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Supplement of

MESSAGEix-GLOBIOM nexus module: integrating water sector and climate impacts

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S1 Scales – Spatial & Temporal

The detailed methodology of spatial and temporal aggregation are mentioned in the main text. However, the following table provides additional details and steps used in post-processing the gridded data for use in nexus module. Also the bias adjustment of the data is done for the different scenarios of the data basically to keep the 2020 year same. Then the difference between both scenarios is applied over the time series as the adjustment in the base year (See Step 4 below). The names of B210 basins and their mapping with R11 region can be found in the model folder (data/node/B210_R11.yaml)

Table S1 Steps used to process the gridded data within the nexus module

Step No.	Scale	Input	Output	Procedure
1	Spatial	gridded	gridded	Convert kg/m2/sec to km3/ yr. and moving monthly average
	Temporal	monthly	monthly	
2	Spatial	gridded	basin	Spatial sum of grid values over basin
	Temporal	monthly	monthly	
3	Spatial	basin	basin	Val_{2020} = (avg. $val_{2015\text{-}2030\ rcp\ 2.6}$ + avg. $val_{2015\text{-}2030rcp60.}$)/2 Val_{2020} is applied to all data frames at this point. Val_{2020} is monthly 2020 data
	Temporal	monthly	monthly (same 2020 value for rcp scenarios)	
4	Spatial	basin	basin	Monthly bias correction is applied for each rcp value to adjust for the previous step. The bias correction is only done at 5 year intervals monthly data. For the 5 year average, MESSAGEix time step formulation is used such that for example ; val_{2025}= (val_{2021}+…+val_{2025})/5 Now for val_{2025}, bias correction is done as; $delta_{rcp6}$ = avg. $val_{2015\text{-}2030\ rcp\ 6}$ – val_{2020} $delta_{rcp2.6}$ = avg. $val_{2015\text{-}2030\ rcp\ 2.6}$ – val_{2020} $val_{rcp\ 6\ bias\ corrected}$ = $val_{rcp\ 6}$ + $delta_{rcp6}$ $val_{rcp\ 2.6\ bias\ corrected}$ = $val_{rcp\ 2.6}$ + $delta_{rcp2.6}$ the delta is reduced by 0.2 in each 5 year interval until the delta reaches zero in 2045
	Temporal	monthly	monthly bias corrected	
5	Spatial	basin	basin	5 year monthly data is prepared from monthly bias corrected data by just filtering the 5 year timesteps (2020,2025,…) from the previous step
	Temporal	monthly bias corrected	5 year monthly	
6	Spatial	basin	basin	Three reliability scenarios are created; val_{q50}, val_{q70}, val_{q90} by taking quantiles of monthly bias corrected data .
	Temporal	monthly bias corrected	5 year annual	

S2 Water Resources

Some selected basins are shown here as an example. However complete data can be accessed in the GitHub repository under data/water/availability where all of the post-processed hydrological data are available.

S2.1 Hydrology

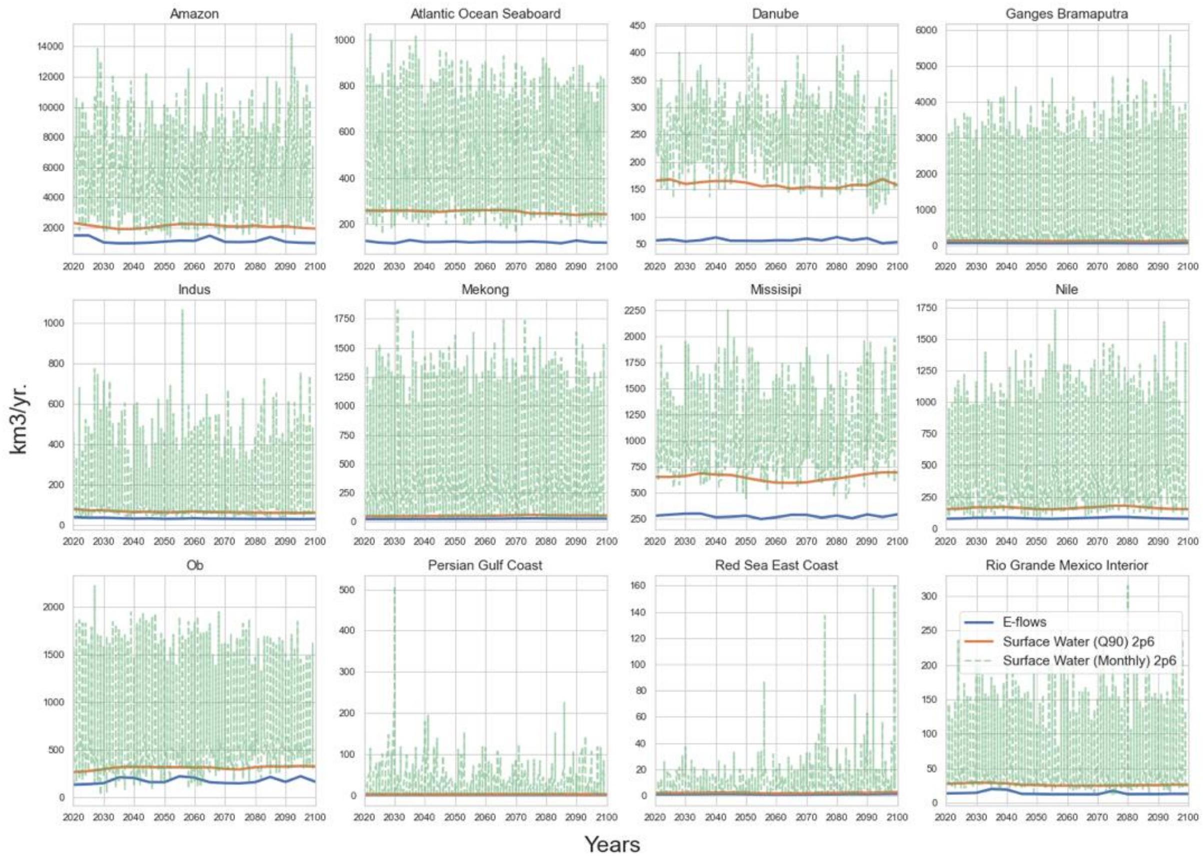


Figure S1 shows the hydrological data used within the nexus module for major B210 basins within the nexus module. Q90 flows which are used as a high reliability scenario, and environmental flows are overlaid on the monthly profiles of time-series to show the reliability of water across the season and over a long time horizon.

