MALAWI, 2035: Drier Wet Years & Changing Rainfall Will Make Livelihoods Even More Precarious

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BLUF

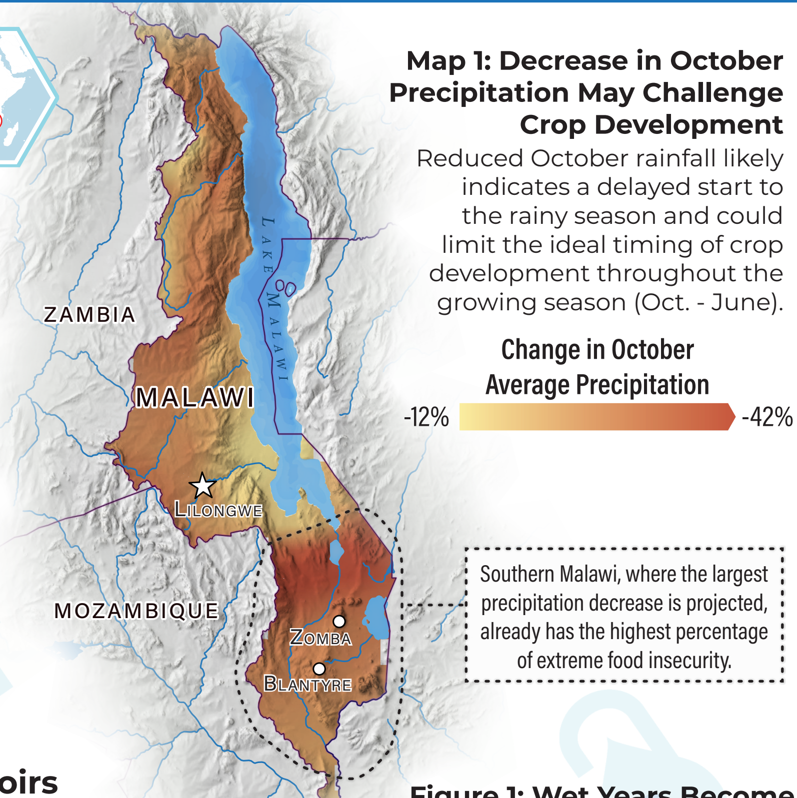
Malawi's limited resilience to water shocks means even small shifts impact food and energy production. Malawi will likely continue to need humanitarian aid.

FOOD SECURITY: Increased dryness makes subsistence agriculture even more difficult

Low yield, including crop failure, increases malnutrition. Rainfed backyard and smallholder farms feed 80% of Malawi's population, with maize the dominant staple crop. A projected increase in seven-day dry spells during the rainy season and delayed onset of the rainy season in October may impact crop growth **(Map 1)**.

Rural households are, on average, 20 km from a paved road. **Limited transportation infrastructure makes accessing alternative food sources difficult** in rural areas.

Waterborne and sanitation-related disease may counteract adequate nutrition by compromising the ability to absorb nutrients. These illnesses account for 53% of outpatients in hospitals.



Map 1: Decrease in October Precipitation May Challenge Crop Development

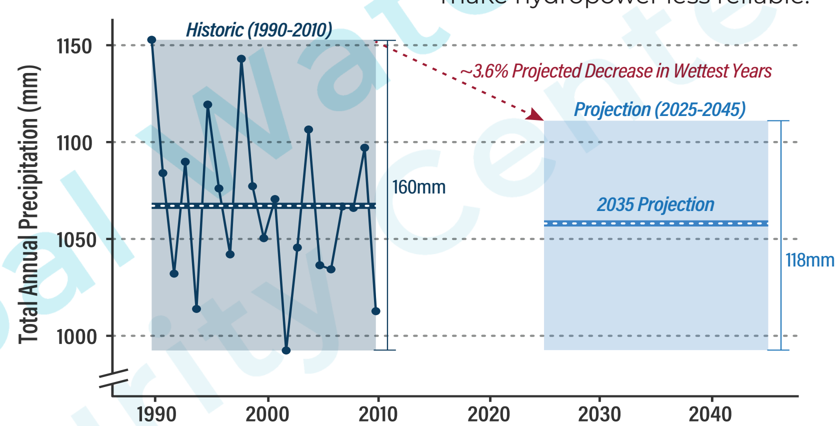
Reduced October rainfall likely indicates a delayed start to the rainy season and could limit the ideal timing of crop development throughout the growing season (Oct. - June).

