. Zambia's key export commodity is copper, which is primarily sold to Switzerland [4]. Food exports are marginal and include maize, cereal meal and pellets, and oil seed flowers [4]. Although Zambia's economy has clearly shifted towards services and industry, the agricultural sector continues to be the **primary means of livelihood** for the country's population, especially in rural areas.

Important **staple crops are maize, soybeans, groundnuts and cassava** [6]. As **agricultural production** in Zambia is primarily **subsistence-based and rainfed**, especially smallholder farmers suffer from the impacts of climate change. They often lack formal safety nets and heavily depend on agriculture for their livelihoods and food security. This is also reflected in the 23.2 % of the total population who suffered from severe food insecurity in 2018–2020. **Limited adaptive capacity in the agricultural sector**, such as limited access to agricultural inputs, formal credit or extension services, **underlines the country's vulnerability to climate change.** In 2018, only 4.1 % of the total national crop land and 13.6 % of the estimated irrigation potential of 523 000 ha were equipped for irrigation and actually irrigated [7], [8]. Different environmental challenges further add pressure on agricultural production in Zambia, including deforestation and overgrazing, which in turn lead to erosion, desertification and reduced quality of agricultural land [2].

Zambia served as a **destination for approximately 170 000 migrants and refugees**, especially from the Democratic Republic of the Congo and Angola [9]. In turn, almost half a million Zambians (493.000 migrant stock in 2019) migrated to South Africa, Malawi and Zimbabwe, or outside of Africa, where the main destinations include the United Kingdom and the Czech Republic [9].

Quality of life indicators [5], [11]–[13]

Human Development Index (HDI) 2019	ND-GAIN Vulnerability Index 2019	Gini Index 2015	Real GDP per capita 2020	Poverty headcount ratio 2015	Prevalence of severe food insecurity 2018–2020
0.584 **146 out of 189** (0 = low, 1 = high)	**40.5** **137 out of 181** (0 = low, 100 = high)	**57.1** (0–100; 100 = perfect inequality)	**1 274 USD** (constant 2015 USD)	**58.7 %** (at 1.9 USD per day, 2011 PPP) [1]	**23.2 %** (of total population)

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[1] Poverty headcount ratio for the year 2012 adjusted to 2011 levels of Purchasing Power Parity (PPP). PPP is used to compare different currencies by taking into account national differences in cost of living and inflation.

Topography and environment

Zambia's topography is **dominated by high plateaus**, including mountains in the northern and north-eastern part of the country. The lowest point in Zambia is the Zambezi River at 329 m, while the highest point is the Mafinga Central at 2 330 m [2]. **The country has a mostly tropical climate with higher amounts of precipitation in the north-west and lower amounts in the south-east.** Accordingly, Zambia is commonly divided into **four Agro-Ecological-Zones** (AEZs), based on precipitation levels as a key marker of climatic differences: The southern river valley (I), the central and eastern plateaus (II A), the western plains (II B) and the northern part (III) (Figure 1) [14][2]. Each of these zones is characterised by specific temperature and moisture regimes, and consequently specific patterns of crop production and pastoral activities. Zambia is drained by **two major rivers** and its tributaries: the **Congo River**, which originates in northern Zambia and flows through the Democratic Republic of the Congo to the Atlantic Ocean, and the **Zambezi River**, which originates in north-western Zambia and flows through the western part of the country, along its southern border, ultimately discharging into the Indian Ocean. These two rivers are also important from a regional perspective, **supplying much of Southern Africa with water** for household consumption, agricultural production and industrial use, among other purposes. At **Victoria Falls**, the Zambezi River falls about 100 m across a width of 1 708 m, subsequently flowing into **Lake Kariba, the world's largest human-made lake** [15]. Climate change is expected to **limit water availability**, particularly in south-western Zambia, which is prone to drought [16]. At the same time, the frequency and intensity of **flooding is likely to increase**, highlighting the **need for adaptation measures to protect biodiversity and maintain fragile ecosystems and their services**.

Present climate [17]

Zambia's climate is largely influenced by latitude and elevation. Mean annual temperatures range from 19 °C to 25 °C with lower values in the mountainous regions in the north and north-east and higher values in the rest of the country, in particular along the Luangwa and Zambezi Rivers.

Annual precipitation sums range from 620 mm in south-western Zambia, which has a drier mountain climate, to 1 480 mm in the north-east, which is also characterised by higher altitudes, but in addition shows some savannah features.

Zambia has a single rainy season (unimodal precipitation regime), which lasts from November to April in most parts of Zambia.

