WESTERN AND
CENTRAL AFRICA

G5 SAHEL REGION ANNEX

World Bank Group

COUNTRY CLIMATE AND DEVELOPMENT REPORT

June 2022

The Annex is provided for supplemental information to the G5 Sahel Countries Climate and Development Report. The contents have not been peer reviewed.

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1.1 Macroeconomic Modeling Methodology

Table 1-1 Growth scenarios for the G5 Sahel

Key Assumptions	Lower growth scenario	Medium-growth scenario:	Higher growth scenario:
Real GDP per capita growth	Stagnation with minimal increase in per capita income to 2050 or a decline in case of Chad.	GDP per capita grows on average by 1.4 percent annually to increase GDP per capita by 2050 by 1.2 – 2x.[1]	Increase the GDP per capita growth rate in the medium-growth scenario to 1.3-3.7% which increases GDP per capita by 2050 by 1.5 – 4x.[2]
Country and policy context including fragility, conflict and violence (FCV)	Deterioration in FCV Economic reforms have limited ambition with patchy implementation. Previous gains in HC index under threat.	Contained FCV situation Economic reforms have limited ambition but are implemented. HC gains recovered, post COVID-19.	Improved FCV situation. Economic reforms are more ambitious and well implemented. HC index improves as investments in key systems increases.
Labor and Population: Working age population (WAP) growth, labor participation (LP) rate, and unemployment (UE) rates.	WAP: Use UNDP medium fertility population projections. WAP growth rate will fall. LP rate is constant. UE rate increases by 1% annually.	WAP: Use UNDP medium fertility population projections. WAP growth rate will fall. LP rate increases by 0.5 pp as a result of higher female participation until 2030 then stabilizes. UE rate is constant.	WAP: Use UNDP low fertility (which reflects improvements in gender equality) population projections. WAP growth rate will fall faster. LP rate increases by 0.5 pp as a result of higher female participation until 2040 then stabilizes. UE rate declines by 2% annually.
Total factor productivity growth	TFP grows at half of the rate assumed under the medium-growth scenario.	TFP grows at the historical average[3]. For Niger and Mauritania, TFP takes into account the hydrocarbon boom in 2023-2025.	TFP grows at double the rate of the medium-growth scenario due to structural transformation, higher quality of investments, human capital improvements.
Sectoral share of GDP/ **Structural change**	No structural transformation. The share of GDP from each sector remains the same as 2021.	Some structural transformation. Small shift away from Agriculture, small shift towards Industry to 2040 and then stabilizes[4].	Significant structural transformation. Larger shift away from Agriculture and larger shift towards Industry to 2040 and then stabilizes.
	For Mauritania and Niger, industry share will also increase due to oil and gas coming on stream in all scenarios.		

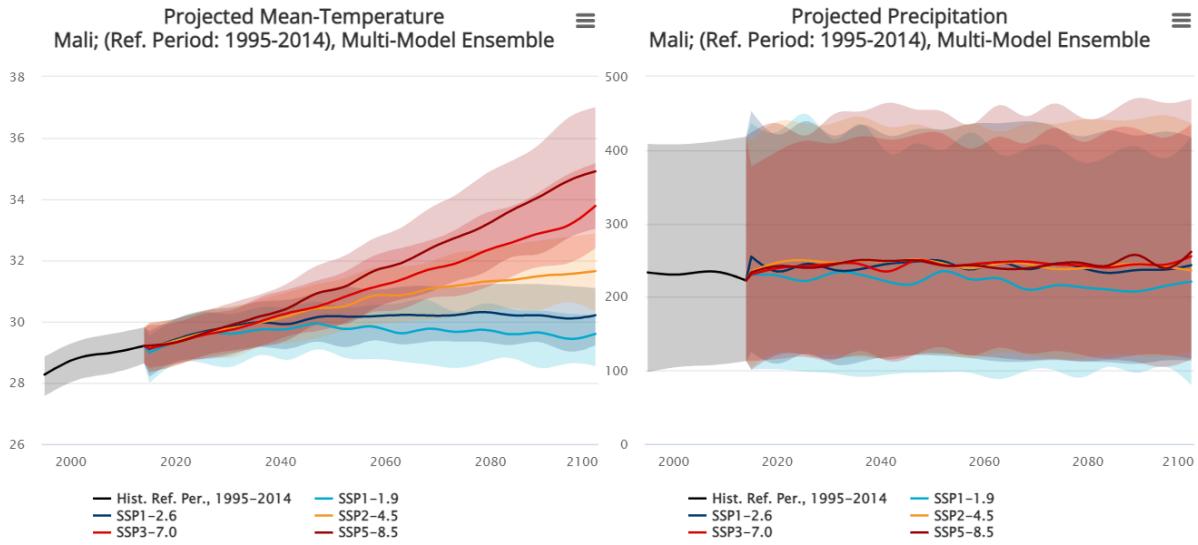
1 1.5% for Chad to multiple GDP pc by 1.2, 1.2% for Niger to multiple GDP pc by 1.4, 1.5% for Burkina Faso to multiple GDP pc by 1.5, 0.9% for Mali to multiple GDP pc by 1.3, and 1.8% for Mauritania to double GDP pc by 2050.

2 1.9% for Chad to multiple GDP pc by 2.4, 1.8 % for Niger to to multiply GDP pc by 1.7, 1.3% for Mali to multiply GDP pc by 1.5, 2.5% for Burkina Faso to multiply GDP pc by 2.2, and 3.7% for Mauritania to quadruple GDP pc, by 2050.

3 Of a relevant historical period where there has been positive TFP growth. Countries used different historical periods within the period 1990-2019, based on relevance for the country context.

4 Services is the residual and will generally increase as a share of GDP but in some cases falls if the shift away from agriculture is smaller than the shift to industry

Figure 1-1 Projected climate variables across a range of SSP-RCPs for Mali



The bold lines are averages across GCM projections for each of the five combinations of SSP-RCP combination. The shaded zones surrounding those lines display the full range of GCM projections within each combination. As can be seen, projected temperatures are always higher than the baseline, while precipitation varies widely across GCMs, but GCM ensemble averages (the bold lines) do not change significantly relative to baseline.

Source: World Bank CCKP.

Table 1-2 Impact Channel Modeling Details

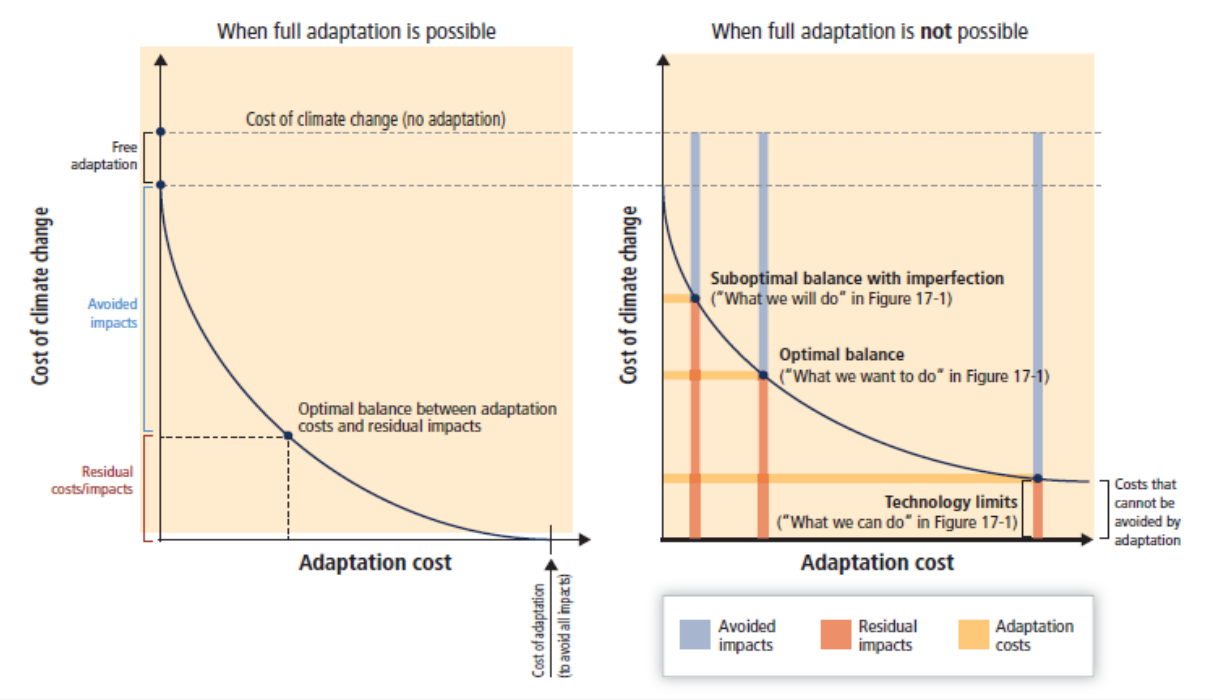
#	Channel of Impact	Impact Channel Modeling Details
1	**Rainfed crop yields**	The effects of water availability and temperature changes for each of the GCM-SSP combinations are analyzed using crop yield models and combined for 6-8 representative crops (including sorghum, millet, maize, cowpeas, cotton, groundnuts) for each country that are selected based on their relevance in terms of harvested area, production, and export value. Crop-specific temperature thresholds are calibrated to the climatic conditions of each Sahel country. This means that when temperatures exceed those thresholds, yields fall based on a damage function. The resulting shocks to crop yield by crops are aggregated to a single shock to agriculture revenues based on the share of the total value of agricultural production that each crop represents. The spatial disaggregation of the crop production analysis corresponds to ½ degree x ½ degree grid cells, which is the resolution of the climate data available. The baseline annual crop yield is calculated by putting into the crop yield model the average historical temperature and precipitation to calculate the annual crop yield for each of the crops. The temperature and precipitation for each year for each of 6 climate scenarios are then used in the crop yield model to calculate the annual crop yield for each of the crops. The difference in total crop value from the baseline is the shock, expressed in percentage terms.
2	**Heat stress and labor productivity**	Impacts are based on a method/model that quantifies the percentage of a typical working hour that a person can work based on wet bulb globe temperatures (WBGT), which measures heat stress from temperature and humidity. The impacts intensify for labor types that are outdoors and with more intense physical work. Workers are split into indoors and outdoors and it is assumed that those who work indoors are not affected by heat. This likely underestimates the impacts of heat stress as some indoor workers - especially those not in temperature-controlled environments - may be affected. The baseline annual labor productivity is calculated by putting into the WBGT model the average historical temperature and precipitation to calculate the annual labor productivity for each of the three sectors. The temperature for each year for each of 6 climate scenarios are then used in the model to calculate labor productivity. The difference in labor productivity from the baseline is the shock, expressed in percentage terms. This approach is consistent with the recently released study (in draft form) by Purdue University: Saeed, Wajiha, Thomas Hertel, Qinqin Kong, and Matthew Huber. 2022. “Heat Stress in Human Labor and Poverty: The Case of West Africa.” Purdue University.