ENERGY: Drier wet years reduce periods that refill hydropower reservoirs

Hydropower provides 95% of electricity. **Variation in annual rain complicates planning and supply.** Years with excess rain that were used to refill reservoirs may decrease **(Figure 1)**. Only 15% of the population is connected to the power grid, and lack of electricity limits industrial growth.

Figure 1: Wet Years Become Drier, Increasing Fragility

Projections for 2025-2045 indicate that high precipitation years may be drier than the wettest years from 1990-2010. Lower amounts of rain could strain food production and make hydropower less reliable.



Background

Malawi's economy depends heavily on agriculture (>25% GDP), which is very sensitive to precipitation and temperature variation. Crop failure has occurred more than 4 times a decade in some areas. Seventy percent of the population lives in poverty, and 51% do not meet daily calorie needs.

From 2000 conditions, average annual temperature is expected to increase by ~1°C, and the wettest years are projected to be ~3.6% (~40mm) drier in 2035 ***(middle of the road scenario, SSP245 – Figure 1)****. Models show uncertainty for the magnitude of change for Malawi due to interannual variability and the Intertropical Convergence Zone's unpredictability.*

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Background

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Map 1 - October Precipitation Decrease

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Data Analysis Methods:

DATASETS: Historical Weather Data from ERA5 [1990-2023] - daily values for precipitation and average temperature . Future Weather Data from CMIP6 downscaled by NASA Earth Exchange Global Daily Downscaled Projection (NEX-GDDP-CMIP6). Scenario: SSP245 and/or SSP585. 17 models: ACCESS-ESM1-5, BCC-CSM2-MR, CanESM5,CMCC-ESM2, FGOALS-g3, GISS-E2-1-G, MIROC-ES2L, MPI-ESM1-2-HR, MRI-ESM2-0, NESM3, NorESM2-MM, CNRM-ESM2-1, EC-Earth3-Veg-LR, GFDL-ESM4, INM-CM5-0, IPSL-CM6A-LR, KIOST-ESM

CALCULATIONS: Baseline (sometimes called "normal") and representative future values for each year of interest are calculated using 21-year time intervals around the date of interest. Our historic normal is based on the year 2000 (1990-2010) using ERA5 data. To bias correct future values, we calculate the difference or ratio between NEX-GDDP-CMIP6 modeled future [2035 (2025-2045) and/or 2050 (2040-2060)] and modeled historic [2000 (1990-2010)] values and add this difference to the historic baseline value or multiply the ratio by the historic baseline value for each metric of interest. All calculations are spatially distributed (quarter-degree grid cells) and aggregated as the final step.

Important note: Values reported are median values based on the 17 model outputs. Error bars are the 95% confidence interval around the median.

Precipitation
- Mean Annual Precipitation: The sum of the total daily precipitation for each year, averaged over the time period of interest.
- Normal Monthly Precipitation: The sum of the total daily precipitation within each month for each year, averaged over the time period of interest.
- Total Monthly Precipitation: The sum of the total daily precipitation within each month for each year.
- Consecutive Dry Days: The number of 7-day periods in a row that received less than 1 mm of rain for each year, averaged over the time period. To calculate the average frequency, we normalized run lengths of 7 or more days to multiples of 7-day streaks. Each run length was then divided by 7 to determine how many full 7-day streaks were in that particular run length, and the result was floored to the nearest whole number. The multiple of 7 was then multiplied by its frequency of occurrence within the given year. To calculate the frequency within a country, we took the maximum frequency within the country for a given year, then averaged over the timespan (including years with a frequency of 0) to obtain the average frequency over the time period of interest.
- Interannual Precipitation Variability: The coefficient of variation (ratio of standard deviation to the mean) of annual total precipitation within a time period of interest.

Temperature
- Mean Annual Temperature: The mean of the daily average temperature for each year, averaged over the time period of interest.