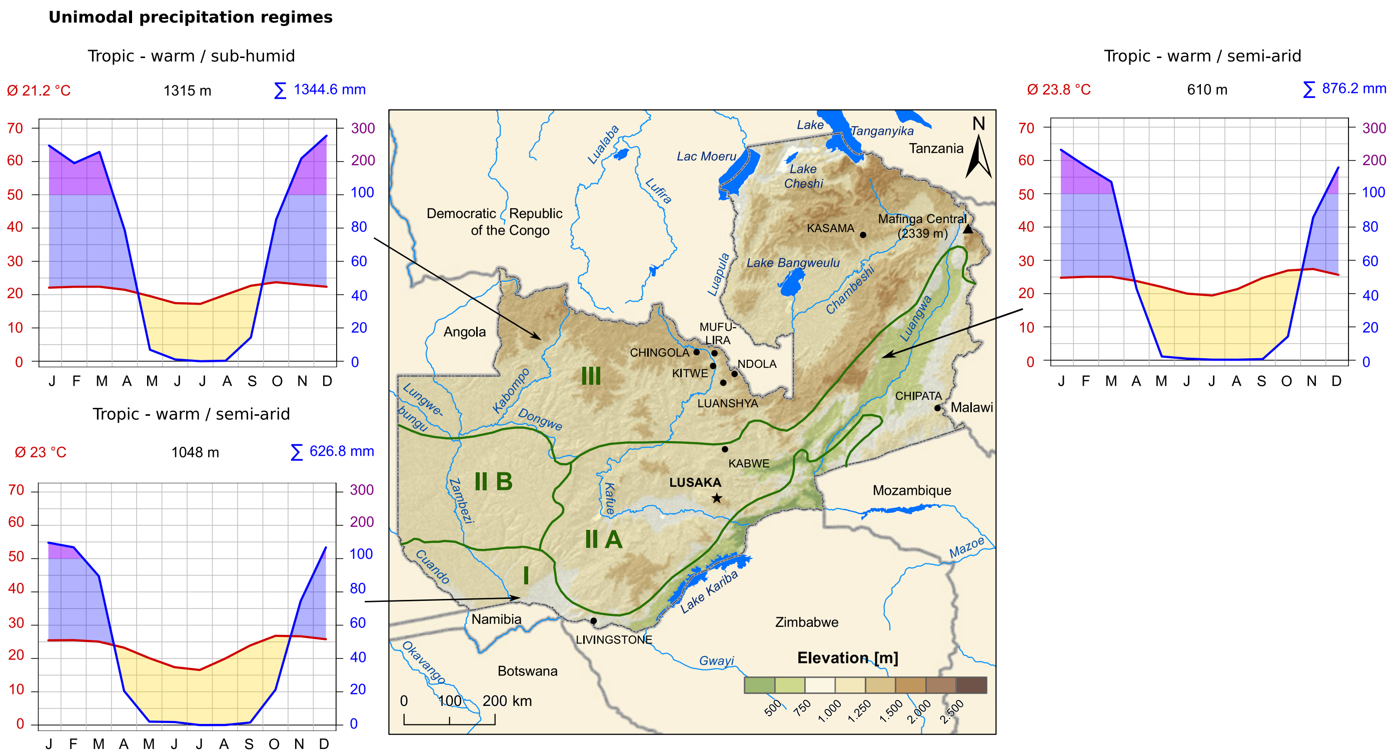

Figure 1: Topographical map of Zambia with agro-ecological zones and existing precipitation regimes.[3]

[2] It should be noted that there are different classifications of AEZs in Zambia. We focused on a commonly used classification of four zones based on the description by the Zambia Development Agency (ZDA) 2011.
[3] The climate diagrams 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.

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 RCP2.6 (low emissions scenario in blue) and RCP6.0 (medium to high emissions scenario in red). Whereas lines represent the best estimate (multi-model median), shaded areas show the likely range (central 66 %) and the very likely range (central 90 %) of all model projections.

How to read the map plots

Colours show multi-model medians of 31-year mean values under RCP2.6 (top row) and RCP6.0 (bottom row) for different 31-year periods (central year indicated above each column). Colours in the leftmost column show these 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 (absence) of a dot in the other columns indicates that at least (less than) 75 % of all models agree on the sign of the difference.
For further guidance and background information about the figures and analyses presented in this profile kindly refer to the supplemental information on how to read the climate risk profile.

Temperature

In response to increasing greenhouse gas (GHG) concentrations, **air temperature over Zambia is projected to rise by 1.9 to 4.3 °C (very likely range) by 2080** relative to the year 1876, depending on the future GHG emissions scenario (Figure 2). Compared to pre-industrial levels, median climate model temperature increases over Zambia amount to approximately 1.9 °C in 2030 and 2.1 °C in 2050 and 2080 under the low emissions scenario (RCP2.6). Under the medium/high emissions scenario (RCP6.0), median climate model temperature increases amount to 1.9 °C in 2030, 2.4 °C in 2050 and 3.4 °C in 2080.