#	Channel of Impact	Impact Channel Modeling Details
3	**Heat-related human health shocks**	The effects are estimated using a statistical model that relates temperature increases to increased morbidity due to vector-borne diseases (malaria, dengue, diarrhea, and respiratory and cardiovascular heat-related diseases). The resulting output corresponds to country-scale annual impacts on total labor productivity for each climate scenario. Changes in morbidity are calculated using country-specific years-of-life lost data gathered from the Institute of Health Metrics and Evaluation global health dataset. The baseline annual labor productivity for the whole economy calculated by using the average historical temperature and precipitation to calculate the annual labor productivity for the whole economy. The temperature for each year for each of 6 climate scenarios are then used in the model to calculate labor productivity. The difference in labor productivity from the baseline is the shock, expressed in percentage terms. The approach follows the method outlined in: Roson, Roberto, and Martina Sartori. 2016. "Estimation of Climate Change Damage Functions for 140 Regions in the GTAP 9 Database." Journal of Global Economic Analysis 1 (2): 38.
4	**Livestock yields**	The effects under each climate scenario are analyzed using a grass yield model to impact feed availability, which affects the main ruminants (cattle, goats, and sheep); and animal-specific temperature-humidity thresholds to impact the productivity of ruminants, chicken, and swine. The effect on feed availability introduces a great deal of variability in this shock – livestock productivity is low in the baseline, so has considerable room to increase during wetter years when pasture productivity is high. The resulting shocks to livestock yield by species are aggregated to a single shock to agriculture revenues based on the share of the total value of livestock production that each species represents. The spatial disaggregation of the analysis corresponds to ½ degree x ½ degree grid cells, which is the resolution of the climate data available. The baseline annual livestock yield is calculated by putting into the livestock yield model the average historical temperature and precipitation to calculate the annual livestock yield for each of the animals. The temperature and precipitation for each year for each of 6 climate scenarios are then used in the livestock yield model to calculate the annual livestock yield for each of the animals. The difference in total livestock revenue value from the baseline is the shock, expressed in percentage terms.
5	**Inland flooding**	The analysis relies on projected changes in the return interval of precipitation events (From the World Bank's Climate Knowledge Portal (CCKP)) between current conditions and future projections, which are translated to runoff using a flooding model. CCKP provided gridded changes in precipitation recurrence intervals for four periods (2010-2039, 2020-2049, 2036-2065, and 2071-2100) and under two emissions scenarios in the CMIP5 climate model ensemble: RCP4.5 and RCP8.5. The two sets of changes from CCKP are developed from the full ensemble of GCMs within each emissions scenario, so the flooding results reflect the broad trend across climate models at each emissions level. The methodology considers shocks to three types of assets: built-up capital (i.e., any hard piece of infrastructures such as roads, bridges, and buildings), agricultural capital and agricultural land. Note that the roads and bridges channel also captures flooding impacts to culverts and bridges, so there may be some overlap between the impacts presented in these two channels The approach to generate these shocks distributes capital in two stages – first using 9-km gridded GDP data, and then to a finer scale using 100-meter gridded land cover data. Although these finer scale land cover data allowed us to identify capital within the floodplain, those data do not provide the productivity of that capital (i.e., whether the grid cell includes a residential home or factory). Because the flood plain is likely to contain lower productivity capital, we dampen the shocks by 50 percent as inputs to CC-MFMod. This factor produces a conservative estimate of inland flooding impacts. The baseline flooding impacts use baseline recurrence intervals to calculate damages to capital and agricultural land. The recurrence interval changes (i.e., events become more/less frequent) from CCKP for each period and under each of the two RCPs are then used in the model to calculate flood impacts. The difference in flood impacts from the baseline is the shock, expressed in percentage terms.
6	**Roads and bridges**	The effects under each climate scenario are analyzed using the Infrastructure Planning Support System (IPSS), also used in the World Bank study Enhancing the Climate Resilience of Africa's Infrastructure. This model analyzes impacts to paved, gravel, and dirt roads; culverts; and bridges, based on stressor-response functions that relate temperature and precipitation changes to repair and reconstruction costs, and traffic delays resulting from road and bridge disruption. In the no adaptation scenario, this channel assumes that no proactive, anticipatory measures are taken to protect the roads and bridges network; it is assumed that the additional maintenance is not done so that the impact translates into a reduction in the capital stock of roads and bridges which then affects economic output. A factor of 0.5 is used to translate maintenance costs to reduction in capital stock to recognize that in the absence of maintenance, the infrastructure may still be partially usable. This factor produces a conservative estimate of damages.

Box 1-1 Limits to adaptation

Generally, greater levels of adaptation can achieve larger reductions in the cost of climate change, but with decreasing marginal benefits for incremental expenses in adaptation (see the left panel in Figure 1-2 from the IPCC's Economics of Adaptation). In practice, the impacts of climate cannot be fully mitigated due to technological limitations and other implementations barriers, leaving unavoidable residual costs (as seen in the right panel). Adaptation scenarios will aim at finding the optimal balance between adaptation costs and residual impacts, where the marginal benefits of adaptation meet the marginal residual costs.

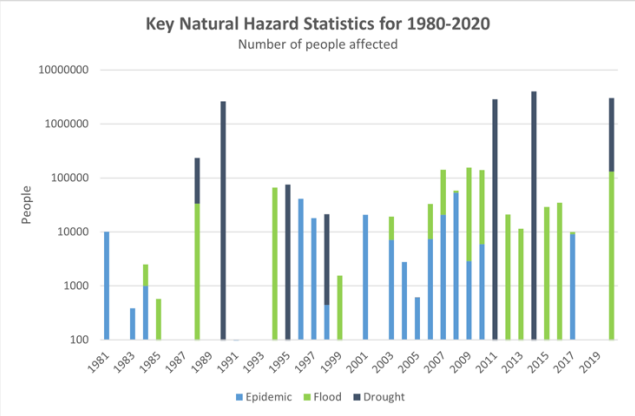
Figure 1-2 Representation of adaptation costs and residual costs of climate change



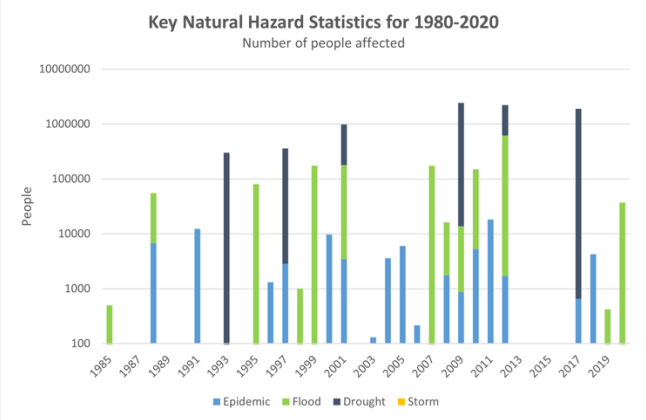
Source: IPCC (Chambwera et al. 2014); IEc methods report, February 2022

Figure 1-3 Key Natural Hazard Statistics, 1980-2020

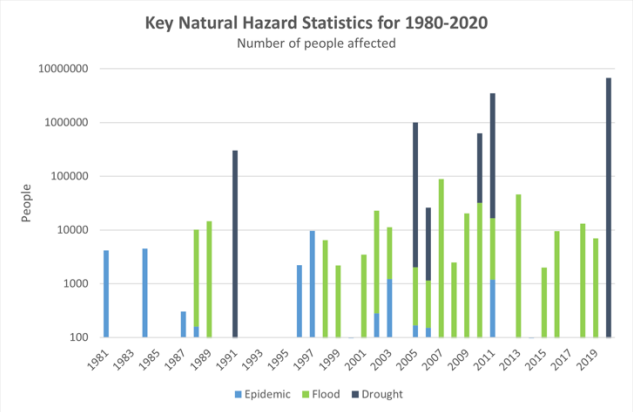
a. Burkina



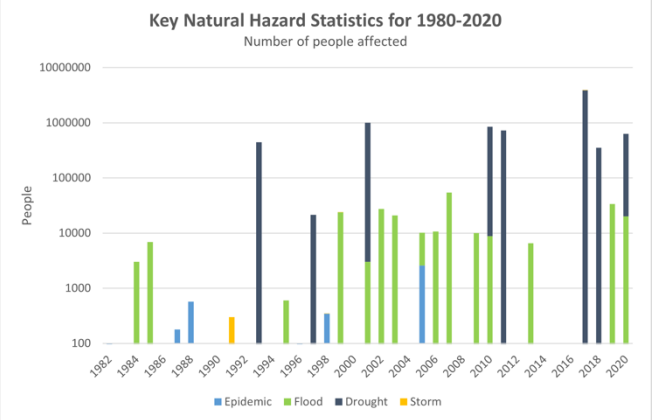
b. Chad



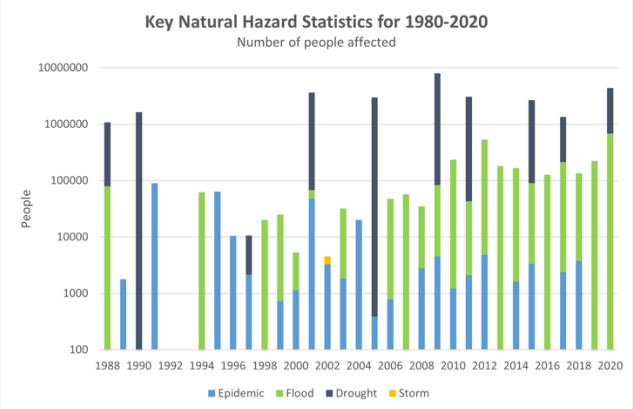
c. Mali



d. Mauritania

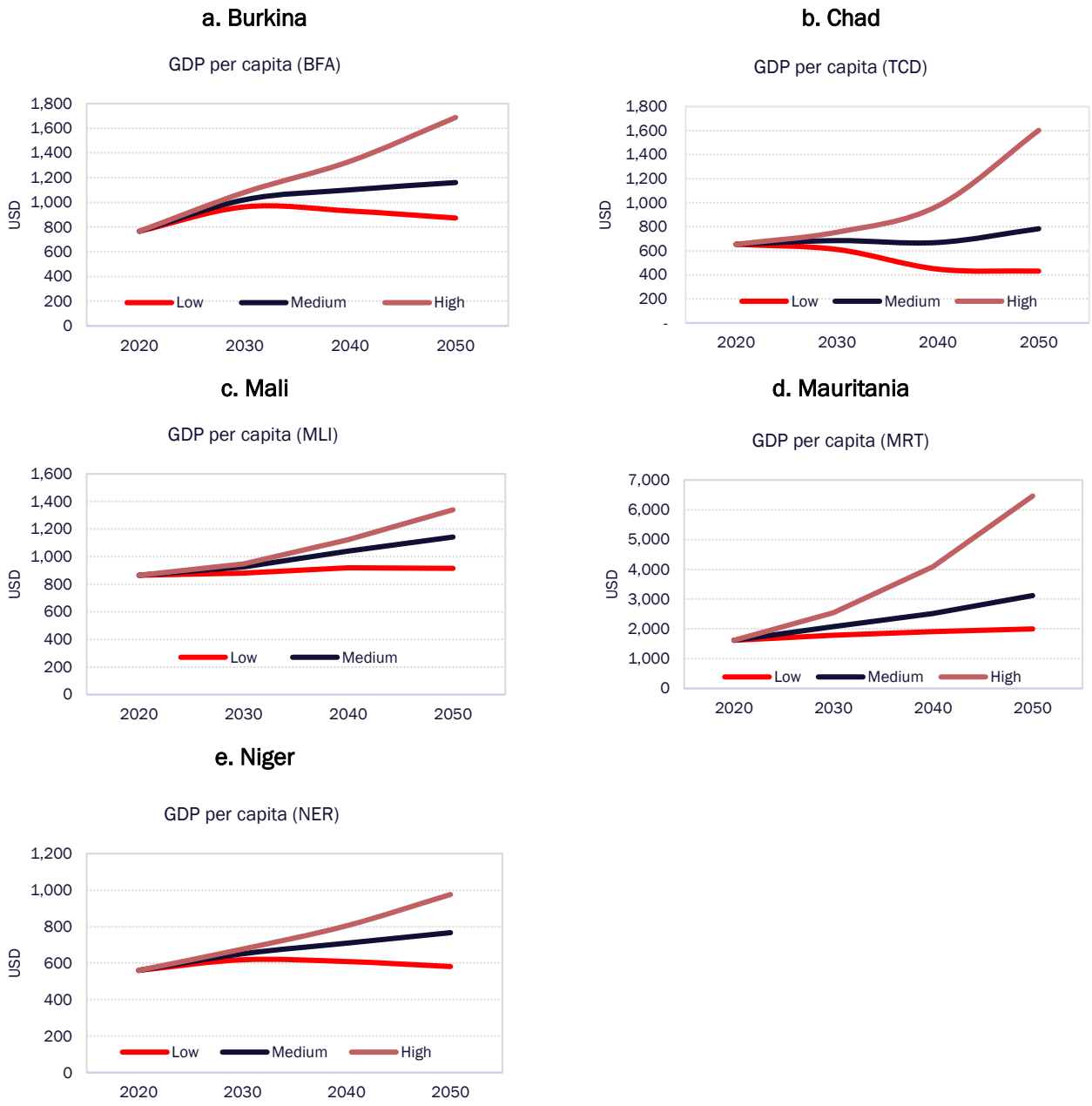


e. Niger



Source: WB Climate Change Knowledge Portal

Figure 1-4 GDP per capita, 2020-2050, (Constant 2020 US$)

