













Climate Risk Profile: Ethiopia

Summary

	<p>This profile provides an overview of projected climate parameters and related impacts on different sectors in Ethiopia until 2080 under different climate change scenarios (called Representative Concentration Pathways, RCPs). RCP2.6 represents the low emissions scenario in line with the Paris Agreement; RCP6.0 represents a medium to high emissions scenario. Model projections do not account for effects of future socioeconomic impacts.</p>	 <p>Agro-ecological zones might shift, affecting ecosystems, biodiversity and crop production. Models project regionally varying changes in species richness and tree cover in response to climate change.</p>	
	<p>Agriculture, biodiversity, 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 in Ethiopia.</p>	 <p>Per capita water availability will decline by 2080 mostly due to population growth. Model projections indicate that water saving measures will become particularly important after 2050 in southern Ethiopia.</p>	
	<p>Depending on the scenario, temperature in Ethiopia is projected to rise by between 1.6 and 3.7 °C by 2080, compared to pre-industrial levels, with higher temperatures and more temperature extremes projected for the east of Ethiopia.</p>	 <p>The population affected by at least one heatwave per year is projected to rise from 0.3 % in 2000 to 2.1 % in 2080. This is related to 50 more very hot days per year over this period. As a consequence, heat-related mortality is estimated to increase by a factor of three by 2080.</p>	
			
			<p>Precipitation trends are highly uncertain and project either little change to an annual precipitation increase of up to 90 mm by 2080. Future dry and wet periods are likely to become more extreme.</p>
			<p>Climate change is likely to cause severe damage to the infrastructure sector in Ethiopia including to roads and bridges. As roads are the backbone of Ethiopia's transportation network, investments will need to be made into building climate-resilient roads and other infrastructure.</p>
			<p>Models project an increase in crop land exposure to drought. Yields of heat- and drought-sensitive crops such as maize and millet are projected to decline while yields of less sensitive crops such as field peas are projected to benefit from CO₂ fertilisation. Farmers will need to adapt to these changing conditions.</p>

Context

Ethiopia is a landlocked country located in the Horn of Africa. Currently home to a **population of 105 million**, Ethiopia is one of the fastest growing countries worldwide with a **projected population of 225 million by 2060** [1]. With a real GDP per capita of 570 USD, Ethiopia is also one of the poorest countries in the world, still **counting as a low-income and least developed country (LDC)**. However, it aims to reach lower-middle-income status by 2025 [2]. Ethiopia's economy is dominated by the services sector, contributing 43.6 % to the country's GDP in 2017, followed by the agricultural sector with 34.8 % and industry with 21.6 % [3]. **Although services have surpassed the agricultural sector, 72.7 % of Ethiopia's population is employed in the latter** and heavily relies on agriculture for their food security and livelihoods [3]. Therefore, concerns are rising about the effects of climate change including the increase of temperature, the availability of water and the occurrence of floods and other extreme weather events.

Agricultural production in Ethiopia is primarily subsistence-based and rainfed. Hence, especially smallholder farmers suffer from the impacts of climate variability, which can reduce their food supply and increase the risk of hunger and poverty. **Limited adaptive capacity in the agricultural sector underlines the country's vulnerability to climate change.** Currently, only about 5 % of the national crop land suitable for irrigation is irrigated [4]. However, adaptation strategies such as irrigation, agroforestry or agricultural insurance can help smallholder farmers to compensate for the negative impacts of climate change by improving agricultural production or protecting them from yield losses. **Staple crop production in Ethiopia is dominated by cereals such as teff, wheat, maize, sorghum and barley** [5]. Coffee is Ethiopia's major cash crop, accounting for around 4 % of GDP and 26 % of total export value [6]. Other cash crops include oil seeds, pulses and khat [7].

Quality of life indicators [8]–[13]

Human Development Index (HDI) 2017	ND-GAIN Vulnerability Index 2017	GINI Coefficient 2015	Real GDP per capita 2018	Poverty headcount ratio 2015	Prevalence of under-nourishment 2016–2018
0.463 173 out of 189 (0 = low, 1 = high)	35.0 163 out of 181 (0 = low, 100 = high)	35.0 (0–100; 100 = perfect inequality)	570 USD (constant 2010 USD)	30.8 % (at 1.9 USD per day, 2011 PPP) ¹	20.6 % (of total population)



© Uwe Bodrecht/flickr

¹ Poverty headcount ratio for the year 2015 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

Ethiopia is largely **located on a volcanic plateau**, which is intersected by the Rift Valley. Although **more than half of the country is above 1500 meters**, Ethiopia has also low-lying areas characterised by tropical savannah and desert with annual mean temperatures of up to 30.8 °C [14], [15]. Areas of higher altitude experience weather typical of moderate climate zones with annual mean temperatures of only 11.9 °C [14], [15]. In a similar way, precipitation patterns depend largely on elevation: **Higher altitudes receive the largest amounts of precipitation per year**, which makes them particularly suitable for agricultural production, **while lower areas receive only minimal amounts**. In the lowlands, people generally support themselves by raising livestock instead of farming [16]. Ethiopia receives most of its precipitation between March and September, starting in the southern and central parts and then slowly heading north [16].