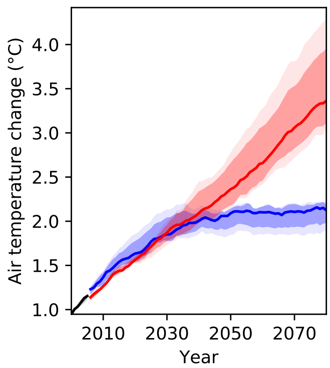

Figure 2: Air temperature projections for Zambia for different GHG emissions scenarios.[4]

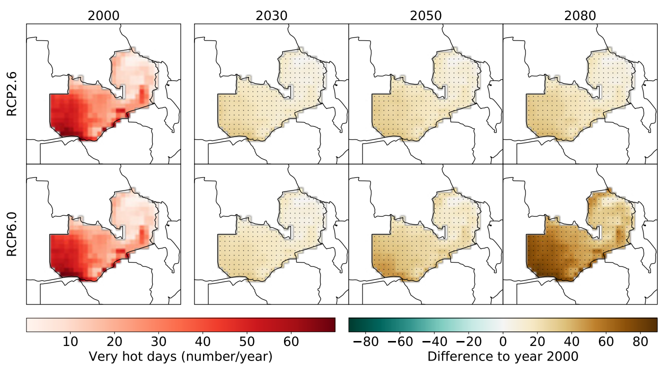

Figure 3: Projections of the annual number of very hot days (daily maximum temperature above 35 °C) for Zambia for different GHG emissions scenarios.

Very hot days

In line with rising mean annual temperatures, the annual number of very hot days (days with daily **maximum temperature above 35 °C**) is projected to rise substantially and with high certainty, in particular over western Zambia (Figure 3). Under the medium/high emissions scenario, the multi-model median, averaged over the whole country, projects **16 more very hot days per year in 2030 than in 2000**, **25 more in 2050** and **45 more in 2080**. In some parts, especially in western Zambia, where the number of very hot days is already high today, this could amount to a total of **up to 155 very hot days** per year by 2080.

[4] 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.

Precipitation

Future projections of precipitation are less certain than projections of temperature change due to **high natural year-to-year variability** (Figure 4). Among the four models underlying this analysis, three models project an **increasing trend in precipitation at the beginning of the century**, with a peak around the year 2030, and a **decreasing trend towards the end of the century**, while one model projects an opposite trend, with a decreasing trend first and an increasing trend afterwards (RCP6.0). In a similar way, projections under RCP2.6 are uncertain, however, pointing to an overall decreasing trend in precipitation towards the end of the century. Specifically, median model projections show a **precipitation decrease of 32 mm under RCP2.6** and an **increase of 5 mm under RCP6.0**.

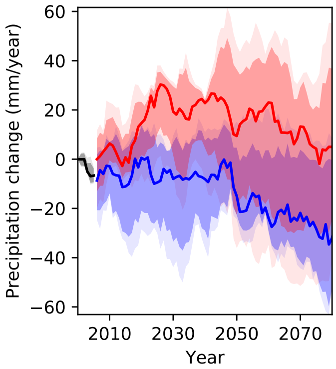

Figure 4: Annual mean precipitation projections for Zambia for different GHG emissions scenarios, relative to the year 2000.

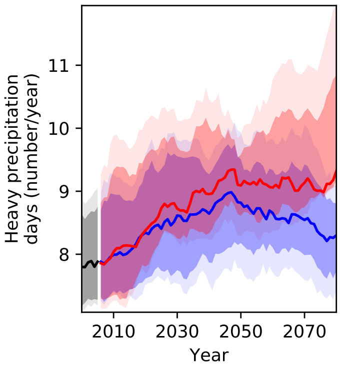

Figure 5: Projections of the number of days with heavy precipitation over Zambia for different GHG emissions scenarios, relative to the year 2000.

Heavy precipitation events

In response to global warming, **heavy precipitation events are expected to become more intense** in many parts of the world due to the increased water vapour holding capacity of a warmer atmosphere. At the same time, the number of days with heavy precipitation events is expected to increase. This tendency is also reflected in climate projections for Zambia (Figure 5). The median shows an **increase in the number of heavy precipitation days** for both RCPs, with a difference of **8.3 days under RCP2.6 and 9.3 days under RCP6.0** by 2080. Considering projections of annual precipitation change (Figure 4), more extreme weather events (excess rain and dry spells) can be observed, particularly under RCP2.6. These trends can have devastating impacts on smallholder farmers, who need to adapt to intense flood events and at the same time to prolonged dry periods.the same time to prolonged dry periods.

Soil moisture

Soil moisture is an important indicator for drought conditions. In addition to soil parameters and management, it depends on both precipitation and evapotranspiration and therefore also on temperature, as higher temperatures translate to higher potential evapotranspiration. Projections for annual mean soil moisture for a soil depth of up to 1-metre **show decreases under both RCPs** by 2080, compared to the year 2000 (Figure 6). These decreases amount to 3.3 % under RCP2.6 and 5.1 % under RCP6.0. However, looking at the different models underlying this analysis, there is **large year-to-year variability and modelling uncertainty**, with some models projecting stronger decreases in soil moisture than others, especially under RCP6.0.