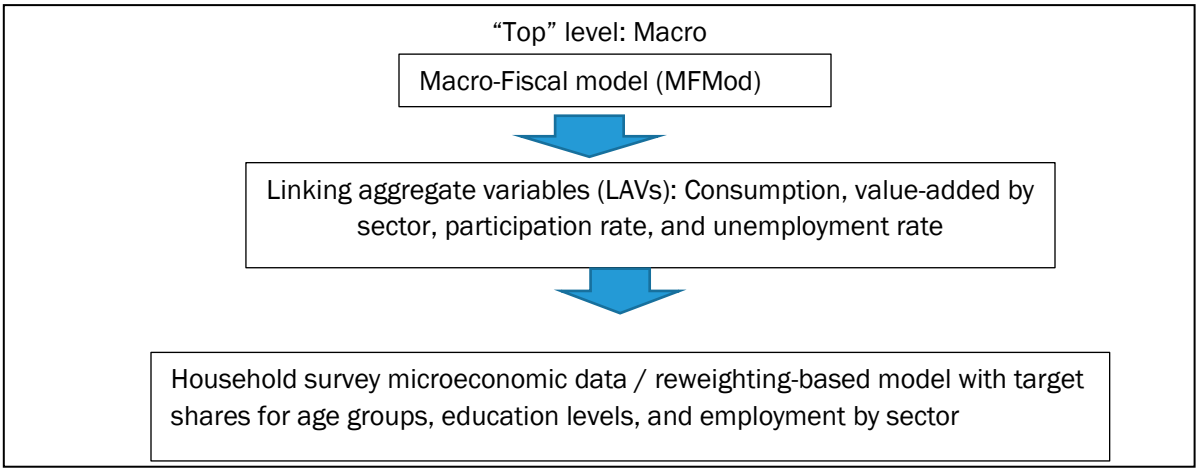


Source: CC-MFMODs for the G5 Sahel Countries, March 2022
Note(s): Local currency is West African CFA for Burkina Faso, Mali and Niger, Central African CFA for Chad, and Mauritanian Ouguiy for Mauritania

1.2 Poverty Analyses Methodology: Reweighting-based approach for top-down micro-simulations with MFMod

The welfare effects of the different climate-related scenarios are estimated with a top-down macro-micro model.[5] At the top, we use the Macro-fiscal model (MFMod), and at the bottom, we apply a reweighting-based approach to the most recent household survey data available for each country (See Figure 1-5).[6]

Figure 1-5: Top-down approach



MFMod generates a small number of macroeconomic time series that can be used as linking aggregate variables; among them, we use aggregate consumption, value-added by sector (agriculture, industry, and services), the participation rate, and the unemployment rate.

Our dataset contains consumption at the household level and employment sector but does not contain individual-level labor income. We split household consumption (without including transfers) among members using a regression between this variable and the average characteristics of the households (e.g., age, gender, education, sector, etc.).

Changes in poverty and inequality are determined by changes in weights and changes in real consumption per capita. We generate a new set of weights for each simulated year and scenario using a procedure that aims to achieve specific population totals for selected variables subject to the constraint that the adjustments to the original weights are as small as possible.[7] The population targets are the total population by gender and age (10-year cohorts) derived from the U.N. population projections, education levels under the assumption that new young cohorts (20-30 years old) entering the population are as educated as the current 20-30 years old group, and the employment share by sector (number of individuals in a sector over total population).[8] We create the target value for the latter using the change in

5 There is a large literature about macro-micro models, which typically considers linking a Computable General Equilibrium model to a microsimulation model. See Ahmed and Donoghue (2007), Bourguignon and Bussolo (2013), Ruijven, O'Neill, and Chateau (2015), and Savard (2003) for reviews of the literature on these methods.

6 Similar strategies have been applied in the literature to link a macroeconomic model to a microeconomic dataset. See for example, Buddelmeyer, Hérault, Kalb, and van Zijl de Jong (2012), Ferreira and Horridge (2006), and Hérault (2010).

7 This problem is solved using the wentropy command developed by Paul Corral and Rodrigo Salcedo in Stata (available at https://github.com/pcorralrodas/wentropy), which is an improved version of the maxentropy command (see Wittenberg, 2010).

8 This follows the assumption made in Global Income Distribution Dynamic (GIDD). See Bussolo, De Hoyos, and Medvedev (2010) for a description of the model.

value-added by sector and an employment-to-value-added elasticity by sector.[9] After we grow employment in the base year following growth in value-added, we scale the ratio of total employment over population up or down to match a total employment number derived from MFMod.[10] After we have a new set of weights, we modify consumption per capita of working individuals by sector assuming that the wage bill is a constant share of value-added and deriving the necessary change in "wages" given the change in employment previously computed such that the wage bill grow as much as value-added. After we modify consumption for working individuals, we re-center the average consumption to its original mean (such that the ratio between average consumption of working individuals to non-working individuals remains constant) and compute household consumption per capita, including working and non-working individuals. Finally, we apply the growth rate of consumption per capita from MFMod to the entire population.

9 We use an historical average for Sub-Saharan Africa taken from the literature (see Kapsos, 2005).

10 We use the participation rate, unemployment rate and the population total derived from the UN projections to estimate the number of individuals that are employed.

1.3 Macroeconomic and Poverty Modeling Results

Table 1-3 Country Summary Macroeconomic and Poverty Indicators

Burkina Faso, Medium Growth Scenario

	MEDIUM GROWTH																			
	NO CLIMATE CHANGE				CLIMATE SHOCKS-NO ADAPTATION								CLIMATE SHOCKS-WITH PARTIAL ADAPTATION							
	Baseline				Dry / Pessimistic				Wet / Optimistic				Dry / Pessimistic				Wet / Optimistic			
	2020	2030	2040	2050	2020	2030	2040	2050	2020	2030	2040	2050	2020	2030	2040	2050	2020	2030	2040	2050
National Income (Constant 2020)																				
Real GDP (CFAF billions)	9,741	17,718	25,733	35,150	9,741	17,428	24,751	32,777	9,741	17,511	24,836	33,927	9,741	17,508	25,136	33,668	9,741	17,620	25,266	34,690
Real GDP (US$ billions)	16.0	29.1	42.3	57.8	16.0	28.7	40.7	53.9	16.0	28.8	40.9	55.8	16.0	28.8	41.4	55.4	16.0	29.0	41.6	57.1
Real GDP Per Capita (US$)	767	1,022	1,102	1,161	767	1,005	1,060	1,082	767	1,010	1,063	1,120	767	1,010	1,076	1,112	767	1,016	1,082	1,146
Real Household Consumption Per Capita (U	449	559	592	628	449	550	568	581	449	553	570	603	449	553	578	599	449	556	580	619
Average Annual Growth, % (1)																				
Real GDP	4.9	6.2	3.8	3.2																
Real GDP per Capita	1.9	2.9	0.8	0.5																
Climate Change Impact (Deviation from no climate change GDP baseline, %)*																				
Total of Impact Channels Modelled on Real GDP					0.0	-1.6	-3.8	-6.8	0.0	-1.2	-3.5	-3.5	0.0	-1.2	-2.3	-4.2	0.0	-0.6	-1.8	-1.3
Shares in GDP (% of GDP)																				
Private Consumption	61.9	57.8	56.7	57.1	0.0	0.0	-0.1	-0.5	0.0	0.1	-0.1	-0.3	0.0	0.0	-0.1	-0.2	0.0	0.0	-0.1	0.0
Government Consumption	16.9	13.0	12.8	13.2	0.0	-0.1	-0.2	-0.2	0.0	-0.1	-0.1	0.0	0.0	-0.2	-0.3	-0.5	0.0	-0.2	-0.3	-0.5
Private Investment	14.5	12.7	10.0	6.9	0.0	0.1	0.1	0.0	0.0	0.2	-0.1	-0.1	0.0	0.0	0.0	0.0	0.0	0.1	-0.1	0.0
Government Investment	5.9	7.4	5.7	4.8	0.0	-0.1	0.0	0.0	0.0	-0.1	0.0	0.0	0.0	0.3	0.2	0.2	0.0	0.4	0.4	0.3
Net Exports	0.9	9.2	14.7	18.0	0.0	-0.1	-0.3	-0.5	0.0	-0.1	-0.2	-0.3	0.0	-0.2	0.1	0.5	0.0	-0.3	0.0	0.2
Sectoral shares in GDP (% of GDP)																				
Agriculture	25.4	23.1	21.8	21.7	0.0	0.0	-1.0	-1.7	0.0	-0.3	0.1	1.6	0.0	1.0	1.2	0.5	0.0	0.7	2.3	3.7
Industry	28.4	29.5	30.1	30.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Services	46.2	47.4	48.1	48.2	0.0	0.0	1.0	1.7	0.0	0.3	-0.1	-1.6	0.0	-1.0	-1.2	-0.5	0.0	-0.7	-2.3	-3.7
External balance (% of GDP)																				
Exports, Goods and Services	42.0	44.7	43.3	47.1	0.0	-0.5	-1.0	-1.5	0.0	-0.5	-0.8	-0.5	0.0	-0.7	-0.6	-0.9	0.0	-0.7	-0.5	0.0
Imports, Goods and Services	38.4	33.0	28.2	27.8	0.0	-0.5	-0.8	-1.3	0.0	-0.4	-0.7	-0.5	0.0	-0.4	-0.5	-0.8	0.0	-0.2	-0.3	-0.2
Current Account Balance	-0.2	9.4	12.7	16.9	0.0	-0.1	-0.2	-0.3	0.0	-0.1	-0.1	0.0	0.0	-0.3	-0.1	-0.1	0.0	-0.5	-0.2	0.2
Fiscal Aggregates (% of GDP)																				
Fiscal revenue	21.8	19.4	19.2	18.8	0.0	-0.1	-0.1	-0.1	0.0	-0.1	-0.1	-0.1	0.0	-0.1	-0.1	-0.1	0.0	-0.1	-0.1	-0.1
Fiscal expenditure	27.5	23.5	22.2	21.5	0.0	-0.2	-0.3	-0.2	0.0	-0.3	-0.1	0.0	0.0	0.5	0.3	0.3	0.0	0.5	0.8	0.8
- o/w Interest payments	1.3	2.4	3.0	3.4	0.0	-0.1	-0.2	-0.3	0.0	-0.1	-0.2	-0.1	0.0	0.1	0.3	0.3	0.0	0.1	0.4	0.7
Overall fiscal balance	-5.7	-4.0	-3.0	-2.7	0.0	0.1	0.2	0.1	0.0	0.2	0.0	0.0	0.0	-0.5	-0.4	-0.4	0.0	-0.6	-0.8	-0.8
Primary fiscal balance	-4.4	-1.6	0.0	0.7	0.0	0.1	0.0	-0.2	0.0	0.1	-0.1	-0.1	0.0	-0.4	-0.1	-0.1	0.0	-0.5	-0.4	-0.1
Public debt	47.6	62.2	67.3	72.0	0.0	-2.1	-4.3	-6.0	0.0	-2.3	-3.3	-1.4	0.0	2.2	4.7	4.9	0.0	2.6	7.7	13.7
- o/w External Public Debt	24.7	19.1	14.1	12.3	0.0	-0.6	-0.9	-1.1	0.0	-0.6	-0.6	-0.4	0.0	-0.6	-0.5	-0.7	0.0	-0.6	-0.3	0.0
Poverty																				
Poverty headcount rate (US$1.9 a day, 2011	30.9	23.4	24.4	27.6	0.0	0.8	2.5	5.3	0.0	0.7	2.0	1.8	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Number of poor (US$1.9 a day, 2011 PPP)	6.4	6.5	9.2	13.8	0.0	0.2	0.9	2.7	0.0	0.2	0.7	0.9	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Gini coefficient	38.7	43.3	46.7	50.6	0.0	0.0	0.2	0.2	0.0	0.1	0.0	-0.3	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Memorandum																				
Climate Change Impact (Deviation from no climate change GDP baseline, %)																				
Total of Impact Channels Modelled					0.0	-1.6	-3.8	-6.8	0.0	-1.2	-3.5	-3.5	0.0	-1.2	-2.3	-4.2	0.0	-0.6	-1.8	-1.3
-o/w Rainfed crops yield					0.0	-0.3	-0.5	-1.1	0.0	0.2	-0.2	0.2	0.0	0.1	0.7	1.0	0.0	0.7	1.0	2.3
-o/w Livestock yields					0.0	0.1	0.0	-0.2	0.0	0.3	0.0	0.7	0.0	0.2	0.1	-0.1	0.0	0.4	0.1	0.7
-o/w Labor productivity (Heat stress)					0.0	-1.1	-2.3	-3.7	0.0	-1.3	-2.1	-2.8	0.0	-1.1	-2.3	-3.6	0.0	-1.2	-2.1	-2.8
-o/w Labor productivity (Health impacts)					0.0	-0.2	-0.3	-0.6	0.0	-0.2	-0.3	-0.4	0.0	-0.2	-0.3	-0.6	0.0	-0.2	-0.3	-0.4
-o/w Flooding					0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
-o/w Roads and bridges					0.0	-0.2	-0.6	-1.3	0.0	-0.3	-0.9	-1.2	0.0	-0.2	-0.5	-0.9	0.0	-0.2	-0.6	-1.0
Population and employment																				
Total Population (Millions)	20.9	28.5	38.4	49.8																
Total Population growth rate (%)	2.9	3.1	2.8	2.4																
Working Age Population (Millions)	11.6	16.2	21.8	28.2																
Working Age Population growth rate (%)	3.5	3.1	2.8	2.4																
Labor Participation Rate (%)	65.4	68.9	69.0	69.0																
Unemployment Rate (%)	5.0	4.9	5.3	4.9																