Compared to most African countries, **Ethiopia has ample surface and groundwater resources** with many rivers originating in the mountains, including the Blue Nile. Ethiopia can be divided into **five major agro-ecological zones (AEZ)**: Moisture Sufficient Highlands (cereals based), Moisture Sufficient Highlands (enset based)², Drought-Prone Highlands, and Pastoralist-Arid Lowland Plains [15].³ Each of these zones is characterised by specific temperature and moisture regimes and, consequently, specific crops grown within its boundaries [17]. Ethiopia is facing major environmental issues including land degradation, soil erosion and desertification. Extreme weather events including intense rainfall and severe droughts are expected to worsen in the context of climate change, highlighting the **need for adaptation measures to protect biodiversity and maintain fragile ecosystems and their services** [18].

Present climate [15]

Ethiopia has a diverse climate largely influenced by elevation: Highland areas like Amhara exhibit mean annual temperatures of 11.9 °C, while lowland areas in north-eastern Ethiopia exhibit mean annual temperatures of up to 30.8 °C.

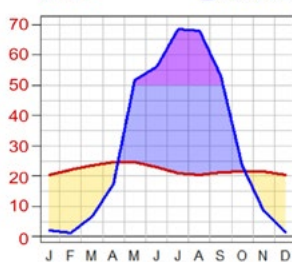
Annual precipitation sums range from 100 mm in north-eastern Ethiopia, which is characterised by steppe and desert, to over 1900 mm in the highlands of central and western Ethiopia, which have a moderate climate and are thus most suitable for agricultural production.

The country has a single rainy season (unimodal precipitation regime) in the centre, north and west, and two rainy seasons (bimodal precipitation regime) in the south and east.

Unimodal precipitation regimes

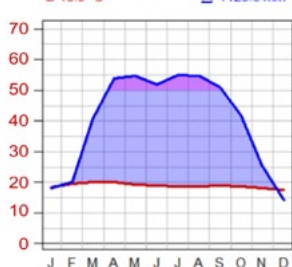
Tropic - cool / semi-arid

Ø 22 °C 1478 m Σ 1094.3 mm



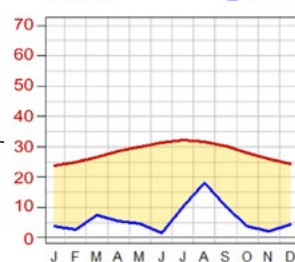
Tropic - cool / humid

Ø 18.9 °C 1879 m Σ 1129.6 mm



Tropic warm / arid

Ø 28.1 °C 13 m Σ 149 mm



Bimodal precipitation regime

Tropic warm / arid

Ø 26.4 °C 566 m Σ 393.7 mm

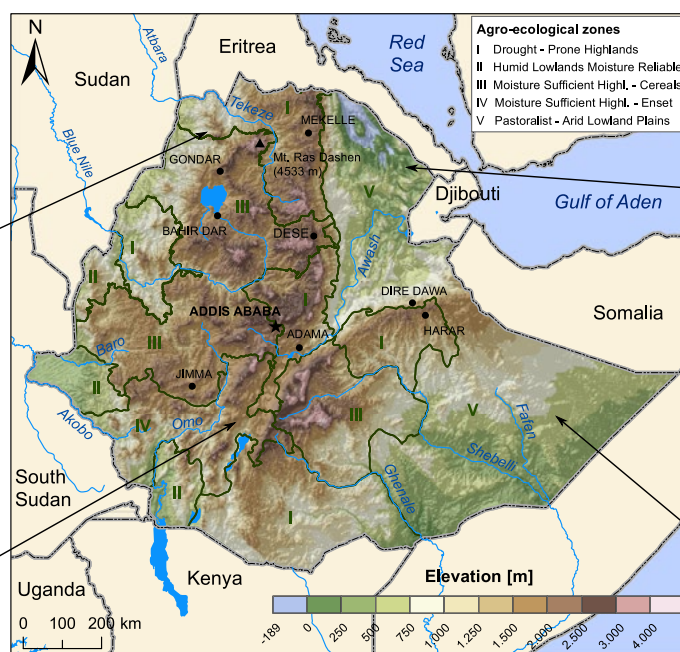
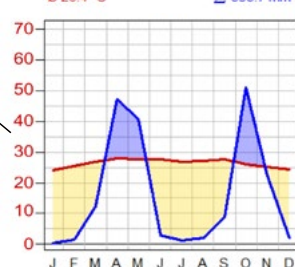


Figure 1: Topographical map of Ethiopia with agro-ecological zones and existing precipitation regimes.⁴

² Enset (*Ensete ventricosum*) is a traditional crop, which resembles the banana plant and is mainly produced in remote highland areas and popular due to its large quantity of carbohydrates.

³ It should be noted that there are different classifications of AEZs in Ethiopia. We focused on a commonly used classification of five AEZs.

⁴ The climate graphs display temperature and precipitation values which are averaged over an area of approximately 50 × 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 (blue) and RCP6.0 (red). In particular, 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.

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 Ethiopia is projected to rise by 1.6 to 3.7 °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 Ethiopia amount to approximately 1.5 °C in 2030 and 1.8 °C in 2050 as well as 2080 under the low emissions scenario RCP2.6. Under the medium/high emissions scenario RCP6.0, median climate model temperature increases amount to 1.5 °C in 2030, 1.8 °C in 2050 and 2.4 °C in 2080.