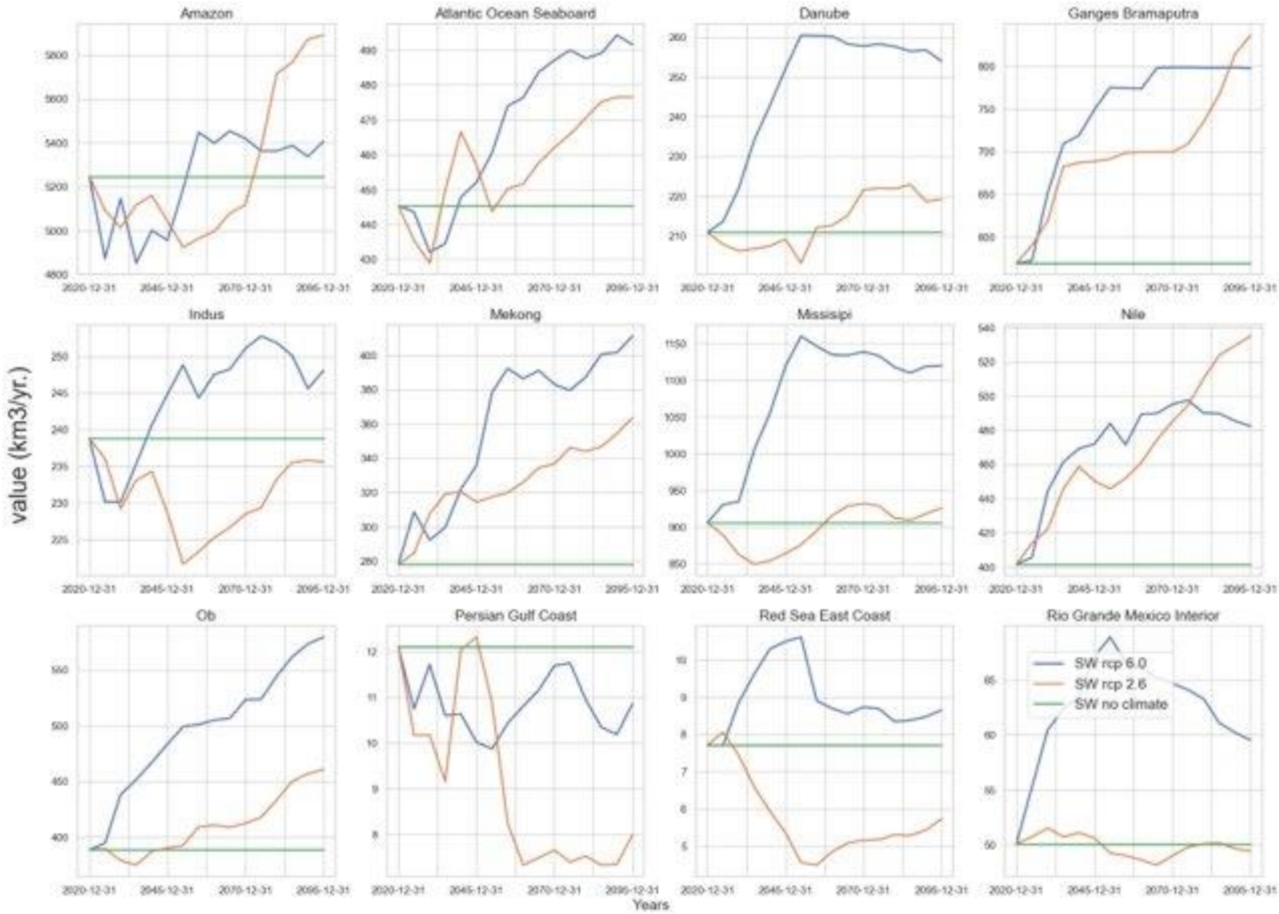


Figure S2: Hydrological flows for different climate scenarios for major B210 basins across timeseries