Notes
*** Deviations from baseline are expressed as percent of baseline level for Real GDP and Emissions. National income variables are presented as level results.**
For all other variables deviations from baseline are expressed as percentage points of GDP in the corresponding scenario less the % of GDP in the baseline scenario.
(1) Average annual growth since preceding period (2010 for the first column)

Source: CC-MFMOD, May 2022
Notes: The figures show the combined effects of climate change shocks from six impact channels as deviation from the Baseline/No climate change real GDP projected under medium growth scenarios. Deviations are expressed as percent of Baseline/No climate change level of Real GDP projected under medium growth scenarios. The indicators are shown for the years 2020, 2030, 2040 and 2050. The impacts are shown with NO adaption, under a wet/optimistic climate scenario and a dry/pessimistic climate scenario, and with partial adaption to three of the six impact channels (rainfed crop yields, livestock yields and roads and bridges) under a wet/optimistic climate scenario and a dry/pessimistic climate scenario.

Chad, Medium Growth Scenario

CHAD	MEDIUM GROWTH																			
	NO CLIMATE CHANGE				CLIMATE SHOCKS-NO ADAPTATION								CLIMATE SHOCKS-WITH PARTIAL ADAPTATION							
	Baseline				Dry / Pessimistic				Wet / Optimistic				Dry / Pessimistic				Wet / Optimistic			
	2020	2030	2040	2050	2020	2030	2040	2050	2020	2030	2040	2050	2020	2030	2040	2050	2020	2030	2040	2050
National Income (Constant 2020)																				
Real GDP (CFAF billions)	6,168	8,474	10,491	15,045	6,168	8,297	10,005	13,463	6,168	8,432	10,258	14,410	6,168	8,468	10,420	14,182	6,168	8,584	10,630	15,202
Real GDP (US$ billions)	10.7	14.8	18.3	26.2	10.7	14.5	17.4	23.5	10.7	14.7	17.9	25.1	10.7	14.8	18.2	24.7	10.7	15.0	18.5	26.5
Real GDP Per Capita (US$)	654	685	669	784	654	671	638	701	654	681	654	751	654	684	665	739	654	694	678	792
Real Household Consumption Per Capita (US$	589	615	588	675	589	595	547	571	589	610	568	632	589	605	576	615	589	618	593	678
Average Annual Growth, % (1)																				
Real GDP	1.8	3.2	2.2	3.7																
Real GDP per Capita	-1.4	0.5	-0.2	1.6																
Climate Change Impact (Deviation from no climate change GDP baseline, %)*																				
Total of Impact Channels Modelled on Real GDP					0.0	-2.1	-4.6	-10.5	0.0	-0.5	-2.2	-4.2	0.0	-0.2	-0.6	-5.7	0.0	1.2	1.4	1.1
Shares in GDP (% of GDP)																				
Private Consumption	72.4	72.1	70.6	69.3	0.0	-0.8	-1.7	-3.8	0.0	-0.1	-0.9	-1.6	0.0	-1.2	-1.0	-2.4	0.0	-0.7	-0.4	-0.5
Government Consumption	2.9	3.7	2.9	2.9	0.0	0.0	0.0	-0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.1	-0.1	0.0
Private Investment	7.9	9.6	16.8	25.2	0.0	0.2	0.8	3.0	0.0	0.1	0.4	1.2	0.0	0.0	0.1	1.5	0.0	-0.1	-0.2	-0.3
Government Investment	4.6	6.0	7.8	8.9	0.0	0.1	0.4	1.0	0.0	0.0	0.2	0.4	0.0	1.7	1.6	2.1	0.0	1.6	1.6	1.7
Net Exports	10.8	7.6	1.1	-6.8	0.0	0.3	0.5	0.6	0.0	0.0	0.3	0.3	0.0	-0.5	-0.7	-0.7	0.0	-0.7	-0.8	-1.0
Sectoral shares in GDP (% of GDP)																				
Agriculture	30.9	32.9	33.2	34.0	0.0	-0.2	-1.0	-6.1	0.0	1.7	3.0	1.3	0.0	1.6	3.5	-1.0	0.0	3.2	6.1	5.3
Industry	32.5	15.8	17.4	18.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Services	18.1	38.2	40.4	41.7	0.0	0.2	1.0	6.1	0.0	-1.7	-3.0	-1.3	0.0	-1.6	-3.5	1.0	0.0	-3.2	-6.1	-5.3
External balance (% of GDP)																				
Exports, Goods and Services	26.7	31.5	21.0	15.2	0.0	0.2	0.1	-0.1	0.0	-0.1	0.1	0.0	0.0	-0.7	-0.6	-0.6	0.0	-0.9	-0.6	-0.5
Imports, Goods and Services	42.0	46.0	42.6	39.2	0.0	-0.1	-0.5	-1.4	0.0	-0.1	-0.1	-0.7	0.0	-0.5	-0.8	-1.5	0.0	-0.6	-0.5	-0.6
Current Account Balance	-1.7	1.2	-5.7	-8.0	0.0	0.3	0.6	1.3	0.0	0.1	0.2	0.6	0.0	-0.2	0.1	0.9	0.0	-0.4	-0.1	0.1
Fiscal Aggregates (% of GDP)																				
Fiscal revenue	20.7	17.9	17.7	17.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Fiscal expenditure	19.1	19.2	19.1	19.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.6	1.5	1.4	0.0	1.4	1.5	1.4
- o/w Interest payments	1.0	0.4	0.3	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.2	0.2	0.0	0.1	0.2	0.2
Overall fiscal balance	1.7	-1.2	-1.4	-1.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-1.6	-1.5	-1.5	0.0	-1.4	-1.5	-1.4
Primary fiscal balance	2.6	-0.8	-1.1	-1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-1.5	-1.3	-1.3	0.0	-1.4	-1.3	-1.2
Public debt	52.4	31.3	23.3	19.9	0.0	0.2	-0.1	-0.3	0.0	-0.1	0.1	-0.2	0.0	6.3	13.9	15.6	0.0	5.4	13.2	15.0
- o/w External Public Debt	25.6	17.5	13.1	11.2	0.0	0.1	0.0	-0.2	0.0	0.0	0.0	-0.1	0.0	3.5	7.8	8.8	0.0	3.1	7.4	8.5
Poverty																				
Poverty headcount rate (US$1.9 a day, 2011 P	33.0	38.1	44.7	39.5	0.0	1.8	4.5	10.6	0.0	-0.1	1.4	3.3	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Number of poor (US$1.9 a day, 2011 PPP)	5.1	7.7	11.5	12.5	0.0	0.4	1.2	3.3	0.0	0.0	0.4	1.0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Gini coefficient	34.5	39.7	42.5	44.5	0.0	0.1	0.1	0.7	0.0	-0.4	-0.4	-0.1	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Memorandum																				
Climate Change Impact (Deviation from no climate change GDP baseline, %)																				
Total of Impact Channels Modelled					0.0	-2.1	-4.6	-10.5	0.0	-0.5	-2.2	-4.2	0.0	-0.2	-0.6	-5.7	0.0	1.2	1.4	1.1
-o/w Rainfed crops yield					0.0	-0.2	0.1	-2.2	0.0	0.0	0.2	0.5	0.0	1.1	2.6	0.7	0.0	1.2	2.6	3.3
-o/w Livestock yields					0.0	0.0	-0.7	-3.2	0.0	1.4	2.2	1.3	0.0	0.5	0.5	-1.4	0.0	1.7	2.3	1.9
-o/w Labor productivity (Heat stress)					0.0	-1.1	-2.1	-2.9	0.0	-1.0	-1.7	-1.9	0.0	-1.1	-2.1	-2.9	0.0	-1.0	-1.7	-1.9
-o/w Labor productivity (Health impacts)					0.0	-0.1	-0.5	-0.6	0.0	-0.1	-0.4	-0.4	0.0	-0.2	-0.5	-0.6	0.0	-0.1	-0.3	-0.4
-o/w Flooding					0.0	-0.1	-1.0	-1.4	0.0	-0.2	-1.1	-1.3	0.0	-0.2	-1.0	-1.4	0.0	-0.2	-1.0	-1.3
-o/w Roads and bridges					0.0	-0.1	-0.8	-0.7	0.0	-0.2	-1.7	-2.5	0.0	0.0	-0.3	-0.2	0.0	0.0	-0.5	-0.5
Population and employment																				
Total Population (Millions)	16.4	21.6	27.3	33.4																
Total Population growth rate (%)	3.0	2.5	2.2	1.8																
Working Age Population (Millions)	8.8	12.4	16.7	21.6																
Working Age Population growth rate (%)	3.6	3.2	2.8	2.3																
Labor Participation Rate (%)	71.3	75.8	75.8	75.8																
Unemployment Rate (%)	2.8	2.9	2.9	2.9																

Notes

*** Deviations from baseline are expressed as percent of baseline level for Real GDP and Emissions. National income variables are presented as level results.**
For all other variables deviations from baseline are expressed as percentage points of GDP in the corresponding scenario less the % of GDP in the baseline scenario.
(1) Average annual growth since preceding period (2010 for the first column)

Source: CC-MFMOD, May 2022

Notes: The figures show the combined effects of climate change shocks from six impact channels as deviation from the Baseline/No climate change real GDP projected under medium growth scenarios. Deviations are expressed as percent of Baseline/No climate change level of Real GDP projected under medium growth scenarios. The indicators are shown for the years 2020, 2030, 2040 and 2050. The impacts are shown with NO adaption, under a wet/optimistic climate scenario and a dry/pessimistic climate scenario, and with partial adaption to three of the six impact channels (rainfed crop yields, livestock yields and roads and bridges) under a wet/optimistic climate scenario and a dry/pessimistic climate scenario.