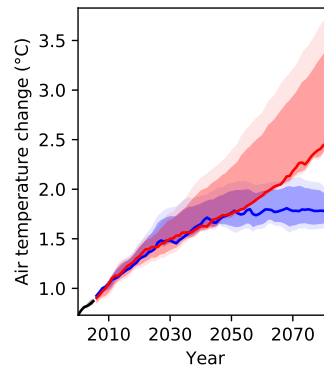


Figure 2: Air temperature projections for Ethiopia for different GHG emissions scenarios.⁵

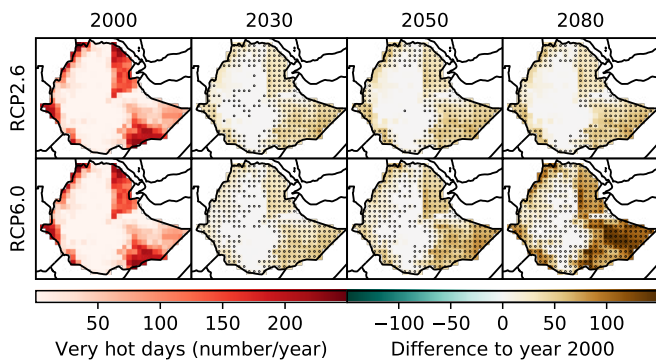


Figure 3: Projections of the annual number of very hot days (daily maximum temperature above 35 °C) for Ethiopia for different GHG emissions scenarios.

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 eastern Ethiopia (Figure 3). Under the medium/high emissions scenario RCP6.0, the multi-model median, averaged over the whole country, projects 18 more very hot days per year in 2030 than in 2000, 26 more in 2050 and 50 more in 2080. In some parts, especially in eastern Ethiopia, this amounts to about 200 days per year by 2080.

⁵ 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). Out of the three climate models underlying this analysis, one model projects almost no change in mean annual precipitation over Ethiopia, while the other two models project an increase. Median model projections for RCP2.6 show **almost no change in total precipitation per year until 2080**, while median model projections for RCP6.0 show a **precipitation increase of 85 mm per year by 2080** compared to year 2000.

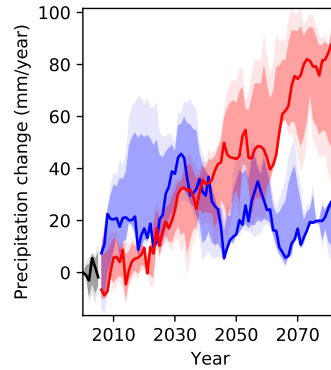


Figure 4: Annual mean precipitation projections for Ethiopia for different GHG emissions scenarios, relative to the year 2000.

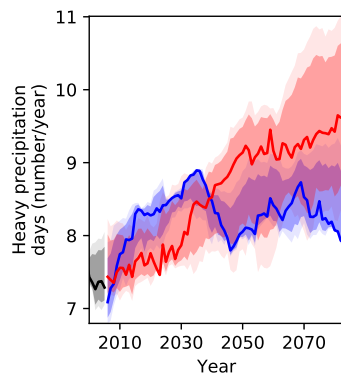


Figure 5: Projections of the number of days with heavy precipitation over Ethiopia for different GHG emissions scenarios.

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 found in climate projections for Ethiopia (Figure 5), with climate models projecting a **slight increase in the number of days with heavy precipitation events**, from 7 days per year in 2000 to 8 days per year in 2080 under RCP2.6 and 9 days per year under RCP6.0 by 2080.



© Mariusz Kluzniak/flickr

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.

Annual mean top 1-m soil moisture projections for Ethiopia show almost no change to a slight decrease for RCP2.6, while under RCP6.0, soil moisture is projected to slightly increase approaching a 1% change by 2080 compared to the year 2000 (Figure 6). However, looking at the different models underlying this analysis, there is large year-to-year variability and modelling uncertainty, which makes it difficult to identify a clear trend.

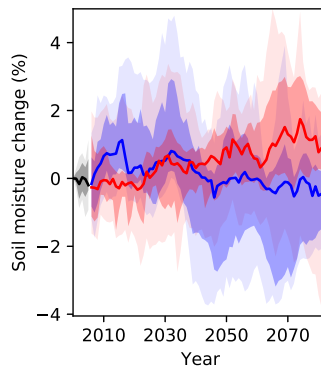


Figure 6: Soil moisture projections for Ethiopia for different GHG emissions scenarios, relative to the year 2000.

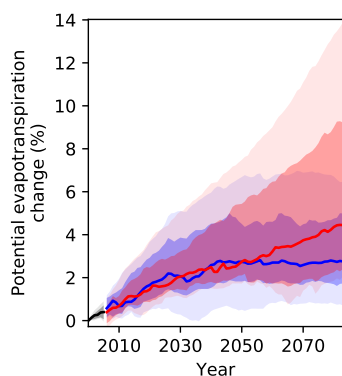


Figure 7: Potential evapotranspiration projections for Ethiopia for different GHG emissions scenarios, relative to the year 2000.

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, hydrology projections for Ethiopia indicate a stronger and more continuous rise of potential evapotranspiration under RCP6.0 than under RCP2.6 (Figure 7). Under RCP6.0, **potential evapotranspiration is projected to increase by 2.0% in 2030, 2.7% in 2050 and 4.4% in 2080** compared to year 2000 levels.