STATISTICAL ANALYSIS
Historic trends (1990-2023) through time were examined for mean annual temperature and total annual precipitation. For each of these metrics, we used values averaged a number of ways, over the entire country, and over the southern and western regions. Linear models were applied to these metrics over time with a significance threshold of $p<0.05$.

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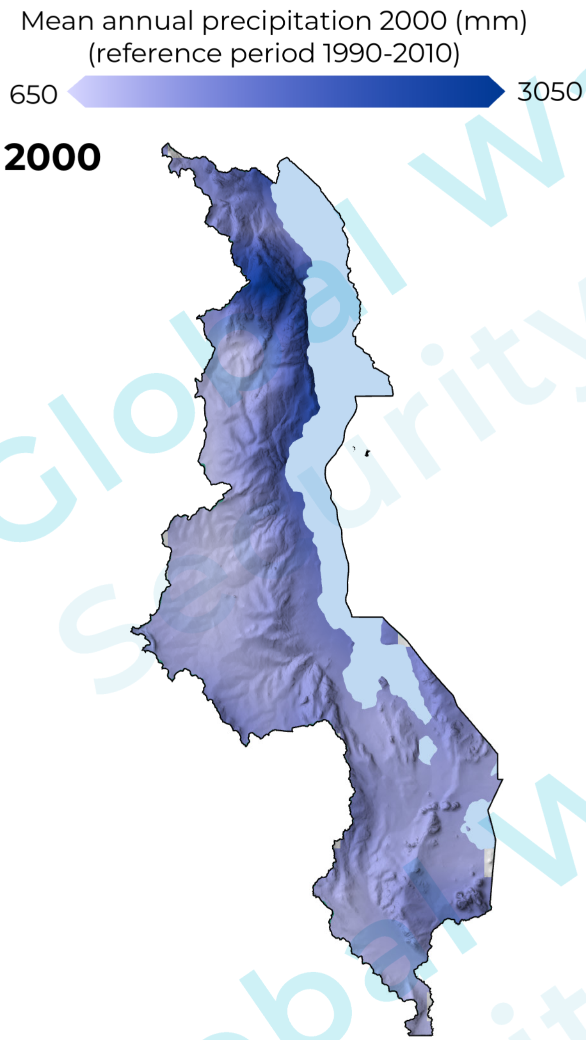
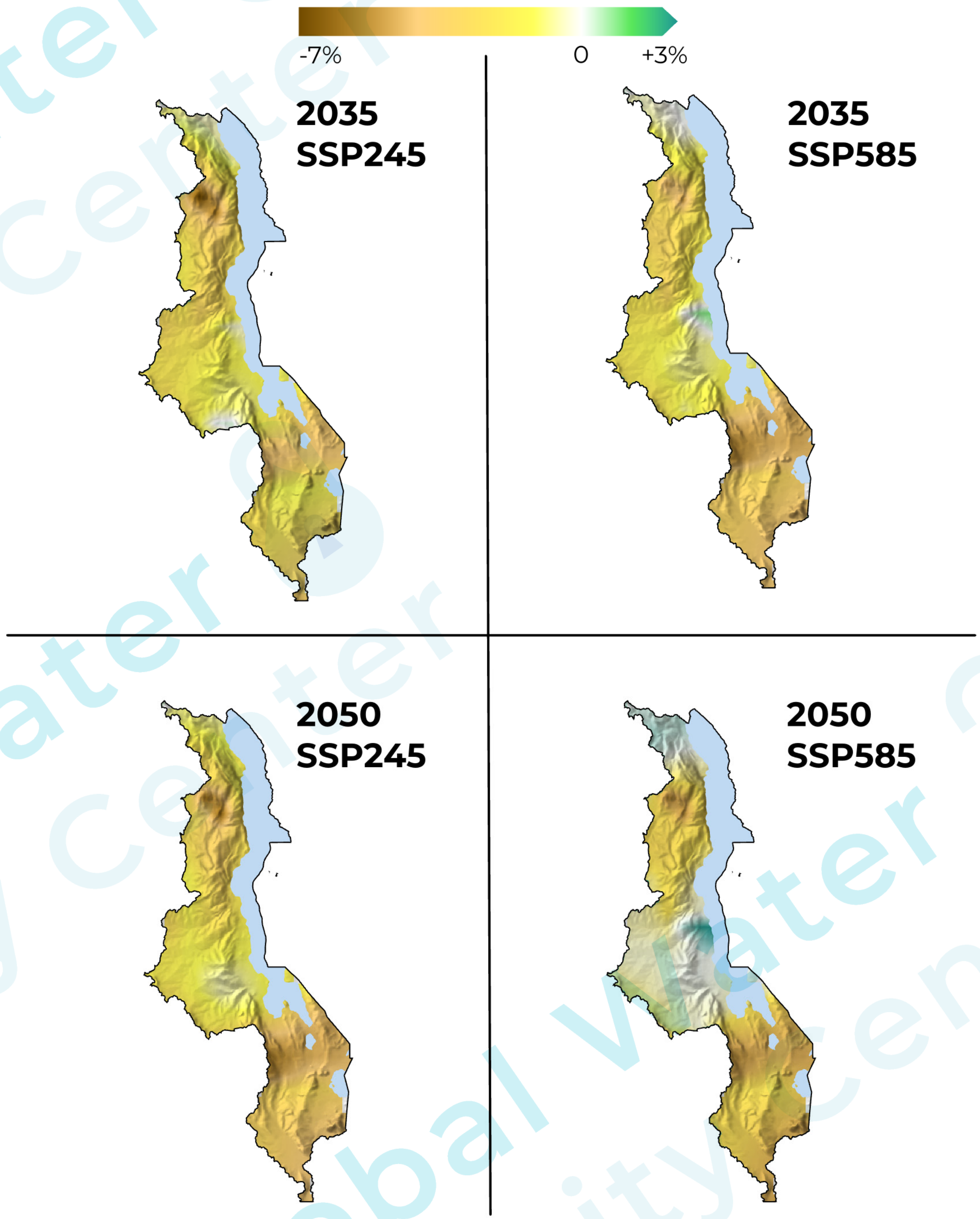
Supplemental Materials:
Precipitation Maps