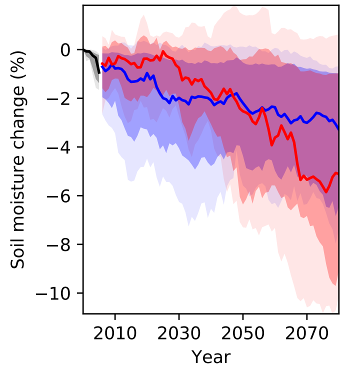

Figure 6: Soil moisture projections for Zambia for different GHG emissions scenarios, relative to the year 2000.

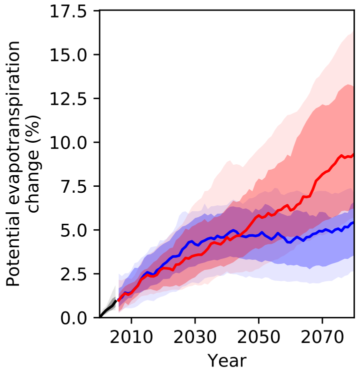

Figure 7: Potential evapotranspiration projections for Zambia for different GHG emissions scenarios, relative to the year 2000.

Potential evapotranspiration

Potential evapotranspiration is the amount of water that would be evaporated and transpired if sufficient water was available at and below land surface. Since warmer air can hold more water vapour, **it is expected that global warming will increase potential evapotranspiration in most regions of the world.** In line with this expectation, hydrological projections for Zambia indicate a stronger rise of potential evapotranspiration under RCP6.0 than under RCP2.6 (Figure 7). Under RCP6.0, **potential evapotranspiration is projected to increase by 3.6 % in 2030, 5.8 % in 2050 and 9.3 % in 2080** compared to year 2000 levels.

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Sector-specific climate change risk assessment

a. Water resources

Current projections of water availability in Zambia display high uncertainty under both GHG emissions scenarios. Assuming a constant population level, multi-model median projections show a slight decrease from 20 820 m³ in per capita water availability in the year 2000 to 18 736 m³ under RCP2.6 and 19 264 m³ under RCP6.0 by the end of the century (Figure 8A). Yet, when accounting for population growth according to SSP2 projections[5], **per capita water availability for Zambia is projected to decline** more dramatically under both RCPs (Figure 8B). It is projected to reach 4 775 m³ under RCP2.6 and 4 897 m³ under RCP6.0 until the end of the century, both of which is still above the threshold for water stress (1 700 m³) and water scarcity (1 000 m³). While this projected decline is primarily driven by population growth, other factors will further increase the pressure on Zambia's water resources, including climate change, the expansion of agricultural production, industrial use and hydropower. Furthermore, water availability will differ both regionally and across time. Parts of Zambia will likely experience insufficient access to water resources with high seasonal variability. Hence, **investments will have to be made in water saving measures and technologies for future water consumption**.

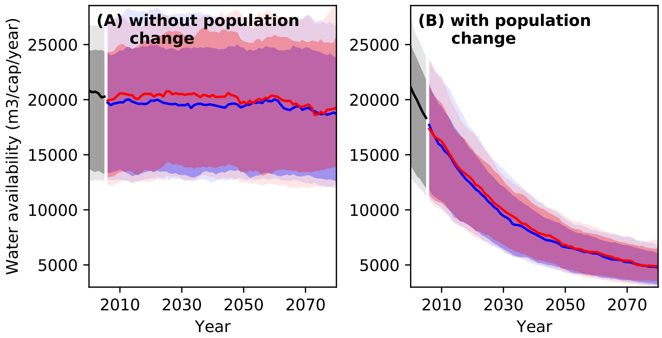

Figure 8: Projections of water availability from precipitation per capita and year with (A) national population held constant at year 2000 level and (B) changing population in line with SSP2 projections for different GHG emissions scenarios.

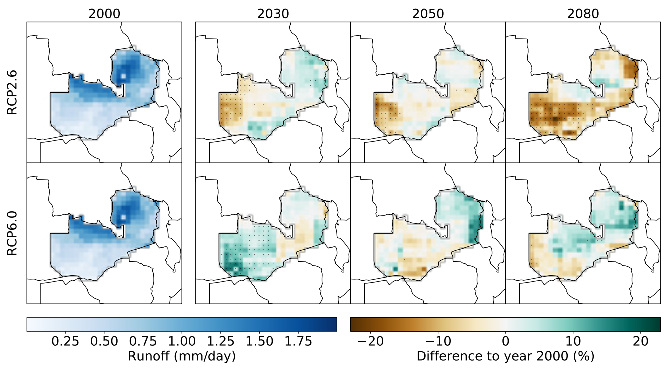

Figure 9: Water availability from precipitation (runoff) projections for Zambia for different GHG emissions scenarios.