Mali, Medium Growth Scenario

MALI	MEDIUM GROWTH																			
	NO CLIMATE CHANGE				CLIMATE SHOCKS-NO ADAPTATION								CLIMATE SHOCKS-WITH PARTIAL ADAPTATION							
	Baseline				Dry / Pessimistic				Wet / Optimistic				Dry / Pessimistic				Wet / Optimistic			
	2020	2030	2040	2050	2020	2030	2040	2050	2020	2030	2040	2050	2020	2030	2040	2050	2020	2030	2040	2050
National Income (Constant 2020)																				
Real GDP (CFAF billions)	10,070	14,503	21,953	32,427	10,070	14,175	20,424	28,963	10,070	14,186	21,179	30,367	10,070	14,433	21,159	30,242	10,070	14,562	22,023	32,381
Real GDP (US$ billions)	17.5	25.2	38.2	56.4	17.5	24.7	35.5	50.4	17.5	24.7	36.8	52.8	17.5	25.1	36.8	52.6	17.5	25.3	38.3	56.3
Real GDP Per Capita (US$)	865	926	1,041	1,142	865	905	968	1,020	865	905	1,004	1,070	865	920	1,002	1,064	865	928	1,043	1,139
Real Household Consumption Per Capita (US$)	635	663	716	735	635	651	678	677	635	652	697	701	635	651	692	696	635	651	708	728
Average Annual Growth, % (1)																				
Real GDP	3.6	3.7	4.2	4.0																
Real GDP per Capita	0.6	0.7	1.2	0.9																
Climate Change Impact (Deviation from no climate change GDP baseline, %)*																				
Total of Impact Channels Modelled on Real GDP					0.0	-2.3	-7.0	-10.7	0.0	-2.2	-3.5	-6.4	0.0	-0.5	-3.6	-6.7	0.0	0.4	0.3	-0.1
Shares in GDP (% of GDP)																				
Private Consumption	71.0	69.3	66.6	62.3	0.0	0.3	1.2	1.9	0.0	0.4	0.6	1.1	0.0	-0.8	0.2	1.0	0.0	-1.4	-0.8	-0.5
Government Consumption	17.4	11.9	10.0	9.2	0.0	0.0	0.1	0.2	0.0	0.0	0.0	0.1	0.0	-0.1	0.0	0.1	0.0	-0.1	0.0	0.0
Private Investment	11.8	17.1	20.8	25.2	0.0	-0.4	-0.5	-0.5	0.0	-0.3	-0.1	-0.7	0.0	-0.2	-0.2	-0.4	0.0	-0.1	0.3	-0.3
Government Investment	6.6	10.0	13.7	16.3	0.0	0.1	0.2	0.3	0.0	0.1	0.1	0.3	0.0	1.7	0.8	0.5	0.0	2.6	1.5	1.1
Net Exports	-18.0	-16.1	-16.2	-16.5	0.0	-0.2	-1.3	-2.4	0.0	-0.3	-0.8	-1.1	0.0	-0.6	-1.0	-1.5	0.0	-1.0	-0.9	-0.4
Sectoral shares in GDP (% of GDP)																				
Agriculture	34.1	31.8	29.8	29.8	0.0	-0.3	-1.7	-2.5	0.0	-0.7	1.8	2.2	0.0	0.7	0.8	-0.3	0.0	0.6	3.5	3.6
Industry	20.6	22.7	23.7	23.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Services	45.3	45.5	46.5	46.5	0.0	0.3	1.7	2.5	0.0	0.7	-1.8	-2.2	0.0	-0.7	-0.8	0.3	0.0	-0.6	-3.5	-3.6
External balance (% of GDP)																				
Exports, Goods and Services	28.6	32.0	30.5	29.8	0.0	-0.3	-0.8	-1.1	0.0	-0.3	-0.4	-0.6	0.0	-0.7	-0.7	-0.8	0.0	-0.9	-0.6	-0.3
Imports, Goods and Services	34.4	31.9	30.0	29.2	0.0	-0.7	-1.2	-1.4	0.0	-0.5	-0.4	-1.0	0.0	-0.4	-0.6	-1.0	0.0	-0.1	0.3	-0.1
Current Account Balance	-0.2	6.2	6.8	6.8	0.0	0.3	0.2	0.0	0.0	0.2	-0.1	0.3	0.0	-0.5	-0.3	-0.1	0.0	-1.0	-1.0	-0.4
Fiscal Aggregates (% of GDP)																				
Fiscal revenue	20.7	20.6	19.4	18.6	0.0	-0.1	-0.1	0.0	0.0	-0.1	0.0	0.0	0.0	-0.1	0.0	0.0	0.0	-0.1	0.0	0.0
Fiscal expenditure	26.1	24.6	26.5	29.5	0.0	-0.1	-0.1	-0.1	0.0	-0.1	0.0	-0.1	0.0	1.8	1.4	1.0	0.0	2.8	2.8	2.5
- o/w Interest payments	1.2	2.3	3.2	5.0	0.0	0.0	-0.1	-0.1	0.0	0.0	0.0	-0.1	0.0	0.6	0.9	0.8	0.0	0.8	1.5	1.7
Overall fiscal balance	-5.4	-4.0	-7.2	-10.9	0.0	0.0	0.1	0.2	0.0	0.0	0.1	0.1	0.0	-1.9	-1.4	-1.0	0.0	-2.9	-2.7	-2.5
Primary fiscal balance	-4.2	-1.7	-4.0	-5.9	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	-1.3	-0.5	-0.2	0.0	-2.1	-1.2	-0.8
Public debt	47.4	54.9	63.8	93.5	0.0	-0.6	-1.2	-2.1	0.0	-0.5	-0.5	-1.5	0.0	10.4	15.7	14.6	0.0	15.5	27.3	30.0
- o/w External Public Debt	29.9	21.1	12.5	11.2	0.0	-0.3	-0.4	-0.3	0.0	-0.2	-0.2	-0.2	0.0	0.5	1.2	1.2	0.0	0.9	2.3	2.6
Poverty																				
Poverty headcount rate (US$1.9 a day, 2011 PP	19.5	19.6	18.1	16.8	0.0	0.8	3.1	4.7	0.0	0.0	0.8	0.9	2.3	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Number of poor (US$1.9 a day, 2011 PPP)	3.9	5.4	6.6	8.0	0.0	0.2	1.2	2.2	0.0	0.0	0.2	0.3	1.1	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Gini coefficient	33.3	35.0	37.6	39.6	0.0	0.0	0.1	0.1	0.0	0.0	0.0	-0.1	-0.1	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Memorandum																				
Climate Change Impact (Deviation from no climate change GDP baseline, %)																				
Total of Impact Channels Modelled					0.0	-2.3	-7.0	-10.7	0.0	-2.2	-3.5	-6.4	0.0	-0.5	-3.6	-6.7	0.0	0.4	0.3	-0.1
-o/w Rainfed crops yield					0.0	-0.1	-0.3	-0.7	0.0	-0.1	0.0	0.2	0.0	1.0	1.2	1.5	0.0	0.9	1.5	2.5
-o/w Livestock yields					0.0	0.4	-1.0	-1.8	0.0	-0.2	0.8	2.2	0.0	0.9	0.4	-0.4	0.0	0.6	1.6	2.5
-o/w Labor productivity (Heat stress)					0.0	-1.7	-4.0	-6.1	0.0	-1.2	-2.7	-4.3	0.0	-1.8	-4.1	-6.2	0.0	-1.2	-2.8	-4.4
-o/w Labor productivity (Health impacts)					0.0	-0.2	-0.5	-0.8	0.0	-0.2	-0.4	-0.6	0.0	-0.2	-0.5	-0.9	0.0	-0.2	-0.4	-0.6
-o/w Flooding					0.0	-0.1	-0.3	-0.4	0.0	0.0	-0.1	-0.2	0.0	-0.1	-0.3	-0.4	0.0	0.0	-0.1	-0.2
-o/w Roads and bridges					0.0	-0.5	-1.0	-1.1	0.0	-0.4	-1.0	-3.6	0.0	-0.3	-0.4	-0.4	0.0	0.5	0.7	0.2
Population and employment																				
Total Population (Millions)	20.3	27.3	36.7	49.4																
Total Population growth rate (%)	3.0	3.0	3.0	3.0																
Working Age Population (Millions)	10.7	15.2	20.9	27.8																
Working Age Population growth rate (%)	3.0	3.0	3.0	3.0																
Labor Participation Rate (%)	72.8	71.2	70.1	68.8																
Unemployment Rate (%)	9.9	8.9	8.8	8.8																

Notes

*** Deviations from baseline are expressed as percent of baseline level for Real GDP and Emissions. National income variables are presented as level results.**
For all other variables deviations from baseline are expressed as percentage points of GDP in the corresponding scenario less the % of GDP in the baseline scenario.
(1) Average annual growth since preceding period (2010 for the first column)

Source: CC-MFMOD, May 2022

Notes: The figures show the combined effects of climate change shocks from six impact channels as deviation from the Baseline/No climate change real GDP projected under medium growth scenarios. Deviations are expressed as percent of Baseline/No climate change level of Real GDP projected under medium growth scenarios. The indicators are shown for the years 2020, 2030, 2040 and 2050. The impacts are shown with NO adaption, under a wet/optimistic climate scenario and a dry/pessimistic climate scenario, and with partial adaption to three of the six impact channels (rainfed crop yields, livestock yields and roads and bridges) under a wet/optimistic climate scenario and a dry/pessimistic climate scenario.