Change in precipitation (averaged across 17 CMIP6 models) in 2035 and 2050 according to SSP245 and SSP585. The year of 2050 and SSP585 are not included on page 1 but are displayed here for informational purposes.





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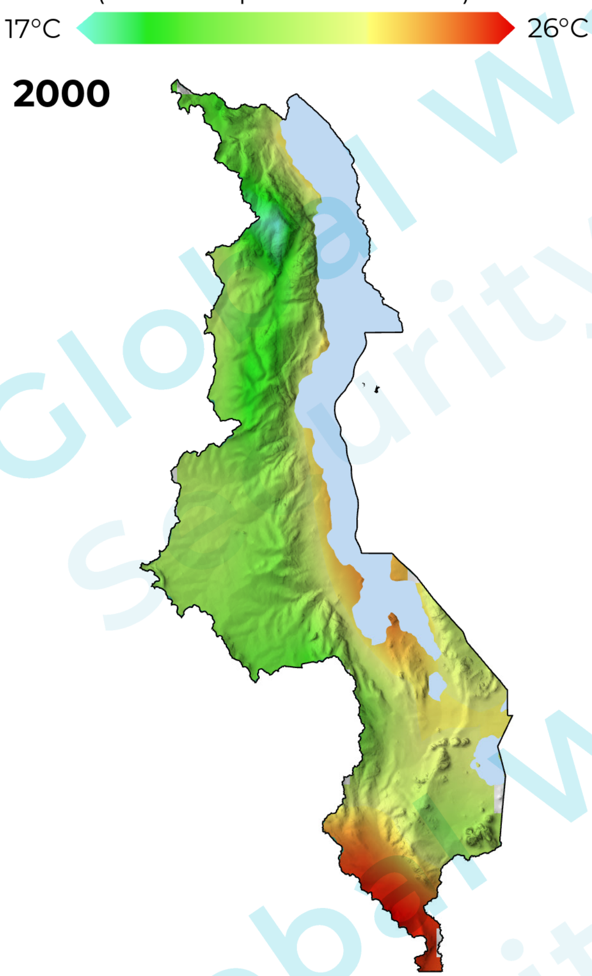
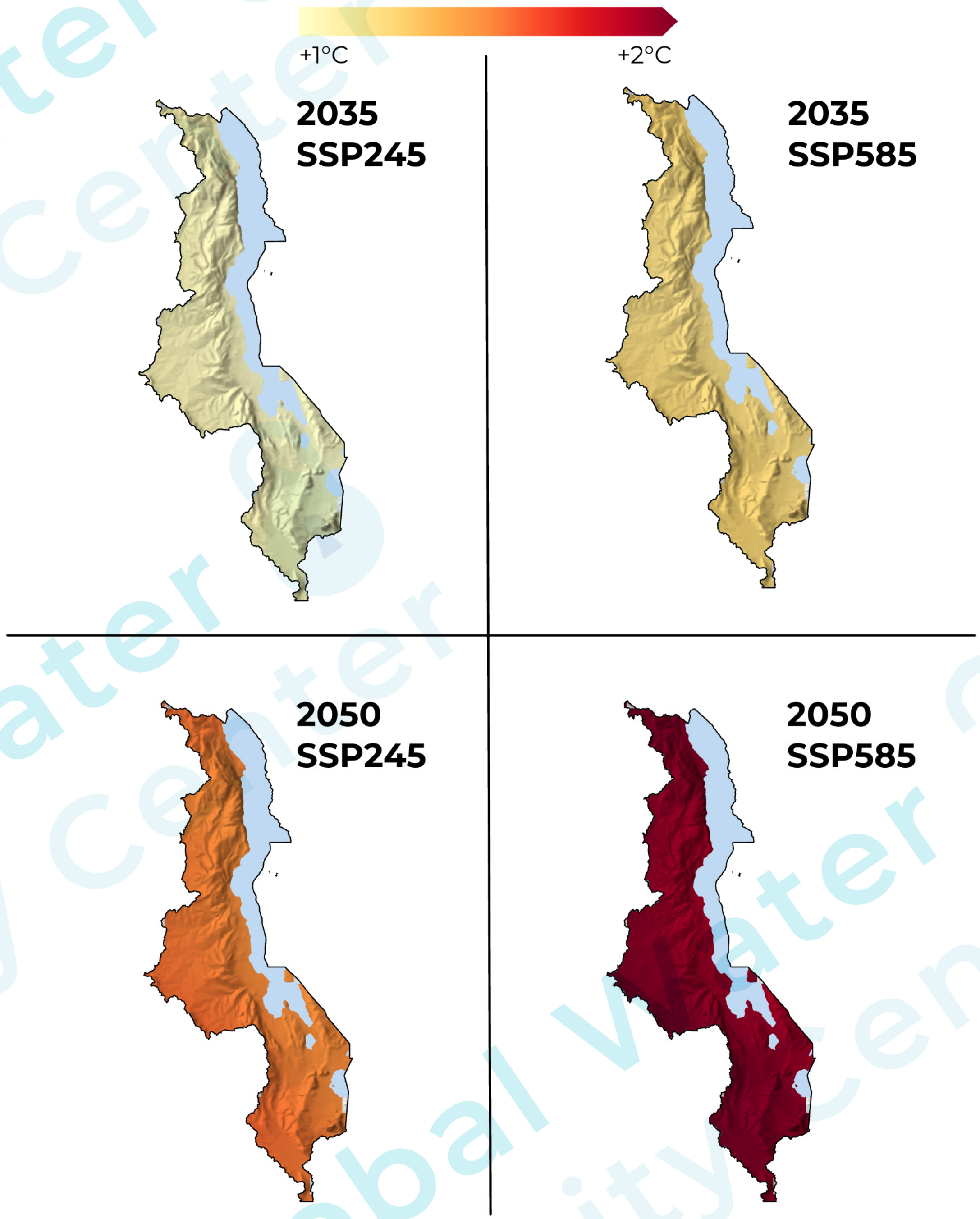
Supplemental Materials:

Temperature Maps

Change in temperature (averaged across 17 CMIP6 models) in 2035 and 2050 according to SSP245 and SSP585. The year of 2050 and SSP585 are not included on page 1 but are displayed here for informational purposes.

Mean annual temperature 2000 (°C)
(reference period 1990-2010)





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