© Brice Synergos / flickr

Sector-specific climate change risk assessment

a. Water resources

Current projections of water availability in Ethiopia display high uncertainty under both GHG emissions scenarios. Assuming a constant population level, multi-model median projections suggest no change in per capita water availability over Ethiopia by the end of the century under RCP2.6 and only a slight increase under RCP6.0 (Figure 8A). Yet, when accounting for population growth according to SSP2 projections⁶, **per capita water availability for Ethiopia is projected to decline by 65 % by 2080** relative to the year 2000 under both scenarios (Figure 8B). While this decline is primarily driven by population growth rather than climate change, it highlights the urgency to invest in water saving measures and technologies for future water consumption.

Projections of future water availability from precipitation vary depending on the region and scenario (Figure 9). Under RCP2.6, water availability will decrease by up to 30 % in southern Ethiopia and increase by up to 35 % in eastern Ethiopia by 2080. All models agree on this trend, making **water saving measures in these regions particularly important after 2050**. However, the picture is different for RCP6.0, where projections for the south and east of Ethiopia are less certain and the projected difference in water availability is smaller, which is why a clear trend cannot be identified.

Ethiopia is known as the “**water tower of Africa**”, having **twelve river basins, 22 major lakes and a groundwater potential of about 2.6 billion m³** [19]. However, rapid population growth and future variability of water resources can affect the economy through a growing energy and water demand in different sectors including agriculture, infrastructure, ecosystems and health. Precipitation strongly depends on elevation: It currently ranges from 1900 mm per year in the highlands to around 100 mm per year in low-lying areas [15]. Agricultural production follows these precipitation patterns. However, **areas with high agricultural production also coincide with high population density and pressure on land**, especially in the *weyna dega* (warm to cool climate) and *dega* (cool climate) zones that are best suited for the production of major staple crops in Ethiopia [20].

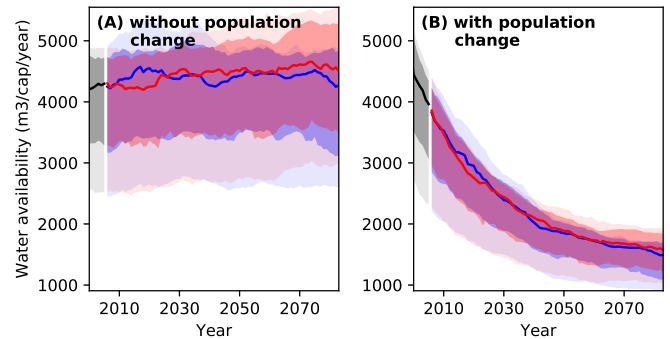


Figure 8: Projections of water availability from precipitation per capita and year with (A) national population held constant at year 2000 level and (B) changing population in line with SSP2 projections for different GHG emissions scenarios, relative to the year 2000.

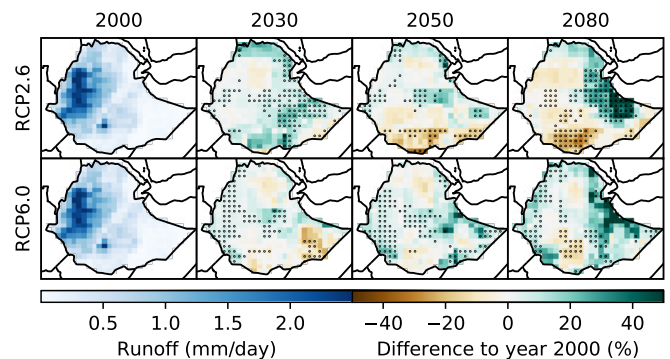


Figure 9: Water availability from precipitation (runoff) projections for Ethiopia for different GHG emissions scenarios.

⁶ Shared Socio-economic Pathways (SSPs) outline a narrative of potential global futures, including estimates 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

Agriculture is amongst the sectors most exposed to climate change. Smallholder farmers in Ethiopia are increasingly challenged by the uncertainty and variability of weather that climate change causes. Since crops are predominantly rainfed (only 5 % of the national crop area is irrigated), crop yields depend on water availability and are prone to drought [4]. **Climate change will have a negative impact on maize, which is the most important staple crop** in terms of caloric intake, number of farmers growing it and production volume in Ethiopia [21]. **Millet will also suffer from climate change impacts** (Figure 11). However, actual yields for both crops will depend on the site and year as well as aggregate, regional and local drivers of crop production. Non-biophysical factors such as access to markets will also influence production levels. Six zones are projected to experience yield losses under climate change, which are Western Tigray, South Omo, North Shewa (Amhara), Metekel, Illubabor and Gamo [22]. It should be noted that teff is another major staple crop in Ethiopia; however, due to lack of modelling data, we were unable to include it as part of our analysis.

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 for this analysis, **the national crop land area exposed to at least one drought per year will hardly change in response to global warming. However, there are models that project an increase in drought exposure.** Under RCP6.0, the likely range of drought exposure of the national crop land area per year widens from 0.04–1.4 % in 2000 to 0.04–3.9 % in 2080. The very likely range widens from 0.01–2.3 % in 2000 to 0.01–7.1 % in 2080. This means that **some models project a tripling of drought exposure over this time period, while others project no change.**

In terms of yield projections, model results indicate a **negative yield trend for maize and millet** under RCP6.0. Compared to the year 2000, yields are projected to decline by 3.8 % for maize and 4.9 % for millet by 2080 under RCP6.0. Under RCP2.6, maize