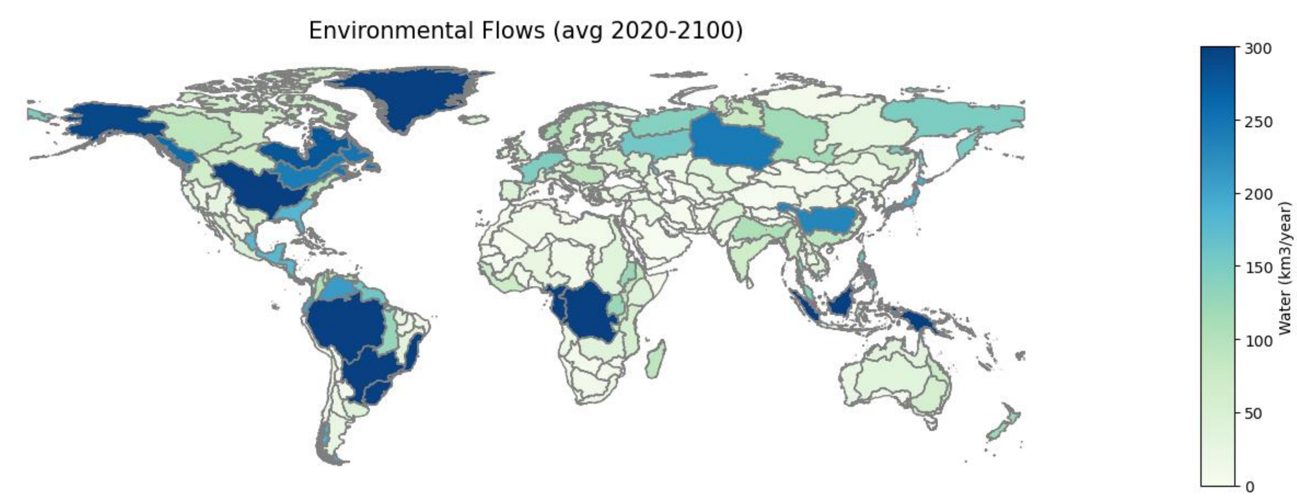


Figure S3 shows average (2020-2100) environmental flows within B210 basins

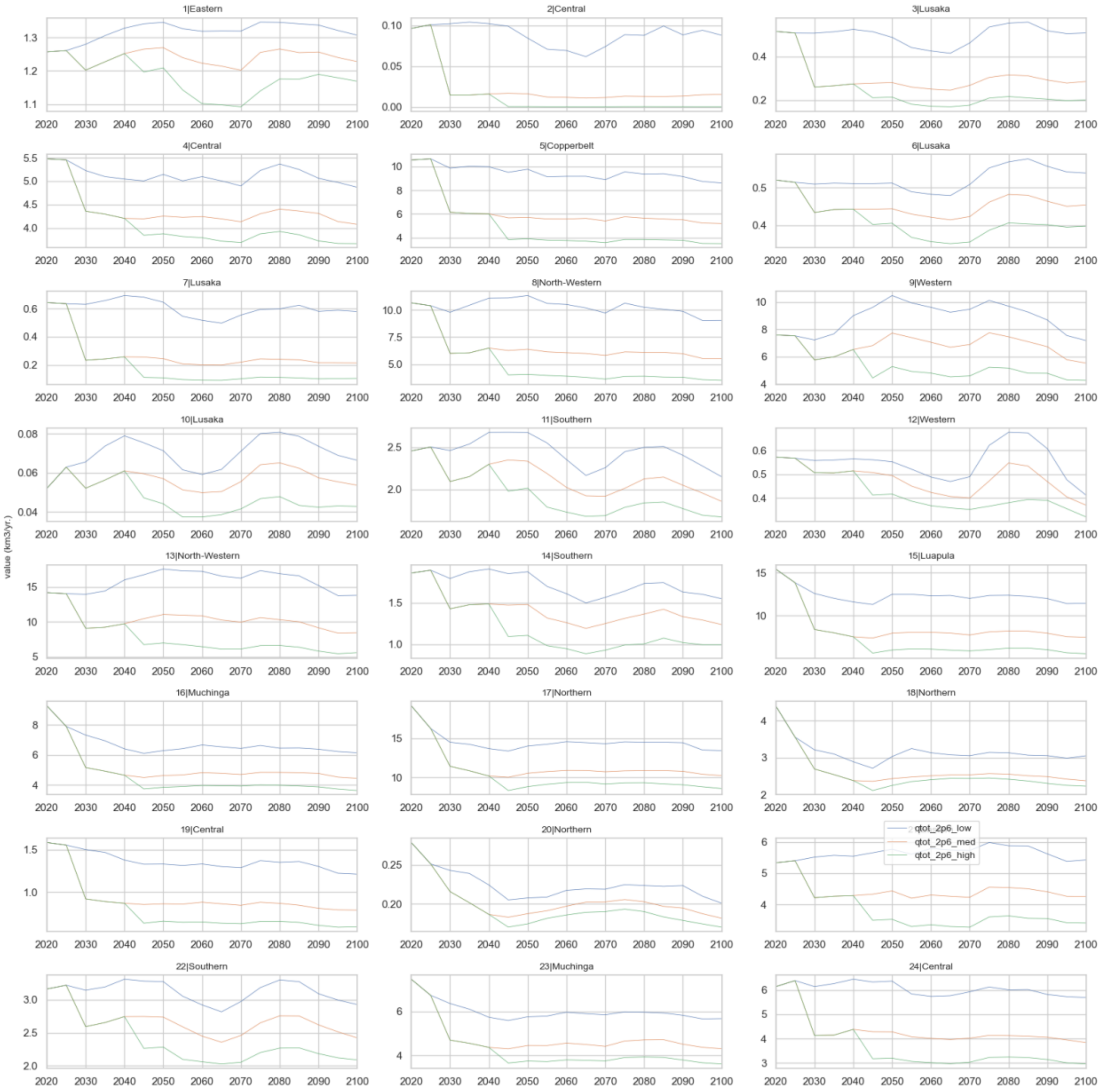


Figure S4 shows the reliability scenarios for the Zambian sub-regions. Per section 3.4 of the main paper, the global model is downscaled to Zambia on a similar structure.

S3 Exogenous Water Demands

S3.1 Muncipal water demands

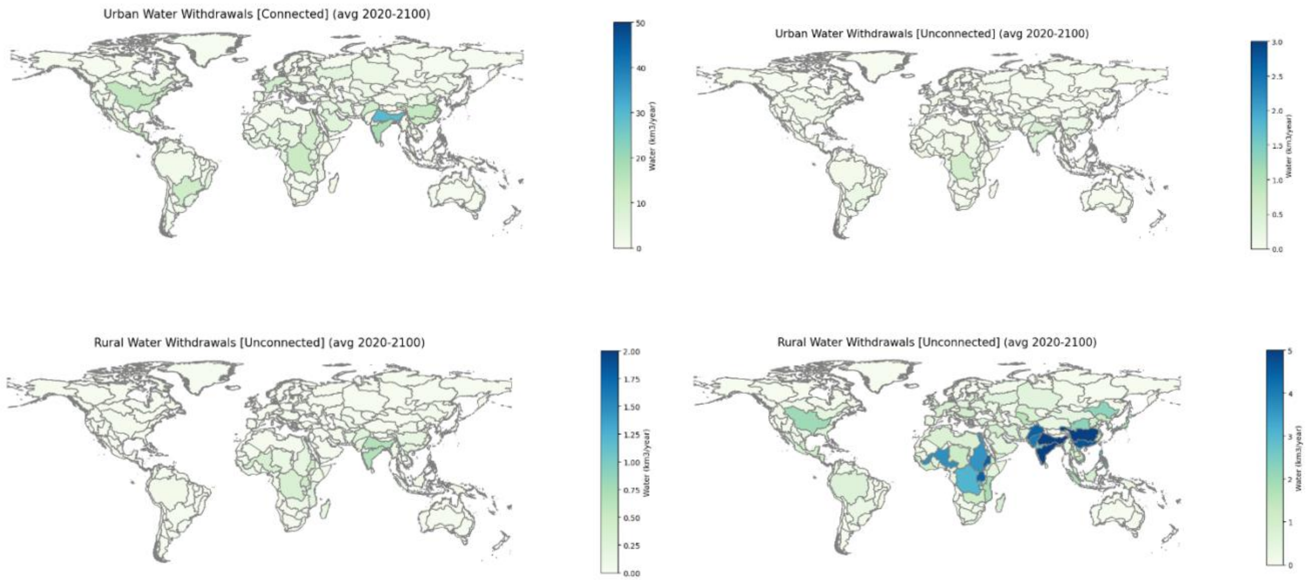


Figure S5 Average municipal withdrawals (Urban, Rual (Connected & Uncconnected)) for B210 basins. The complete data is available in the GitHub repository under data/water/water_demands