Mauritania, Medium Growth Scenario

	MEDIUM GROWTH																			
	NO CLIMATE CHANGE				CLIMATE SHOCKS-NO ADAPTATION								CLIMATE SHOCKS-WITH PARTIAL ADAPTATION							
	Baseline				Dry / Pessimistic				Wet / Optimistic				Dry / Pessimistic				Wet / Optimistic			
	2020	2030	2040	2050	2020	2030	2040	2050	2020	2030	2040	2050	2020	2030	2040	2050	2020	2030	2040	2050
National Income (Constant 2020)																				
Real GDP (CFAF billions)	293	481	723	1,081	293	469	682	1,004	293	467	701	1,045	293	474	695	1,026	293	473	717	1,086
Real GDP (US$ billions)	7.6	12.5	18.7	28.0	7.6	12.2	17.7	26.0	7.6	12.1	18.2	27.1	7.6	12.3	18.0	26.6	7.6	12.3	18.6	28.1
Real GDP Per Capita (US$)	1,617	2,079	2,522	3,120	1,617	2,029	2,380	2,895	1,617	2,021	2,443	3,014	1,617	2,048	2,423	2,961	1,617	2,046	2,501	3,132
Real Household Consumption Per Capita	904	1,044	844	650	904	1,018	779	579	904	1,014	816	629	904	1,049	841	632	904	1,052	899	722
Average Annual Growth, % (1)																				
Real GDP	3.3	5.1	4.2	4.1																
Real GDP per Capita	0.4	2.5	1.9	2.2																
Climate Change Impact (Deviation from no climate change GDP baseline, %)*																				
Total of Impact Channels Modelled on Real GDP					0.0	-2.4	-5.6	-7.2	0.0	-2.8	-3.1	-3.4	0.0	-1.5	-3.9	-5.1	0.0	-1.6	-0.8	0.4
Shares in GDP (% of GDP)																				
Private Consumption	57.8	68.4	58.6	48.7	0.0	-0.4	-0.5	-0.9	0.0	-0.3	-0.2	-0.3	0.0	-0.5	-0.5	-0.7	0.0	-0.5	-0.3	-0.1
Government Consumption	15.5	16.3	17.1	18.3	0.0	0.1	0.1	0.1	0.0	0.1	0.0	0.0	0.0	0.0	0.0	-0.1	0.0	-0.1	-0.3	-0.5
Private Investment	30.4	28.8	27.5	26.0	0.0	-0.5	-1.3	-1.3	0.0	-0.6	-0.5	-0.5	0.0	-0.6	-1.1	-1.2	0.0	-0.8	-0.6	-0.7
Government Investment	7.5	5.1	2.7	1.0	0.0	0.0	-0.2	-0.2	0.0	-0.1	-0.1	-0.1	0.0	0.9	0.8	1.0	0.0	1.4	1.9	3.0
Net Exports	-11.3	-18.5	-5.9	6.0	0.0	0.8	1.9	2.3	0.0	1.0	0.8	0.9	0.0	0.2	0.8	1.1	0.0	0.0	-0.7	-1.6
Sectoral shares in GDP (% of GDP)																				
Agriculture	20.3	21.4	21.1	22.1	0.0	-0.5	-2.4	-2.8	0.0	-0.3	0.3	0.7	0.0	0.0	-1.2	-1.7	0.0	0.2	1.2	1.7
Industry	28.0	27.8	26.9	28.4	0.0	0.2	0.7	1.9	0.0	0.3	0.5	0.7	0.0	0.7	1.0	2.0	0.0	0.9	1.2	1.6
Services	51.7	50.8	52.1	49.5	0.0	0.2	1.7	0.9	0.0	0.1	-0.8	-1.5	0.0	-0.7	0.3	-0.3	0.0	-1.2	-2.5	-3.3
External balance (% of GDP)																				
Exports, Goods and Services	30.0	25.4	29.2	34.1	0.0	0.4	1.0	1.2	0.0	0.5	0.5	0.4	0.0	0.1	0.5	0.4	0.0	0.1	-0.4	-1.2
Imports, Goods and Services	40.5	46.3	41.0	34.5	0.0	-0.3	-0.6	-0.6	0.0	-0.3	-0.2	-0.1	0.0	0.0	-0.2	-0.1	0.0	0.1	0.5	0.9
Current Account Balance	-11.0	-16.6	-7.1	4.8	0.0	0.7	1.6	1.8	0.0	0.8	0.7	0.6	0.0	0.1	0.5	0.3	0.0	-0.1	-1.1	-2.5
Fiscal Aggregates (% of GDP)																				
Fiscal revenue	20.9	20.7	20.0	19.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Fiscal expenditure	18.4	16.9	15.9	15.0	0.0	0.0	-0.1	-0.1	0.0	0.0	-0.1	0.0	0.0	0.7	0.6	0.8	0.0	1.1	1.5	2.5
- o/w Interest payments	1.3	1.0	0.5	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.2	0.2	0.0	0.1	0.2	0.4
Overall fiscal balance	2.4	3.8	4.1	4.2	0.0	0.0	0.1	0.1	0.0	0.0	0.1	0.0	0.0	-0.8	-0.6	-0.9	0.0	-1.1	-1.5	-2.5
Primary fiscal balance	3.8	4.8	4.7	4.3	0.0	0.0	0.1	0.1	0.0	0.1	0.1	0.0	0.0	-0.7	-0.5	-0.7	0.0	-1.0	-1.3	-2.2
Public debt	73.5	60.7	31.0	0.4	0.0	1.3	1.8	0.7	0.0	1.6	0.8	0.2	0.0	5.3	9.8	12.1	0.0	7.9	15.2	25.2
- o/w External Public Debt	65.5	55.8	28.1	-1.3	0.0	1.2	1.7	0.7	0.0	1.5	0.8	0.2	0.0	5.3	9.7	12.1	0.0	7.9	15.2	25.2
Poverty																				
Poverty headcount rate (US$1.9 a day, 2	4.7	0.8	0.8	0.8	0.0	0.0	0.2	0.2	0.0	0.0	0.1	0.1	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Number of poor (US$1.9 a day, 2011 PPP	0.2	0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Gini coefficient	32.4	33.6	34.4	34.6	0.0	0.0	0.1	0.1	0.0	0.0	0.0	0.0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Memorandum																				
Climate Change Impact (Deviation from no climate change GDP baseline, %)																				
Total of Impact Channels Modelled					0.0	-2.4	-5.6	-7.2	0.0	-2.8	-3.1	-3.4	0.0	-1.5	-3.9	-5.1	0.0	-1.6	-0.8	0.4
-o/w Rainfed crops yield					0.0	0.1	-0.1	-0.2	0.0	0.0	0.0	0.1	0.0	0.5	0.6	0.6	0.0	0.6	0.8	1.0
-o/w Livestock yields					0.0	-0.1	-1.7	-2.0	0.0	0.2	0.5	1.0	0.0	0.2	-0.8	-1.1	0.0	0.5	1.1	1.6
-o/w Labor productivity (Heat stress)					0.0	-1.1	-1.9	-2.7	0.0	-1.1	-1.5	-1.7	0.0	-1.1	-1.9	-2.7	0.0	-1.1	-1.5	-1.7
-o/w Labor productivity (Health impacts)					0.0	-0.4	-0.6	-0.9	0.0	-0.4	-0.5	-0.5	0.0	-0.4	-0.6	-0.9	0.0	-0.4	-0.5	-0.5
-o/w Flooding					0.0	-0.4	-0.7	-0.8	0.0	-0.5	-0.5	-0.5	0.0	-0.4	-0.7	-0.8	0.0	-0.5	-0.5	-0.5
-o/w Roads and bridges					0.0	-0.5	-0.8	-0.9	0.0	-1.0	-1.1	-1.8	0.0	-0.4	-0.5	-0.4	0.0	-0.7	-0.2	0.4
Population and employment																				
Total Population (Millions)	4.7	6.0	7.4	9.0																
Total Population growth rate (%)	2.7	3.0	3.0	3.0																
Working Age Population (Millions)	2.8	3.6	4.4	5.4																
Working Age Population growth rate (%)	2.7	3.0	3.0	3.0																
Labor Participation Rate (%)	3.1	3.0	3.0	3.0																
Unemployment Rate (%)	44.6	49.8	49.8	49.8																

Notes

*** Deviations from baseline are expressed as percent of baseline level for Real GDP and Emissions. National income variables are presented as level results.**

For all other variables deviations from baseline are expressed as percentage points of GDP in the corresponding scenario less the % of GDP in the baseline scenario.

(1) Average annual growth since preceding period (2010 for the first column)

Source: CC-MFMOD, May 2022

Notes: The figures show the combined effects of climate change shocks from six impact channels as deviation from the Baseline/No climate change real GDP projected under medium growth scenarios. Deviations are expressed as percent of Baseline/No climate change level of Real GDP projected under medium growth scenarios. The indicators are shown for the years 2020, 2030, 2040 and 2050. The impacts are shown with NO adaption, under a wet/optimistic climate scenario and a dry/pessimistic climate scenario, and with partial adaption to three of the six impact channels (rainfed crop yields, livestock yields and roads and bridges) under a wet/optimistic climate scenario and a dry/pessimistic climate scenario.