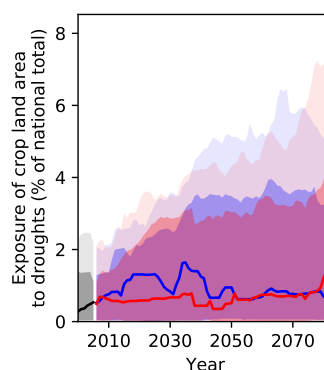


Figure 10: Projections of crop land area exposed to drought at least once a year for Ethiopia for different GHG emissions scenarios.

yields are projected to decrease only slightly and millet yields do not change. **Yields of field peas, on the other hand, are projected to significantly gain from climate change.** Under RCP6.0, yields are projected to increase by 17 % by 2080 relative to the year 2000. A possible explanation for the positive results under RCP6.0 is that field peas are so-called C3 plants, which follow a different metabolic pathway than maize and millet (C4 plants), and benefit more from the CO₂ fertilisation effect under higher concentration pathways. **Wheat is projected to slightly decrease under both RCP2.6 and RCP6.0.** Although there appears to be almost no change in national-level wheat yields, it is likely that crop yields will increase more strongly in some areas and, conversely, decrease more strongly in other areas as a result of climate change impacts.

A complimentary climate risk study for Ethiopia provides in-depth information on climate impacts and selected adaptation strategies in the agricultural sector.

Overall, adaptation strategies such as switching to improved varieties in climate change sensitive crops need to be considered, yet should be carefully weighed against adverse outcomes, such as a resulting decline of agro-biodiversity and loss of local crop types.

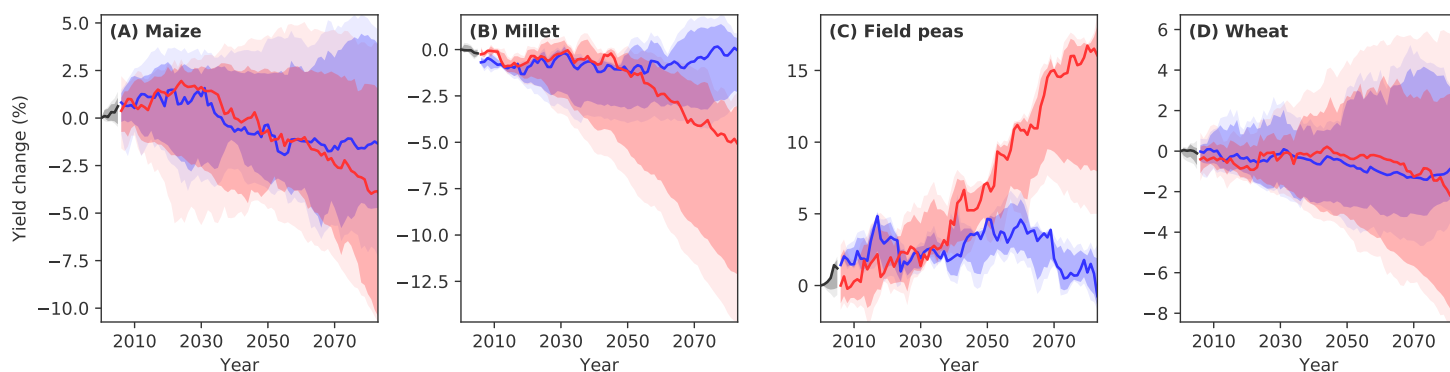


Figure 11: Projections of crop yield changes for major staple crops in Ethiopia for different GHG emissions scenarios assuming constant land use and agricultural management, relative to the year 2000.

c. Infrastructure

Climate change is expected to significantly affect Ethiopian infrastructure through extreme weather events, such as floods and droughts. High precipitation amounts can lead to **flooding of transport infrastructure including roads, railroads and airports**, while high temperatures can cause **roads, bridges and protective structures to develop cracks and degrade more quickly**. This will require earlier replacement and lead to **higher maintenance and replacement costs** [23]. Transport infrastructure is vulnerable to extreme weather events, yet essential for agricultural livelihoods. Roads serve communities to trade goods and access healthcare, education, credit and other services. Especially in rural areas, **roads are the backbone of Ethiopia's transportation network with more than 90 % of exports and imports transported by road** [24]. Investments will have to be made into building climate-resilient road networks [25].

Extreme weather events will also have **devastating effects on human settlements and economic production sites**, especially in urban areas with high population densities like Addis Ababa, Dire Dawa or Mekelle. **Informal settlements are particularly vulnerable to extreme weather events**: Makeshift homes are often built in unstable geographical locations including steep slopes or river banks, where flooding can lead to loss of housing, contamination of water, injury or death. Dwellers usually have low adaptive capacity to respond to such events due to high levels of poverty and lack of risk-reducing infrastructures. For example, heavy rains in May and June 2019 have caused flooding in 38 districts across seven regions of Ethiopia, displacing 42306 families and causing livestock death and property damage [26]. **Flooding and droughts will also affect hydropower generation**: Ethiopia is planning to increase its hydropower capacity from 3.7 gigawatts in 2015 to a volume of 19.5 gigawatts in 2030, however, variability in precipitation and climatic conditions could severely disrupt hydropower generation [27].