S3.2 Industrial water dmeands

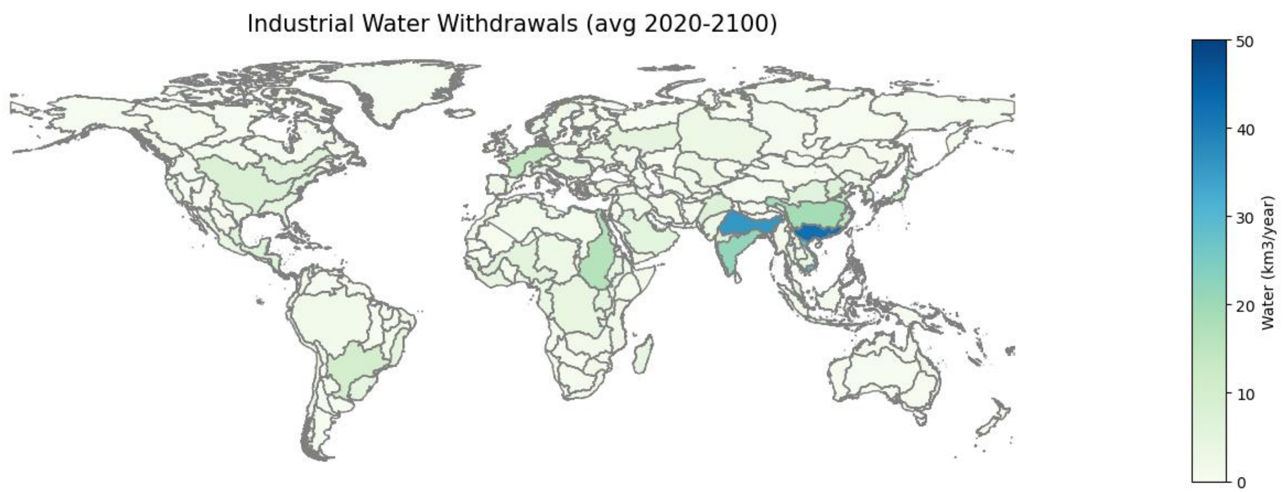


Figure S6 Average industrial water withdrawals

S3.3 Water Infrastructure

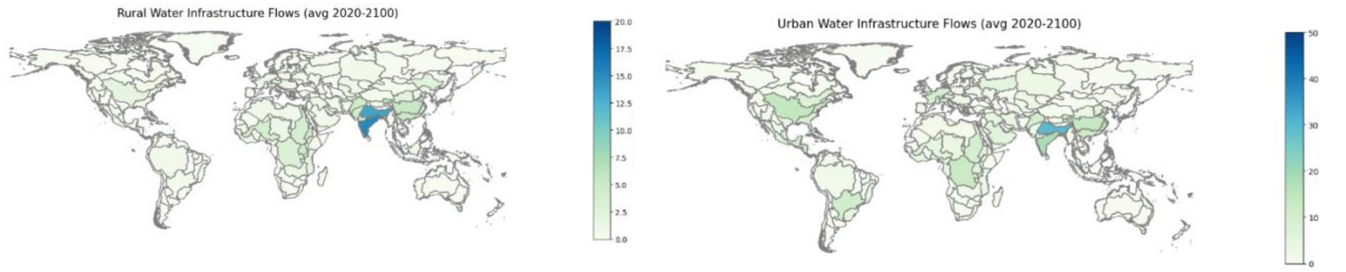


Figure S7 Average Urban & rural water transmission

S3.4 Recycled wastewater

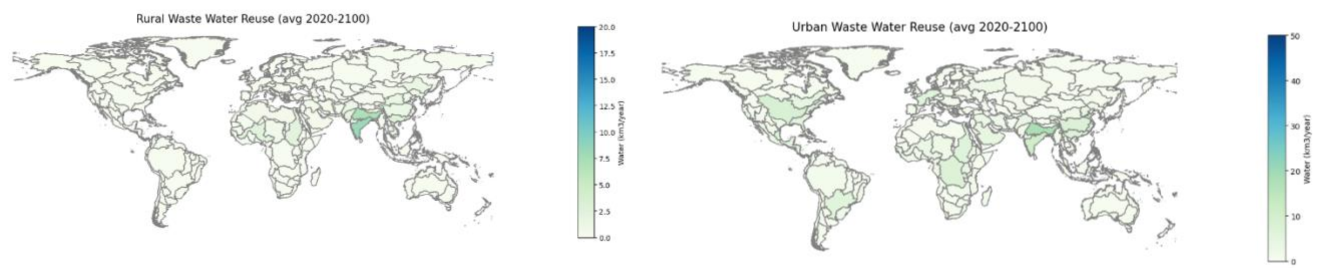


Figure S8 Average wastewater reuse available as additional supply in the supply system