Projections of future water availability from precipitation vary depending on the region and scenario (Figure 9). Under **RCP2.6**, models agree on **decreases in runoff throughout the 21st century in south-western Zambia** resulting in reductions of up to 22 % by 2080, while projections for the rest of the country are more uncertain. Under RCP6.0, models agree on an increase in runoff in southern Zambia by 2030, but in the later 21st century the south tends towards drying. In contrast, there is a tendency towards wetting in the north of Zambia. However, there is **little agreement on the projections for the later 21st century under RCP6.0.**

The distribution of Zambia's **water resources show high spatial variations**. While the north-west of Zambia receives up to 1 480 mm of annual precipitation over a period of around five months, the south-west of the country receives as little as 620 mm over a period of around three months (Lange, 2016). Climate change is likely to impact Zambia's water resources through variability in precipitation, rising temperatures and drought [16]. Over the period from 1981 to 2017, Zambia has experienced an **increase in droughts**, particularly in its south-western part, e.g. in Sesheke district on the border to Namibia, where droughts were more intense and persistent, compared to other parts of the country [16]. Droughts also materialise in **decreasing water levels in many of Zambia's lakes and reservoirs**, for example, in Lake Kariba, whose water levels dropped by six metres in the three years preceding 2016, due to an extended period of drought [18]. These decreases threaten the food, water and energy supply of millions of people in the entire South African region who depend on these water resources for domestic use and their livelihoods, which especially in rural areas are related to farming, pastoralism and fishing [19], [20]. **Various socio-economic developments add further pressure on Zambia's water resources, such as rapid population growth, unplanned urbanisation, agricultural expansion,** due to low production on existing land, and **industrial intensification** [21].

[5] Shared Socio-economic Pathways (SSPs) outline a narrative of potential global futures, including estimations of broad characteristics such as country-level population, GDP or rate of urbanisation. 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.

b. Agriculture

Smallholder farmers in Zambia are increasingly challenged by the uncertainty and variability of weather caused by climate change [22]. Since **crops are predominantly rainfed**, yields highly depend on water availability from precipitation and are prone to drought. However, both the length and the intensity of the rainy season are becoming more and more unpredictable and the availability and **use of irrigation facilities remains limited**: In 2018, only 4.1 % of the total national crop land and 13.6 % of the estimated irrigation potential of 523 000 ha were equipped for irrigation and actually irrigated [7], [8]. According to the AQUASTAT database, the **main irrigated crop is wheat**, followed by rice, vegetables and maize [7]. Constraints to the implementation of adaptation strategies usually include limited financial means and access to credit, lack of information and technical advice, e.g. through extension services or membership in relevant groups, and limited access to agricultural inputs, e.g. improved seeds [23]. Deforestation and agricultural expansion are the main drivers, contributing to **losses in soil organic carbon and soil fertility**, which in turn will further limit the potential for crop production [24].

Currently, the high uncertainty of projections regarding water availability (Figure 9) translates into high uncertainty of drought projections (Figure 10). According to the median over all models employed, **the national crop land area exposed to at least one drought per year will increase from 1.5 % in 2000 to 3.2 % and 4.5 % in 2080 under RCP2.6 and RCP6.0, respectively.** Under RCP6.0, the likely range of drought exposure of the national crop land area per year widens from 0.12–3.17 % in 2000 to 1.37–16.1 % in 2080. The very likely range of drought exposure widens from 0.02–5.56 % in 2000 to 0.56–22.54 % in 2080. This means that **some models project an increase of drought exposure by a factor of four over this time period.**

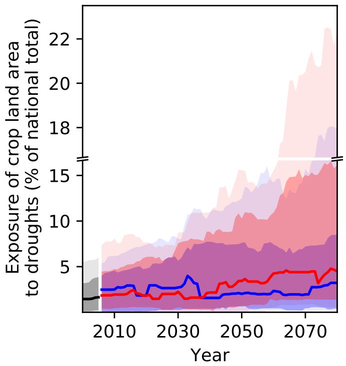

Figure 10: Projections of crop land area exposed to drought at least once a year for Zambia for different GHG emissions scenarios.

In terms of yield projections, model results indicate a **positive trend for cassava and soybeans** under both RCPs (Figure 11). By 2080, compared to the year 2000, yields are projected to increase by 23.8 % and 55.5 % for cassava and 1.8 % and 6.4 % for soybeans under RCP2.6 and RCP6.0, respectively. Yields of **groundnuts show a diverging trend**, with an increase of up to 1.7 % under RCP6.0 and a decrease of up to 3.1 % under RCP2.6. Finally, yields of maize show little change until the end of the century when considering the median of both scenarios. However, the likely range of projections indicates that most models project a **decreasing trend in maize yields**. Overall, projections show that s**ome crops are projected to benefit from higher CO_2 emissions**, while others are projected to be adversely affected. A possible explanation for the positive trend, particularly that of cassava, is that cassava is a so-called C3 plant, which follows a different metabolic pathway than, for example, maize (C4 plant), and benefits more from the CO_2 fertilisation effect under higher concentration pathways. Although some yield changes may appear small at the national level, such as for maize or groundnuts, they will likely increase more strongly in some areas and, conversely, decrease more strongly in other areas as a result of climate change.