Despite **the risk of infrastructure damage being likely to increase due to climate change**, precise predictions on specific location and 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). Among the models applied for this analysis, two models project only a slight increase and one model projects a stronger increase in the exposure of major roads to river floods at least once a year. The very likely range of model results indicates that **road exposure to floods may increase by 70 % by 2080** (from 1.3 % of the national road network exposed in 2000 to 2.1 % in 2080). However, projections are characterised by high modelling uncertainty with median projections for RCP6.0 showing only a 0.2 % change from 2000 to 2080 (Figure 12). Hence, **no reliable estimations on future occurrence of river**

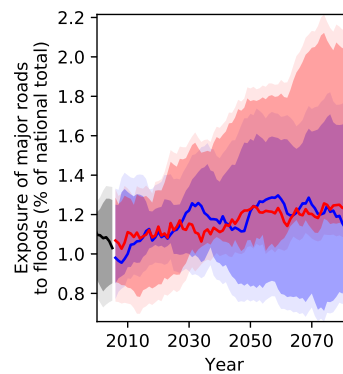


Figure 12: Projections of major roads exposed to river floods at least once a year for Ethiopia for different GHG emissions scenarios.

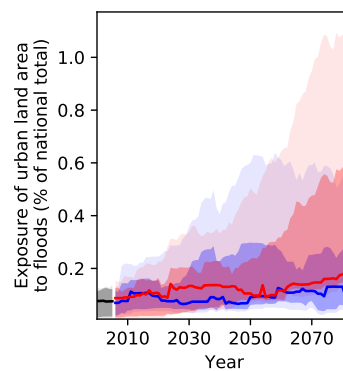


Figure 13: Projections of urban land area exposed to river floods at least once a year for Ethiopia for different GHG emissions scenarios.

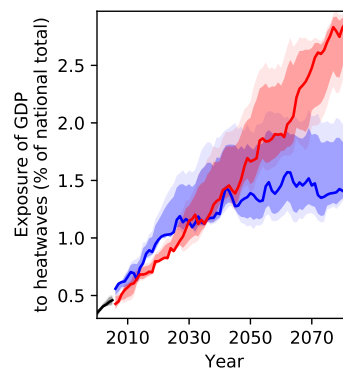


Figure 14: Exposure of GDP in Ethiopia to heatwaves for different GHG emissions scenarios.

floods can be made. Also, urban land area exposed to floods at least once a year is projected to increase (Figure 13), with a very likely range of 0.1–1.1 % by 2080 under RCP6.0.

With the **exposure of the GDP to heatwaves projected to increase** from around 0.3 % in 2000 to 1.4 % (RCP2.6) and 2.8 % (RCP6.0) by the end of the century, it is recommended that economic policy planners start identifying heat-sensitive production sites and activities, and integrating climate adaptation strategies, such as improved solar-powered cooling systems or switching the operating hours from day to night.

d. Ecosystems

Climate change is expected to have a significant influence on the ecology and distribution of tropical ecosystems, even though the magnitude, rate and direction of these changes are uncertain [28]. Under rising temperatures, increased frequency and intensity of droughts and shorter growing periods, **wetlands and riverine systems are increasingly at risk of being converted to other ecosystems** with plant populations being succeeded and animals losing habitats. Increased temperatures and droughts can also influence succession in forest systems while concurrently increasing the risk of invasive species, all of which affect ecosystems. In addition to these climate drivers, reduced agricultural productivity and population growth might motivate further agricultural expansion resulting in increased deforestation, land degradation and forest fires, all of which will impact animal and plant biodiversity.

Model projections of species richness (including amphibians, birds and mammals) and tree cover for Ethiopia are shown in Figure 15 and 16, respectively. The models applied for this analysis show particularly strong agreement on the development of animal species richness under RCP6.0: **Northern Ethiopia is expected to gain up to 40 % in the number of animal species due to climate change, while eastern Ethiopia is expected to lose around 20 %.** With regard to tree cover, model results are less certain. For RCP2.6, no reliable estimates can be made. However, under RCP6.0, tree cover is projected to start changing around 2050 with more significant and certain changes towards the end of the century: **Median model projections agree on an increase in tree cover by more than 10 % in the eastern part of the country** (Figure 16).

Although these results paint an overall positive picture for climate change impacts on ecosystems and biodiversity, 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 [29].

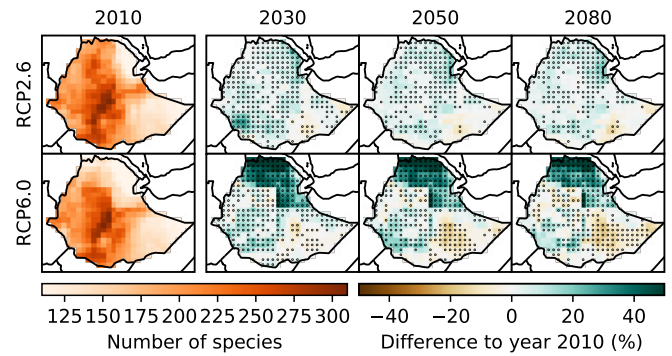


Figure 15: Projections of the aggregate number of amphibian, bird and mammal species for Ethiopia for different GHG emissions scenarios.