S4 Biophysical Climate Impacts

S4.1 Water Sector

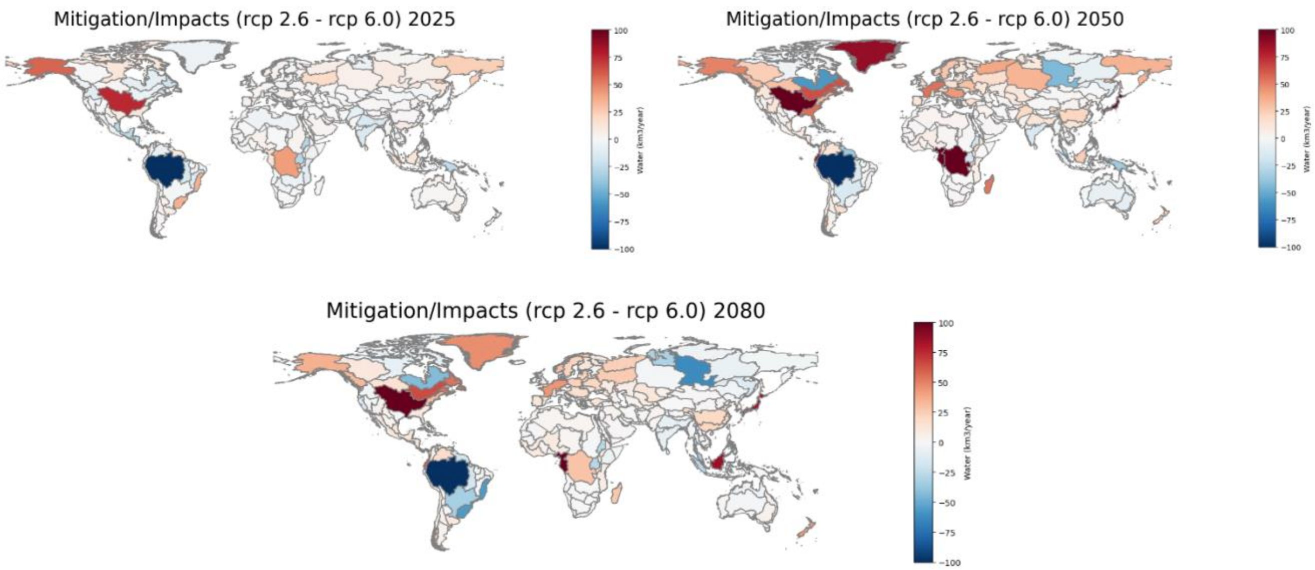


Figure S9 Water Resources (surface water & groundwater) variation between rcp 6 & rcp 2.6 scenarios

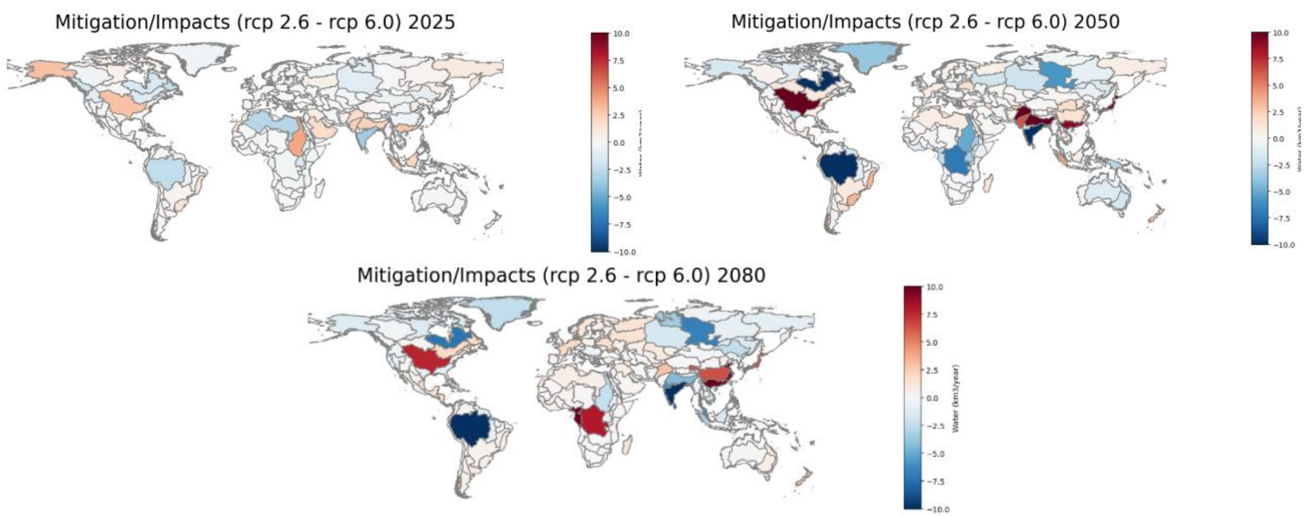
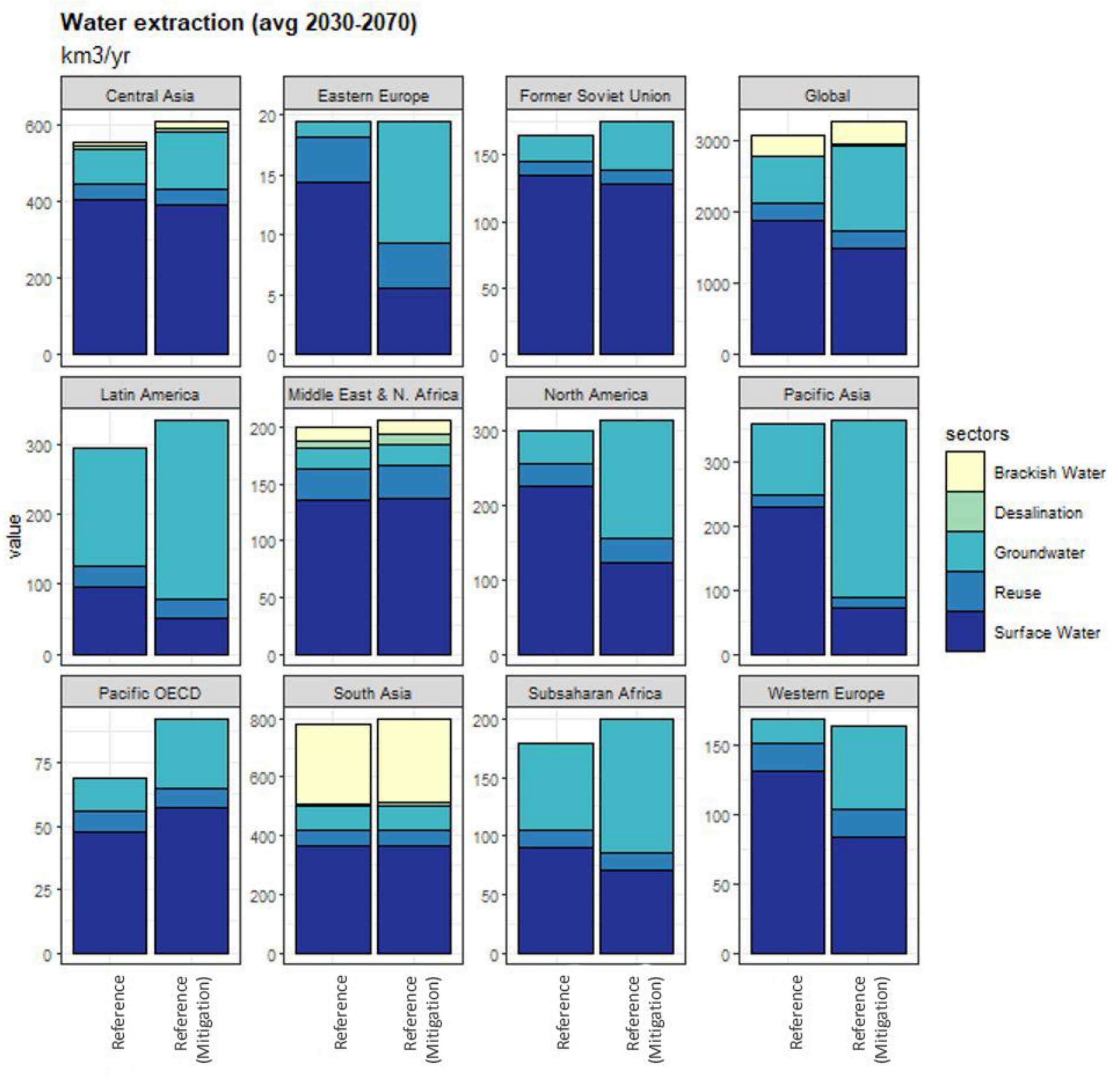