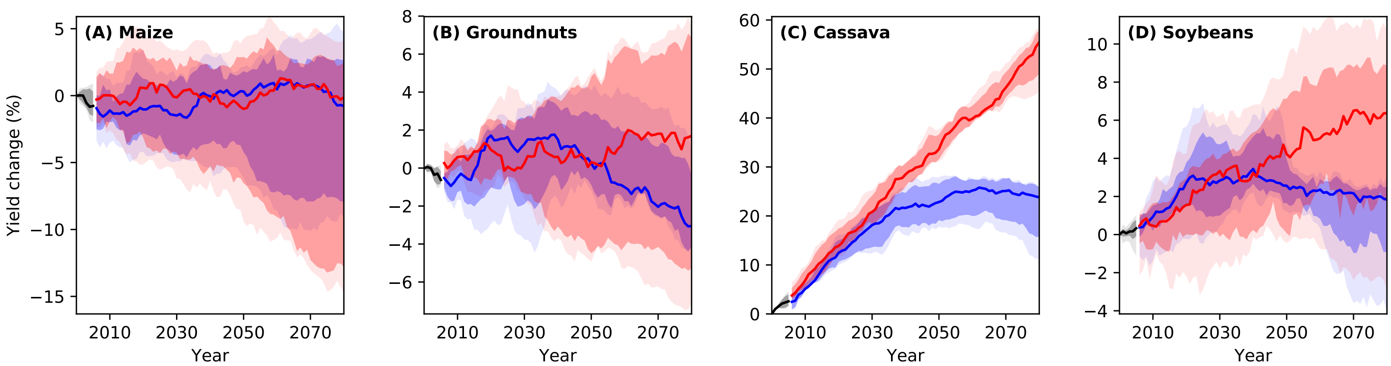

Figure 11: Projections of crop yield changes for major staple crops[6] in Zambia for different GHG emissions scenarios assuming constant land use and agricultural management, relative to the year 2000.

[6] Modelling data is available for a selected number of crops only. Hence, the crops listed on page 2 may differ.

c. Infrastructure

Climate change is expected to significantly impact Zambia's infrastructure through extreme weather events. High precipitation amounts lead to the **flooding of roads**, while high temperatures can cause **roads, bridges and coastal infrastructures to develop cracks and degrade more quickly**. This will require the establishment of climate proofed infrastructure, as otherwise earlier replacement and higher maintenance and replacement costs are necessary. Despite efforts to expand the country's railway network, especially for its mineral-based economy and **transports from the so-called Copperbelt** in the north, Zambia continues to be reliant on road transportation [25]. While paved roads are in fairly good condition, connecting Lusaka with the main trading hubs in the region, overall **road coverage is characterised by an asymmetry** between centre and margins. Especially during the rainy season, many of the inland **rural roads are inaccessible**, cutting off villages and communities [26]. Investments will have to be made to build climate-resilient road networks.

Extreme weather events also have **devastating effects on human settlements and economic production sites**, especially in urban areas with high population densities like Lusaka, Kitwe and Ndola. **Informal settlements are particularly vulnerable to extreme weather events**: Makeshift homes are often built at unstable geographical locations including steep slopes or river banks, where strong winds and flooding can lead to loss of housing, contamination of water, injury or death. Dwellers usually have a low adaptive capacity to respond to such events due to high levels of poverty and lack of risk-reducing infrastructures. Although floods are a yearly occurrence in the country, **January 2022** brought **heavy precipitation** in the districts of Namwala, Kaloma and Choma in the Southern Province, causing severe **flooding** [27]. More than **22 000 people were affected**, with hundreds homeless and damages to infrastructures and property, including cultivated land and livestock, such as cattle, goat and chicken, which were carried away by the floods [27]. Flooding and droughts will also affect hydropower generation: Zambia draws 85 % of its energy from hydropower with a total installed hydropower capacity of 2 393 MW in 2021 [28]. However, variability in precipitation and **climatic conditions could severely disrupt hydropower generation**.

Despite the risk of infrastructure damage being likely to increase due to climate change, precise predictions of the location and the extent of exposure 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 also Figure 4). In the case of Zambia, median projections show little impact of climate hazards towards major roads and urban land area to river floods. (Figure 13 and Figure 14). Around the year 2000, 1.23 % of major roads were

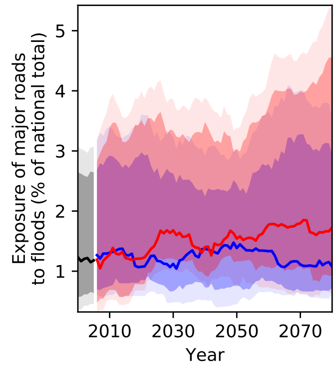

Figure 12: Projections of major roads exposed to river floods at least once a year for Zambia for different GHG emissions scenarios.