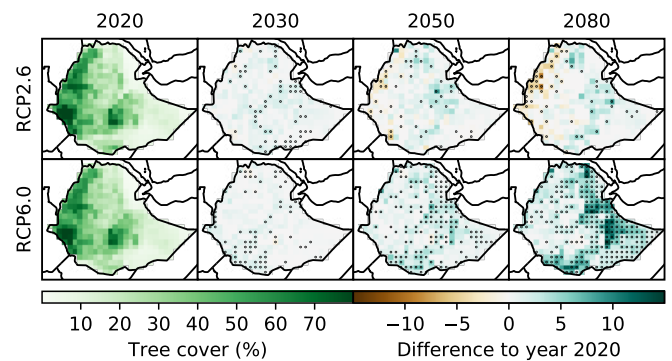


Figure 16: Tree cover projections for Ethiopia for different GHG emissions scenarios.

e. Human health

Climate change threatens the health and sanitation sector

through more frequent incidences of heatwaves, floods, droughts and storms [30]. Among the key health challenges in Ethiopia are morbidity and mortality through temperature extremes, vector-borne diseases, such as malaria, non-vector borne diseases related to extreme weather events (e.g. flooding and droughts) such as diarrhoea and cholera, respiratory diseases, injury and mortality through extreme weather events as well as **climate impacts on food and water supply, which can increase the risk of malnutrition and hunger** [31]. Many of these challenges are expected to become more severe under climate change. The Ethiopian Ministry of Health estimates that already today, around 68 % of the population is at risk of contracting malaria [32]. **Climate change is likely to lengthen transmission periods and alter the geographic range of vector-borne diseases**, for instance, due to rising temperatures. Malaria could expand from lowland areas in Somali and Afar to highland areas in Tigray or Amhara [33].

Rising temperatures will result in **more frequent heatwaves** in Ethiopia, leading to **increased heat-related mortality**. Under RCP6.0, the population affected by at least one heatwave per year is projected to increase from 0.3 % in 2000 to 2.1 % in 2080 (Figure 17). Furthermore, under RCP6.0, **heat-related mortality will likely increase from about 2 to about 6 deaths per 100 000 people per year**, which translates to an increase by a factor of more than three towards the end of the century compared to year 2000 levels, provided that no adaptation to hotter conditions will

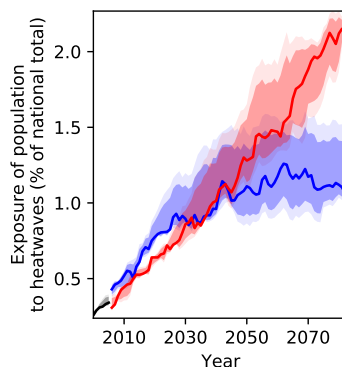


Figure 17: Projections of population exposure to heatwaves at least once a year for Ethiopia for different GHG emissions scenarios.

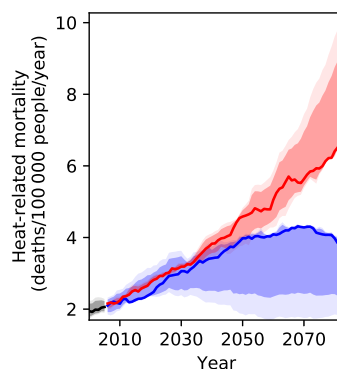


Figure 18: Projections of heat-related mortality for Ethiopia for different GHG emissions scenarios assuming no adaptation to increased heat.

take place (Figure 18). Under RCP2.6, heat-related mortality is projected to increase to about 4 deaths per 100 000 people per year in 2080.