Figure S10 Water extraction (all sectors) variation between rcp 6 & rcp 2.6 scenarios



70 **Figure S11** Water Extraction outlook for no climate feedback scenarios

S4.2 Energy Sector

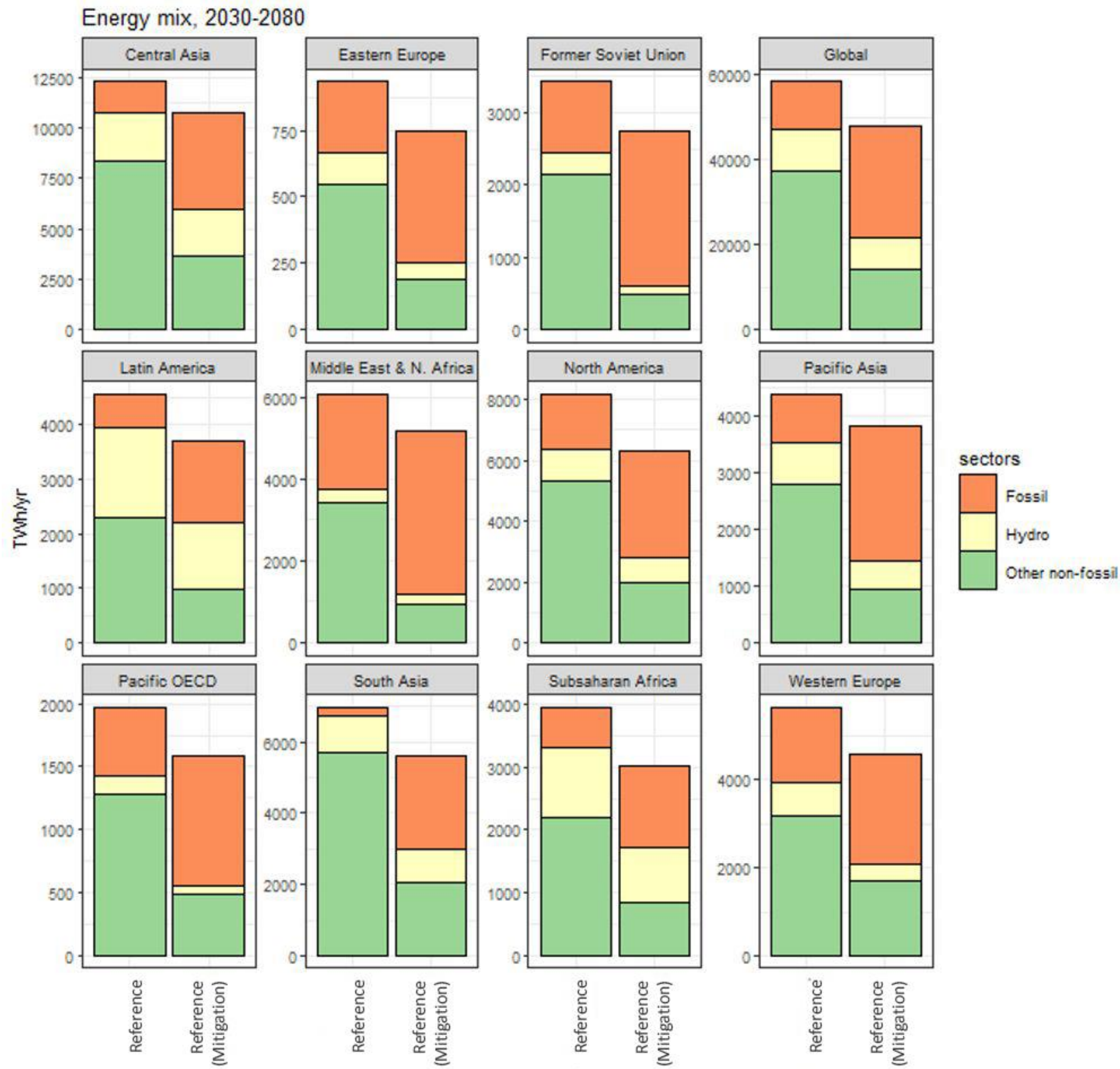