Niger, Medium Growth Scenario

	MEDIUM GROWTH																			
	NO CLIMATE CHANGE				CLIMATE SHOCKS-NO ADAPTATION								CLIMATE SHOCKS-WITH PARTIAL ADAPTATION							
	Baseline				Dry / Pessimistic				Wet / Optimistic				Dry / Pessimistic				Wet / Optimistic			
	2020	2030	2040	2050	2020	2030	2040	2050	2020	2030	2040	2050	2020	2030	2040	2050	2020	2030	2040	2050
National Income (Constant 2020)																				
Real GDP (CFAF billions)	7,904	13,159	19,878	28,682	7,904	12,572	18,540	25,265	7,904	12,786	19,046	28,049	7,904	12,879	19,024	26,265	7,904	13,102	19,606	29,567
Real GDP (US$ billions)	13.6	22.6	34.1	49.2	13.6	21.6	31.8	43.3	13.6	21.9	32.7	48.1	13.6	22.1	32.6	45.1	13.6	22.5	33.6	50.7
Real GDP Per Capita (US$)	560	651	709	767	560	622	661	675	560	632	680	750	560	637	679	702	560	648	700	790
Real Household Consumption Per Capita (U	380	453	482	505	380	436	451	447	380	441	462	492	380	445	468	464	380	452	481	519
Average Annual Growth, % (1)																				
Real GDP	5.7	5.2	4.2	3.7																
Real GDP per Capita	1.7	1.5	0.9	0.8																
Climate Change Impact (Deviation from no climate change GDP baseline, %)*																				
Total of Impact Channels Modelled on Real GDP					0.0	-4.5	-6.7	-11.9	0.0	-2.8	-4.2	-2.2	0.0	-2.1	-4.3	-8.4	0.0	-0.4	-1.4	3.1
Shares in GDP (% of GDP)																				
Private Consumption	70.3	72.1	70.4	68.2	0.0	0.5	0.2	0.3	0.0	0.2	0.0	-0.2	0.0	0.3	0.9	0.3	0.0	0.2	0.8	-0.2
Government Consumption	16.9	17.4	19.7	23.7	0.0	0.2	0.2	0.4	0.0	0.2	0.1	0.1	0.0	-0.6	-1.1	-0.9	0.0	-0.9	-1.6	-1.8
Private Investment	19.3	16.7	13.3	11.2	0.0	-0.9	-0.6	-0.8	0.0	-0.5	-0.3	0.1	0.0	-1.0	-0.8	-0.7	0.0	-0.8	-0.6	0.2
Government Investment	9.2	8.3	8.5	8.5	0.0	0.1	0.0	-0.1	0.0	0.1	0.0	0.0	0.0	2.3	0.7	0.6	0.0	2.5	1.3	1.1
Net Exports	-16.4	-15.7	-13.2	-12.7	0.0	0.0	0.3	0.2	0.0	0.1	0.2	0.1	0.0	-1.0	0.3	0.9	0.0	-1.1	0.2	0.7
Sectoral shares in GDP (% of GDP)																				
Agriculture	38.2	36.3	35.3	32.1	0.0	-1.0	-0.2	-2.1	0.0	1.2	1.7	4.9	0.0	0.4	2.8	0.7	0.0	2.5	4.4	7.2
Industry	21.3	26.1	27.8	27.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Services	40.4	39.5	39.1	35.6	0.0	0.2	-0.4	1.1	0.0	-1.6	-2.0	-6.3	0.0	-4.2	-3.0	-0.1	0.0	-6.4	-4.6	-6.0
External balance (% of GDP)																				
Exports, Goods and Services	12.2	12.6	13.2	14.0	0.0	0.4	0.3	0.6	0.0	0.2	0.2	-0.1	0.0	0.0	0.4	0.5	0.0	-0.1	0.2	-0.3
Imports, Goods and Services	29.3	29.6	28.5	28.1	0.0	0.0	-0.1	0.0	0.0	0.0	0.0	-0.1	0.0	0.0	0.2	-0.2	0.0	0.0	0.2	-0.3
Current Account Balance	-12.9	-13.1	-12.0	-11.4	0.0	0.4	0.5	0.6	0.0	0.3	0.2	0.0	0.0	0.0	0.3	0.7	0.0	-0.2	0.0	0.0
Fiscal Aggregates (% of GDP)																				
Fiscal revenue	17.1	17.1	19.5	22.7	0.0	0.1	0.2	0.3	0.0	0.1	0.1	0.1	0.0	-0.2	0.1	0.2	0.0	-0.3	0.0	-0.2
Fiscal expenditure	20.9	19.4	19.0	19.1	0.0	0.3	0.2	0.2	0.0	0.2	0.2	0.0	0.0	2.6	1.7	1.4	0.0	3.0	2.4	1.8
- o/w Interest payments	1.1	1.8	1.0	-0.8	0.0	0.1	0.1	0.0	0.0	0.1	0.1	0.0	0.0	0.8	1.7	1.5	0.0	1.0	2.0	1.9
Overall fiscal balance	-3.8	-2.3	0.5	3.6	0.0	-0.2	-0.1	0.1	0.0	-0.1	0.0	0.1	0.0	-2.9	-1.6	-1.2	0.0	-3.2	-2.4	-1.9
Primary fiscal balance	-2.7	-0.4	1.4	2.8	0.0	-0.1	0.1	0.2	0.0	-0.1	0.0	0.1	0.0	-2.1	0.0	0.3	0.0	-2.2	-0.4	0.0
Public debt	42.3	55.9	43.3	15.4	0.0	2.2	4.1	4.4	0.0	1.6	2.7	0.8	0.0	13.7	28.2	26.5	0.0	17.7	33.8	30.8
- o/w External Public Debt	28.1	33.3	37.2	39.4	0.0	1.1	2.5	4.7	0.0	0.8	1.6	1.0	0.0	-0.7	2.1	3.9	0.0	-1.1	1.0	-0.2
Poverty																				
Poverty headcount rate (US$1.9 a day, 2011	36.1	28.9	29.6	30.4	0.0	2.7	4.7	8.6	0.0	1.5	2.8	1.7	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Number of poor (US$1.9 a day, 2011 PPP)	8.2	9.4	13.4	18.5	0.0	0.9	2.1	5.2	0.0	0.5	1.3	1.0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Gini coefficient	35.6	39.1	42.3	43.9	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.1	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Memorandum																				
Climate Change Impact (Deviation from no climate change GDP baseline, %)																				
Total of Impact Channels Modelled					0.0	-4.5	-6.7	-11.9	0.0	-2.8	-4.2	-2.2	0.0	-2.1	-4.3	-8.4	0.0	-0.4	-1.4	3.1
-o/w Rainfed crops yield					0.0	-0.6	-0.1	-2.2	0.0	1.0	0.6	2.4	0.0	1.2	2.1	1.3	0.0	2.8	2.8	6.0
-o/w Livestock yields					0.0	-0.2	0.0	-0.9	0.0	1.2	1.9	4.9	0.0	0.4	0.4	-0.4	0.0	1.5	2.1	4.8
-o/w Labor productivity (Heat stress)					0.0	-2.7	-4.5	-6.3	0.0	-2.9	-3.3	-3.5	0.0	-2.7	-4.5	-6.3	0.0	-2.9	-3.3	-3.5
-o/w Labor productivity (Health impacts)					0.0	-0.4	-0.6	-0.9	0.0	-0.3	-0.4	-0.5	0.0	-0.4	-0.6	-0.9	0.0	-0.3	-0.4	-0.5
-o/w Flooding					0.0	-0.5	-1.2	-1.7	0.0	-0.5	-1.2	-1.7	0.0	-0.5	-1.2	-1.7	0.0	-0.5	-1.2	-1.7
-o/w Roads and bridges					0.0	-0.2	-0.4	-0.4	0.0	-1.3	-1.7	-3.4	0.0	-0.1	-0.4	-0.5	0.0	-0.9	-1.2	-1.5
Population and employment																				
Total Population (Millions)	24.2	34.7	48.1	64.2																
Total Population growth rate (%)	3.9	3.4	3.1	2.7																
Working Age Population (Millions)	11.6	16.5	22.9	30.5																
Working Age Population growth rate (%)	-1.2	3.4	3.1	2.7																
Labor Participation Rate (%)	-1.2	3.4	3.1	2.7																
Unemployment Rate (%)	78.7	78.4	78.1	77.6																

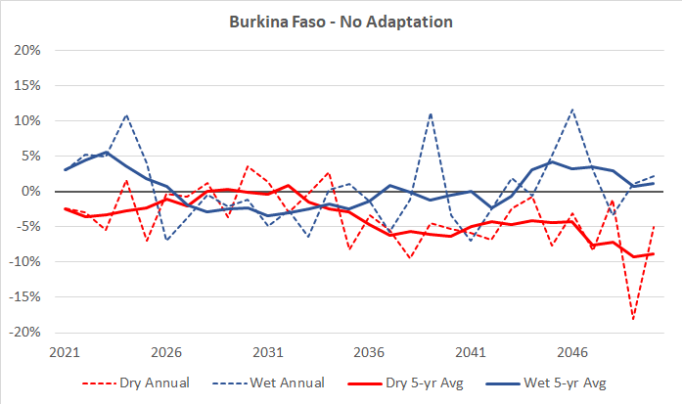
Notes
*** Deviations from baseline are expressed as percent of baseline level for Real GDP and Emissions. National income variables are presented as level results.**
For all other variables deviations from baseline are expressed as percentage points of GDP in the corresponding scenario less the % of GDP in the baseline scenario.
(1) Average annual growth since preceding period (2010 for the first column)

Source: CC-MFMOD, May 2022

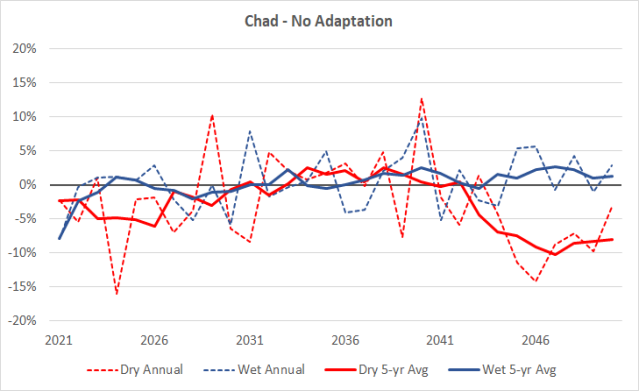
Notes: The figures show the combined effects of climate change shocks from six impact channels as deviation from the Baseline/No climate change real GDP projected under medium growth scenarios. Deviations are expressed as percent of Baseline/No climate change level of Real GDP projected under medium growth scenarios. The indicators are shown for the years 2020, 2030, 2040 and 2050. The impacts are shown with NO adaption, under a wet/optimistic climate scenario and a dry/pessimistic climate scenario, and with partial adaption to three of the six impact channels (rainfed crop yields, livestock yields and roads and bridges) under a wet/optimistic climate scenario and a dry/pessimistic climate scenario.

Figure 1-6 Impact Channel #1: Rainfed crop yield shocks, by dry and wet scenarios, NO adaptation

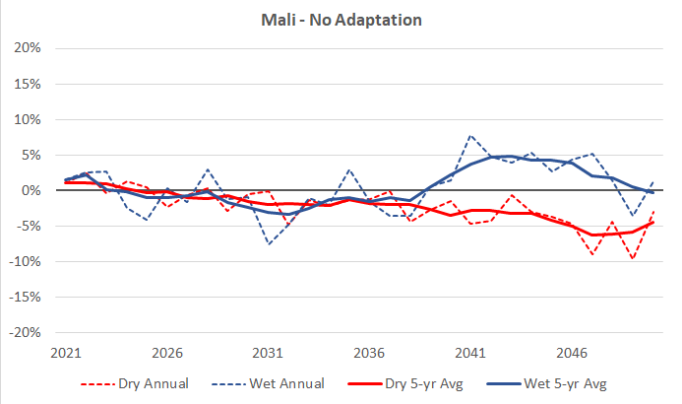
a. Burkina Faso



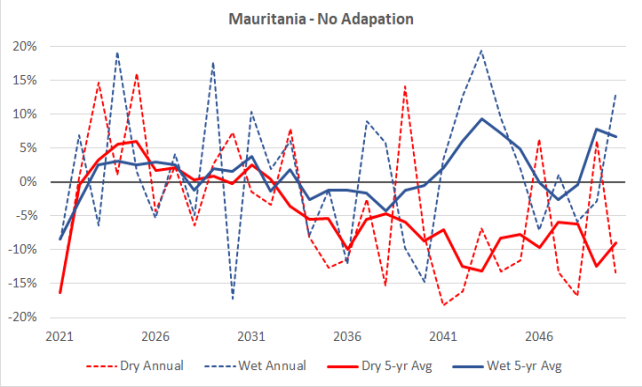
b. Chad



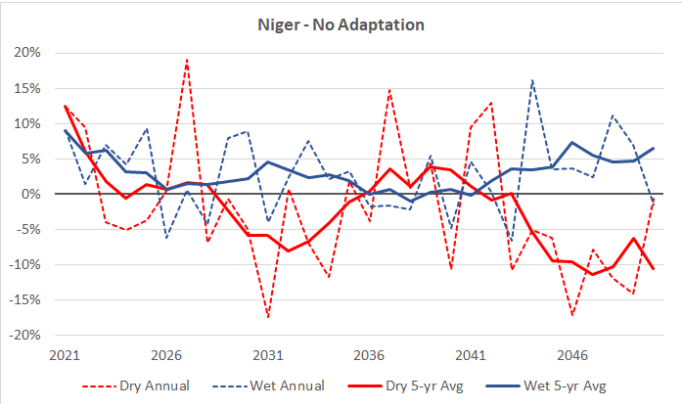
c. Mali



d. Mauritania



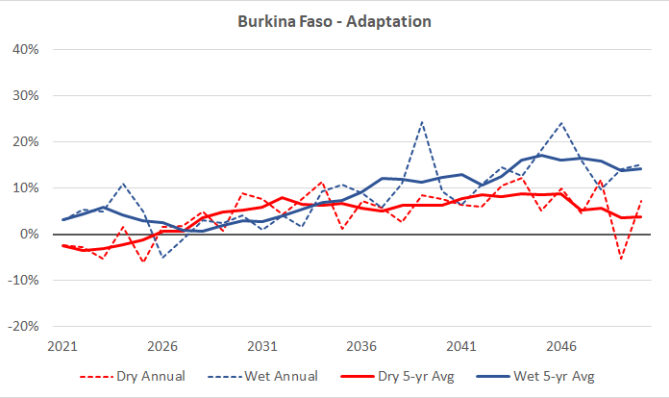
e. Niger



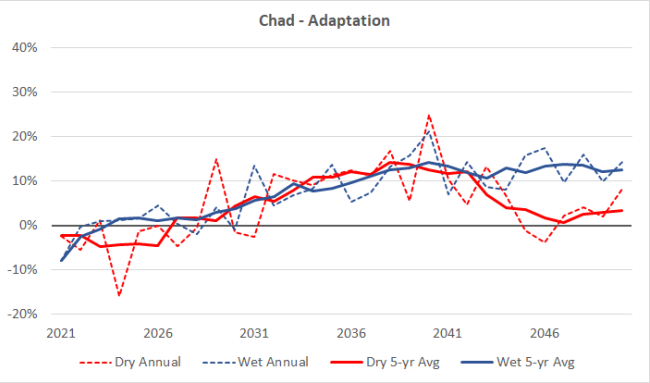
Source: IEc analysis for the World Bank
Notes: The figures show percent change in rainfed crop revenues from changes in temperature and precipitation, relative to a no climate change scenario. Given the large annual variability, five-year moving averages (the solid lines) are also shown.