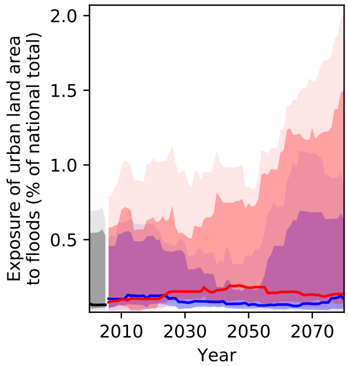

Figure 13: Projections of urban land area exposed to river floods at least once a year for Zambia for different GHG emissions scenarios.

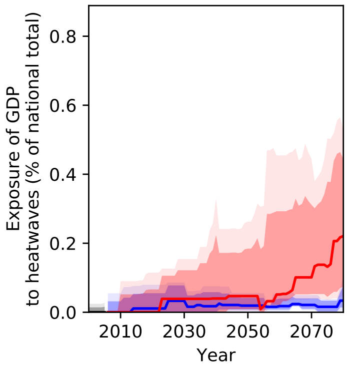

Figure 14: Exposure of GDP in Zambia to heatwaves for different GHG emissions scenarios.

exposed to river floods at least once a year. By 2080, this value is projected to increase to 1.73 % under RCP6.0 and to decrease to 1.07 % under RCP2.6 (Figure 13). The exposure of urban land area to river floods is projected to change from 0.07 % in the year 2000 to 0.10 % and 0.14 % under RCP 2.6 and RCP6.0, respectively (Figure 14). While these changes may appear marginal, it should be noted that projections for exposure to river floods are **subject to high modelling uncertainty**, with some models projecting much higher increases than others.

The **exposure of the GDP to heatwaves is projected to increase** only marginally from 0.0 % in 2000 to 0.03 % (RCP2.6) and 0.22 % (RCP6.0) by 2080 (Figure 15)[7]. Nevertheless, in light of rising temperatures, it is recommended that policy planners start identifying heat-sensitive economic production sites and activities, and integrating climate adaptation strategies such as improved solar-powered cooling systems, "cool roof" isolation materials or switching the operating hours from day to night [29].

[7] The exposure of the GDP to heatwaves in Zambia is small, as there are hardly any heatwaves identified (see definition of a heatwave in Supplemental Information document).

d. Ecosystems

Climate change is expected to have a significant impact on the ecology and distribution of tropical ecosystems, though the magnitude, rate and direction of these changes are uncertain [30]. With rising temperatures and increased frequency and intensity of droughts, **wetlands and riverine systems are increasingly at risk of being disrupted and altered,** with structural changes in plant and animal populations. Increased temperatures and droughts can also impact succession in forest systems while concurrently increasing the risk of invasive species, all of which affect ecosystems. In addition to these climatic drivers, low agricultural productivity and population growth might motivate unsustainable agricultural practices, resulting in increased deforestation, land degradation and forest fires, which will impact animal and plant biodiversity [31], [32].

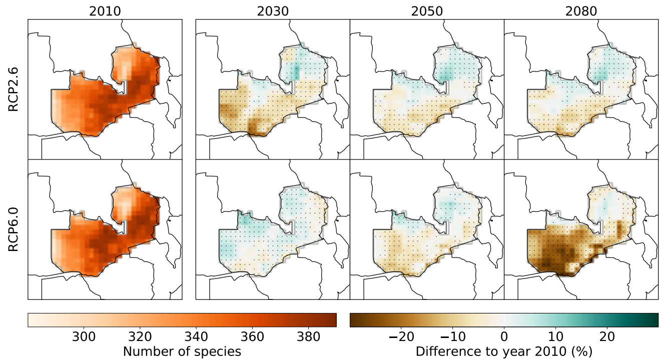

Figure 15: Projections of the aggregate number of amphibian, bird and mammal species for Zambia for different GHG emissions scenarios.

Model projections of species richness (including amphibians, birds and mammals) and tree cover for Zambia are shown in Figure 15 and 16, respectively. Results for species richness show a clear trend, in particular under RCP6.0: **Species richness is projected to decrease** in most parts of Zambia, except for the north-east, with decreases along the border to Zimbabwe of up to 29 % (Figure 15). **Tree cover projections show an opposite trend:** With higher modelling uncertainty than for species richness, models project **increases** in the south-western and eastern part of the country and along the border with the Democratic Republic of the Congo, where increases amount to 13 % (Figure 16). However, it is important to keep in mind that model projections exclude human activites such as charcoal production, which is a major driver of deforestation and forest degradation in Zambia [33].