Figure S12 Energy Generation mix for no climate feedback scenarios

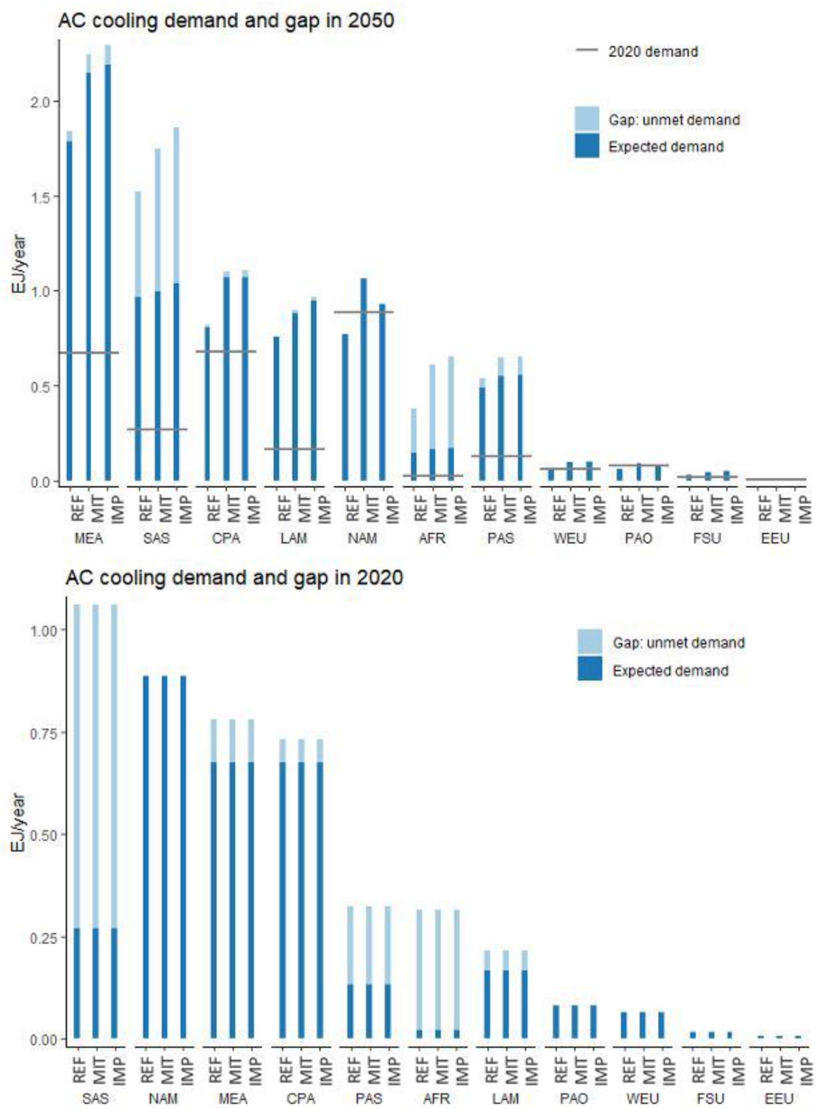


Figure S13 A/C cooling demand

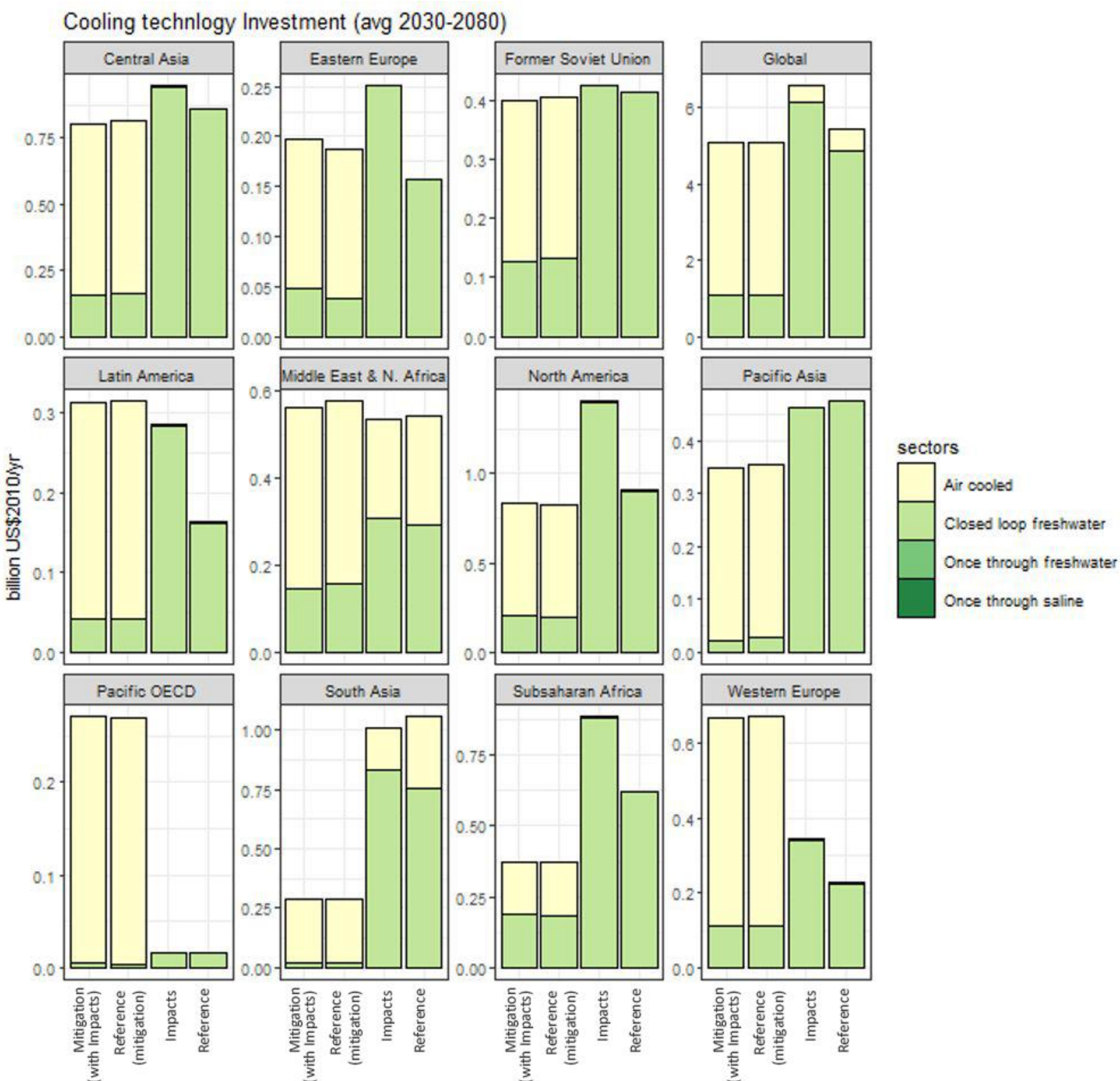
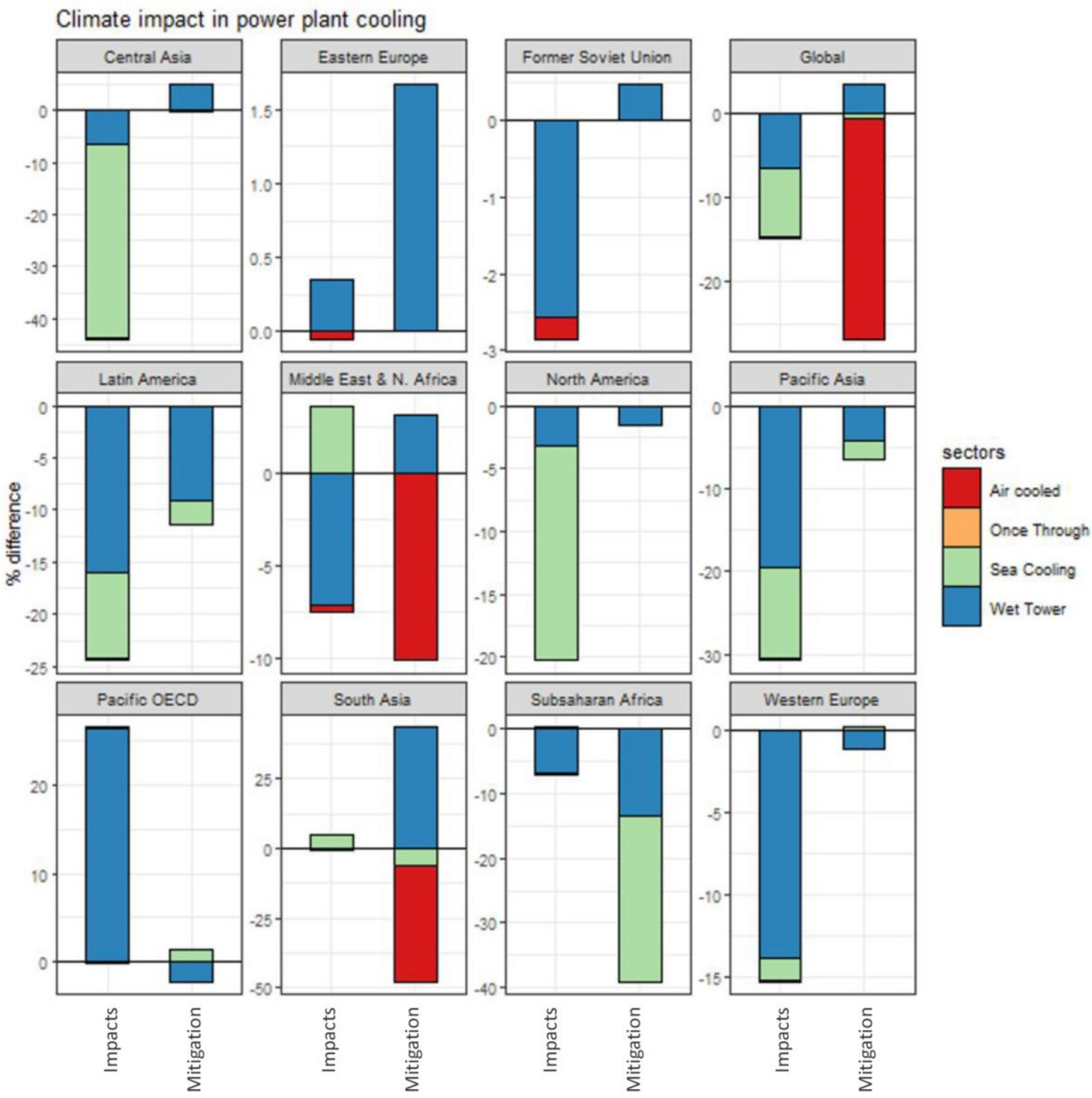