©UNICEF Ethiopia/2012/Getachew

References

- [1] Pardee Center for International Futures, "Country Profile - Ethiopia," 2017. [Online]. Available: http://www.ifs.du.edu/ifs/frm_CountryProfile.aspx?Country=ET. [Accessed: 23-Jul-2019].
- [2] World Bank, "The World Bank in Ethiopia: Overview," 2019. [Online]. Available: <https://www.worldbank.org/en/country/ethiopia/overview>. [Accessed: 23-Jul-2019].
- [3] CIA World Factbook, "Ethiopia," CIA World Factbook, 2019. [Online]. Available: <https://www.worldbank.org/en/country/ethiopia/overview>. [Accessed: 11-Jul-2019].
- [4] P. Woldemariam and Y. Gecho, "Determinants of Small-Scale Irrigation Use: The Case of Boloso Sore District, Wolaita Zone, Southern Ethiopia," *Am. J. Agric. For.*, vol. 5, no. 3, p. 49, 2017.
- [5] A. S. Taffesse, P. Dorosh, and S. A. Gemessa, "Crop Production in Ethiopia: Regional Patterns and Trends," in *Food and Agriculture in Ethiopia: Progress and Policy Challenges*, P. Dorosh and S. Rashid, Eds. Philadelphia: University of Pennsylvania Press, 2012.
- [6] FAO, "Ethiopia: Small Family Farms Country Factsheet," 2018. [Online]. Available: <http://www.fao.org/3/i8911en/I8911EN.pdf>. [Accessed: 08-Oct-2019].
- [7] Export.gov, "Ethiopia - Market Overview," 2019. [Online]. Available: <https://www.export.gov/apex/article?id=Ethiopia-Market-Overview>. [Accessed: 21-Nov-2019].
- [8] UNDP, "Human Development Index (HDI)," 2017. [Online]. Available: <http://hdr.undp.org/en/indicators/137506#>. [Accessed: 08-Oct-2019].
- [9] Notre Dame Global Adaptation Initiative, "ND-GAIN Ranking since 1995 Ethiopia," 2017. [Online]. Available: <https://gain-new.crc.nd.edu/country/ethiopia>. [Accessed: 08-Oct-2019].
- [10] World Bank, "GINI Index," 2015. [Online]. Available: <https://data.worldbank.org/indicator/SI.POV.GINI>. [Accessed: 08-Oct-2019].
- [11] World Bank, "Poverty headcount ratio at 1.90 USD a day (2011 PPP) (% of population)," 2015. [Online]. Available: <https://data.worldbank.org/indicator/SI.POV.DDAY>. [Accessed: 08-Oct-2019].
- [12] FAO, IFAD, UNICEF, WFP, and WHO, *The State of Food Security and Nutrition in the World 2019. Safeguarding against economic slowdowns and downturns*. Rome, 2019.
- [13] World Bank, "GDP per capita (constant 2010 USD)," 2018. [Online]. Available: <https://data.worldbank.org/indicator/NY.GDP.PCAP.KD>. [Accessed: 08-Oct-2019].
- [14] USAID Ethiopia, "Ethiopia - Country Information," 2019. [Online]. Available: http://www.uhep.jsi.com/About/country_info.htm. [Accessed: 24-Jul-2019].
- [15] L. Murken et al., "Climate Risk Analysis for Identifying and Weighing Adaptation Strategies in Ethiopia's Agricultural Sector," Potsdam, 2019.
- [16] C. Funk et al., "A Climate Trend Analysis of Ethiopia," Bonn, 2012.
- [17] Central Statistical Agency of Ethiopia, *Atlas of the Ethiopian Rural Economy*. 2006.
- [18] World Bank, "Climate Change Knowledge Portal: Ethiopia," 2019. [Online]. Available: <https://climateknowledgeportal.worldbank.org/country/ethiopia>. [Accessed: 24-Jul-2019].
- [19] D. Mulugeta, D. Weijun, and J. H. Zhao, "Hydropower for sustainable water and energy development in Ethiopia," *Sustain. Water Resour. Manag.*, vol. 1, no. 4, pp. 305–314, 2015.
- [20] J. Chamberlin and E. Schmidt, "2 Ethiopian Agriculture: A Dynamic Geographic Perspective," in *Food and Agriculture in Ethiopia*, 2014.
- [21] T. Abate et al., "Factors that transformed maize productivity in Ethiopia," *Food Secur.*, 2015.
- [22] L. Murken et al., "Climate Risk Analysis for Identifying and Weighing Adaptation Strategies in Ghana," 2019.
- [23] Ministry of Transport of Ethiopia, "Ethiopia's Climate Resilient Transport Sector Strategy," Addis Ababa.
- [24] EPCC, "First Assessment Report - Summary of Reports for Policy Makers," Addis Ababa, 2015.
- [25] T. Gebre and F. Nigussa, "Greenhouse Gas Emission Reduction Measures in the Urban Road Transport Sector of Ethiopia," *Environ. Prog. Sustain. Energy*, vol. 38, no. 5, pp. 1–8, 2019.
- [26] OCHA, "Ethiopia: Situation Report No. 23," 2019.
- [27] D. Conway, P. Curran, and K. E. Gannon, "Policy brief: Climate risks to hydropower supply in eastern and southern Africa," no. August, 2018.
- [28] T. M. Shanahan et al., "CO₂ and fire influence tropical ecosystem stability in response to climate change," *Nat. Publ. Gr.*, no. July, pp. 1–8, 2016.
- [29] IPBES, "Report of the Plenary of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services on the work of its seventh session," 2019.
- [30] B. Simane, H. Beyene, W. Deressa, A. Kumie, K. Berhane, and J. Samet, "Review of Climate Change and Health in Ethiopia: Status and Gap Analysis," *Ethiop. J. Heal. Dev.*, vol. 30, no. 1, pp. 28–41, 2016.
- [31] Environmental Protection Authority of Ethiopia, "CRGE Vision: Ethiopia's Vision for a Climate Resilient Green Economy."
- [32] Ministry of Health of Ethiopia, "Malaria Prevention & Control Program," 2013. [Online]. Available: <http://www.moh.gov.et/ejcc/en/malaria-prevention-control-program>. [Accessed: 07-Oct-2019].
- [33] Ministry of Water of Ethiopia, "Climate Change National Adaptation Programme of Action (NAPA) of Ethiopia," Addis Ababa, 2007.

This climate risk profile was commissioned and is conducted on behalf of the German Federal Ministry for Economic Cooperation and Development (BMZ) in close cooperation with the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) as the implementing partner.

The risk profile is based on data and analysis generated as part of the Inter-Sectoral Impact Model Intercomparison Project (ISIMIP), which is gratefully acknowledged. Background information about the figures and analysis presented in this profile is available in the Climate Risk Profile - Supplemental Information.

On behalf of:
Federal Ministry for Economic Cooperation and Development (BMZ)
BMZ Bonn
Dahlmannstraße 4
53113 Bonn, Germany
www.bmz.de

Scientific content developed by:
Potsdam Institute for Climate Impact Research (PIK)
Telegraphenberg A 31
14473 Potsdam, Germany
<http://www.pik-potsdam.de>

Scientific coordination:
Christoph Gornott (PIK)

Main authors:
Stefan Lange (PIK),
Felicitas Röhrig (PIK),
Julia Tomalka (PIK)

Contributors:
Paula Aschenbrenner (PIK),
Abel Chemura (PIK),
Christoph Gornott (PIK),
Ylva Hauf (PIK)
Lisa Murken (PIK),
Enrico Grams (GIZ),
Lena Klockemann (GIZ),
Elisa Romanato (GIZ),
Josef Haider (KfW)

Published and implemented by:
Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

In cooperation with:
KfW Development Bank