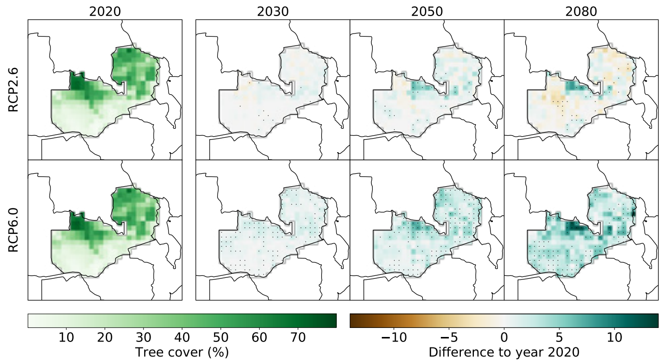

Figure 16: Tree cover projections for Zambia for different GHG emissions scenarios.

Human activities, such as land use, have been responsible for significant losses of global biodiversity in the past and are expected to remain its main driver in the future [34]. In recent years, Zambia's vegetation has experienced profound disturbances, primarily through the expansion of smallholder farming, linked to rural population growth and the demand for land for subsistence agriculture [35]. Increasing demand for fuelwood and timber extraction present further pressures on Zambia's forests, in addition to, albeit to a smaller degree, livestock grazing, mining operations and road expansion [35]. The country has **lost 2.2 million ha of tree cover** between 2001 and 2020, which is equivalent to a **5 % decrease** of national forest area [36]

e. Human health

Climate change threatens the health and sanitation sector through more frequent incidences of heatwaves, floods and droughts. Among the key health challenges in Zambia are morbidity and mortality through HIV, vector-borne diseases such as malaria, waterborne diseases such as diarrhoea, acute respiratory diseases and tuberculosis [37]. Many of these challenges are expected to **become more severe under climate change**. According to the World Health Organization, Zambia recorded an estimated 3.4 million cases of malaria including 8 946 deaths in 2020 [38]. **Climate change is likely to have an impact on the geographic range of vector-borne diseases**: In particular, temperature increases could expand malaria prevalence to higher-lying areas, which were previously malaria-free. As a study in southern Zambia shows, households at higher elevations faced lower risk of malaria infection [39]. Malaria is furthermore likely to increase, **due to flooding and stagnant waters**, which provide a breeding ground for mosquitos [40]. **Climate change also impacts food and water supply**, thereby increasing the risk of food insecurity, malnutrition and death by famine, particularly for subsistence farmers. A study found that both rising temperatures and decreasing precipitation can increase levels of food insecurity in Zambia [42]. Already today, **food insecurity in Zambia is high**: In the period from July to September 2021, more than approximately 1.18 million people faced high acute food insecurity, in addition to many more facing moderate levels of food insecurity [42]. In particular the western part and regions along the border with Zimbabwe were prone to food insecurity, due to a combination of flooding and waterlogging of farms, locust pests and higher food prices [42]. Among other macro-economic factors, **higher food prices are also a result of the COVID-19 pandemic**, which has stifled supply chains and aggravated the situation [42]. Access to **healthcare is distributed unequally** across Zambia, with a sharp divide between urban and rural areas: Compared to urban health centres, many rural health centres are understaffed [43] and often lack essential drugs, due to inefficient distribution systems, lack of demand data and transportation bottlenecks [44].

In contrast to from more tropical and thus more humid countries, heatwaves are a rare phenomenon in Zambia. They will likely not occur more frequently in the future, since they are defined as a combination of temperature and humidity (see more detailed definition in Supplemental Information document). Accordingly, the **exposure of the population to heatwaves will increase only marginally** from 0.0 % in 2000 to 0.22 % in 2080 under RCP6.0 (Figure 17). However, rising temperatures will result in **increased heat-related mortality.** Under RCP6.0, **heat-related mortality will likely increase from 5.2 to 18.1 deaths per 100 000 people per year by 2080**, provided that no adaptation to hotter conditions takes place. This translates to an increase by a factor of more than three towards the end of the century, compared to year 2000 levels (Figure 18). Under RCP2.6, heat-related mortality is projected to increase to 10.0 deaths per 100 000 people per year in 2080.

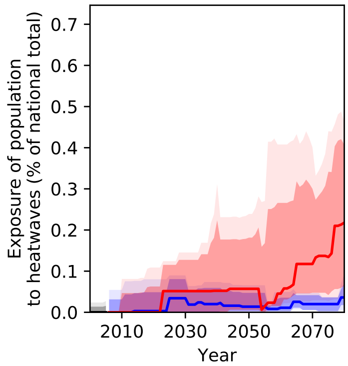

Figure 17: Projections of population exposure to heatwaves at least once a year for Zambia for different GHG emissions scenarios.

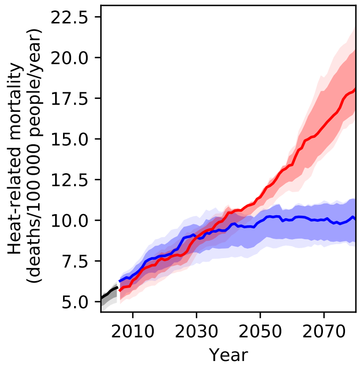

Figure 18: Projections of heat-related mortality for Zambia for different GHG emissions scenarios assuming no adaptation to increased heat.

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