Figure S14 Climate impact on cooling water discharge



95 **Figure S15** Percentage of investments of climate impacts on cooling water discharge

S5 Flexibility across scales

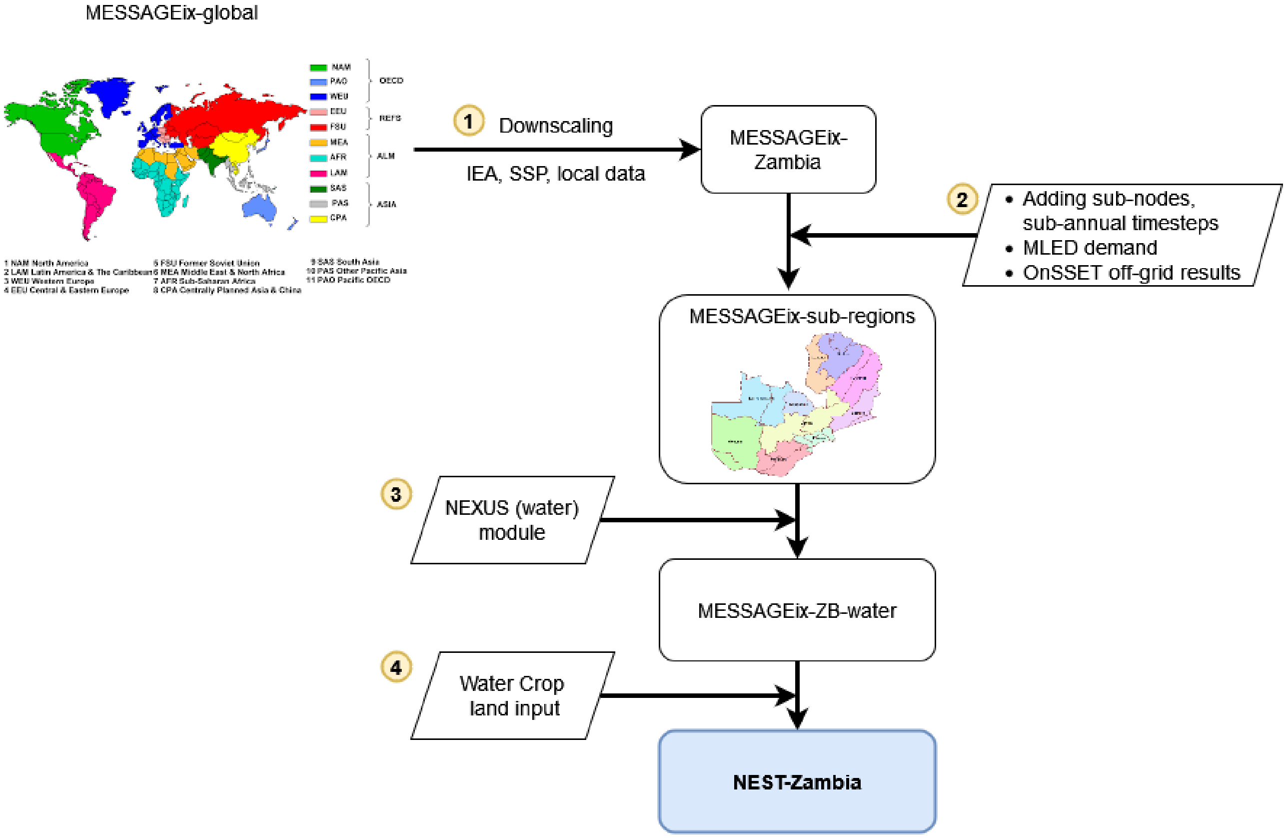


Figure S16 Downscaling global nexus module at national scale