Figure 1-7 Impact Channel #1: Rainfed crop yield shocks, by dry and wet climate scenarios, WITH adaptation

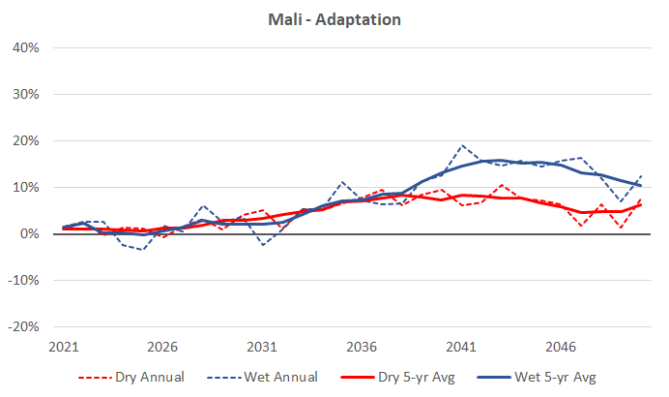
a. Burkina Faso



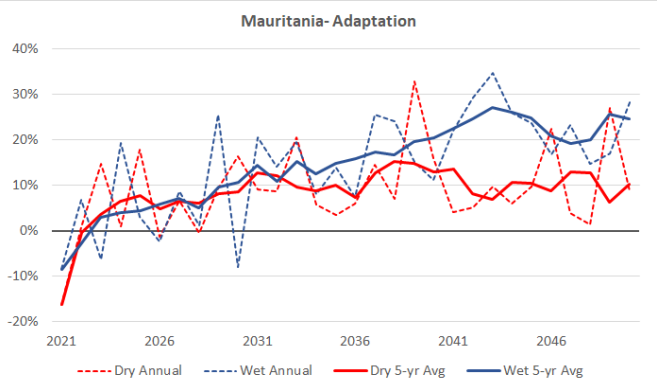
b. Chad



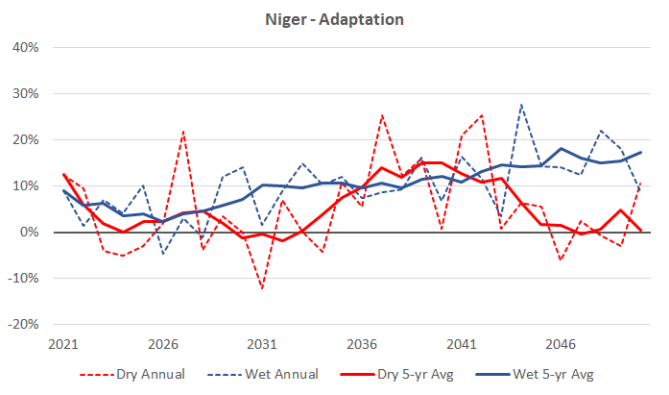
c. Mali



d. Mauritania



e. Niger

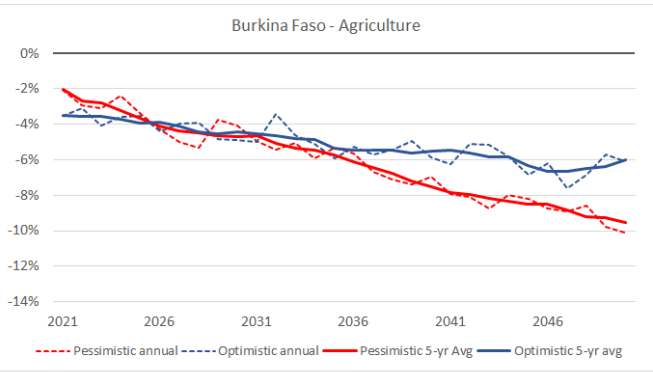


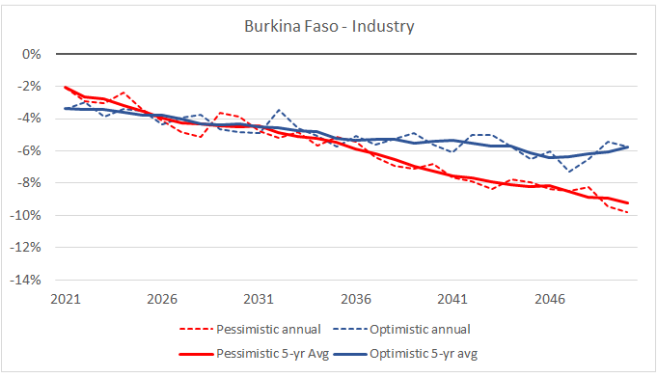
Source: IEc analysis for the World Bank

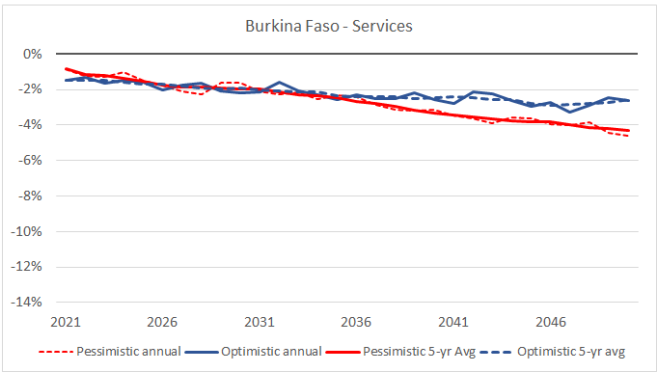
Note: The figures show percent change in crop revenues considering two adaptation measures: (1) Rehabilitation of irrigation infrastructure for currently irrigated crops, boosting yields of irrigated crops. Estimated investment needs linearly prorated between 2021-2035; (2) Construction of shallow GW pumps for high value crops and most important food crops, partially boosting crop yields and mitigating negative shocks of climate change in terms of insufficient precipitation. Estimated investment needs linearly prorrated between 2021-2035. Given the large annual variability, five-year moving averages (the solid lines) are also shown.

Figure 1-8 Impact Channel #2: Heat shock on labor productivity for the climate optimistic (SSP1-1.9) and pessimistic (SSP3-7.0) scenarios, NO adaptation

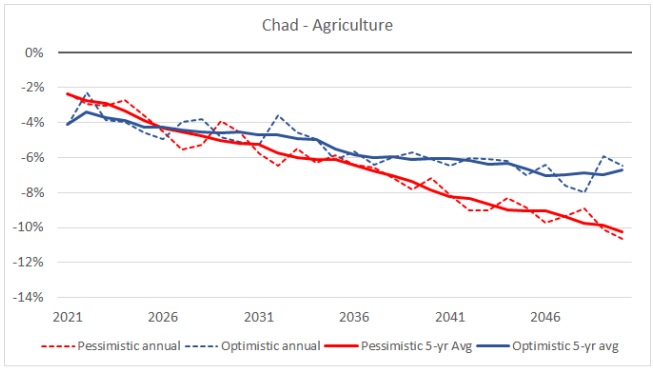
a. Burkina Faso

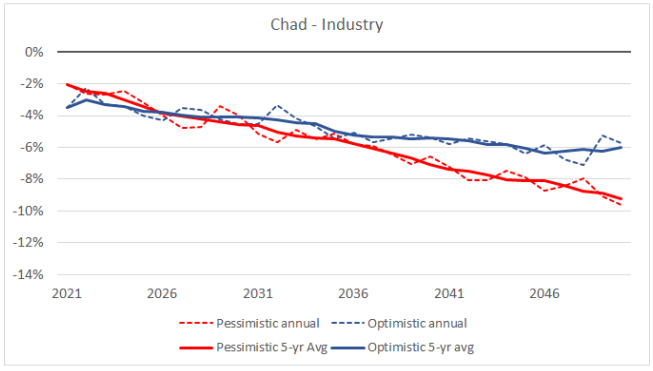


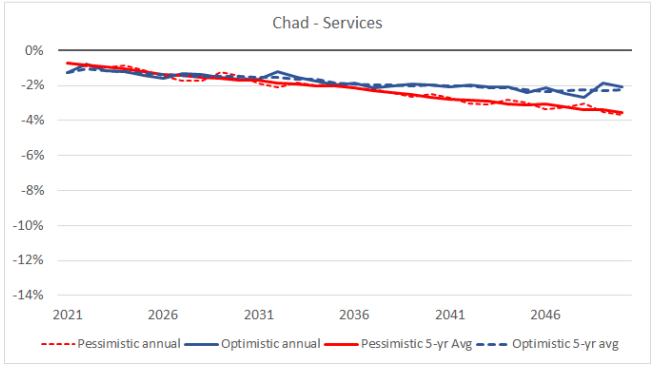




b. Chad





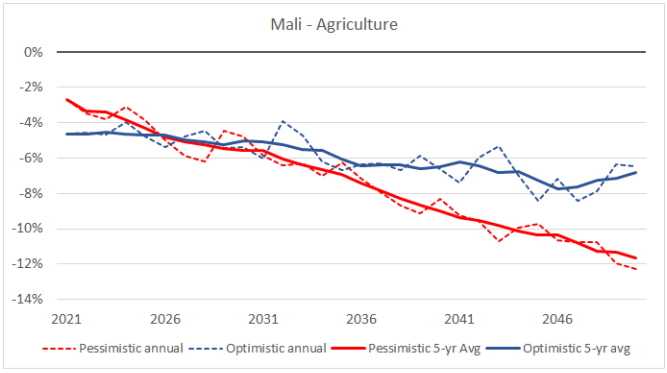


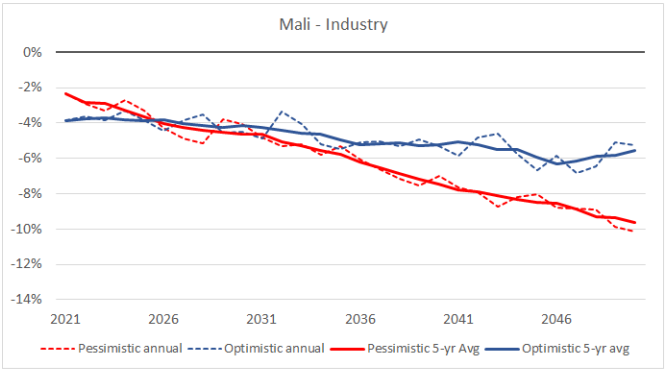
Source: IEc analysis for the World Bank

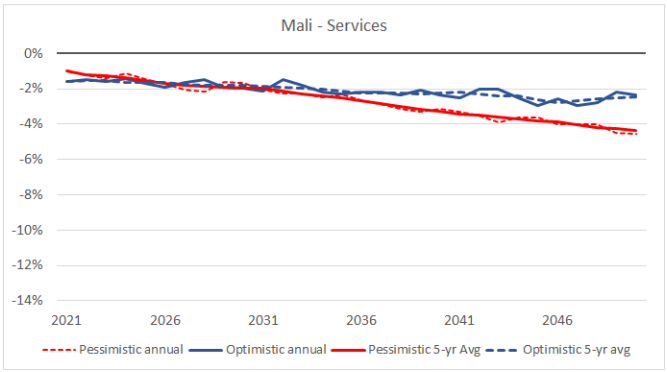
Notes: The figures show percent change in labor productivity by sector from changes in projected temperature, which reduce outdoor workers' performance, relative to a no climate change scenario. Given the large annual variability, five-year moving averages (the solid lines) are also shown.

Figure 1-9 Impact Channel #2: Heat shock on labor productivity for the climate optimistic (SSP1-1.9) and pessimistic (SSP3-7.0) scenarios, NO adaptation

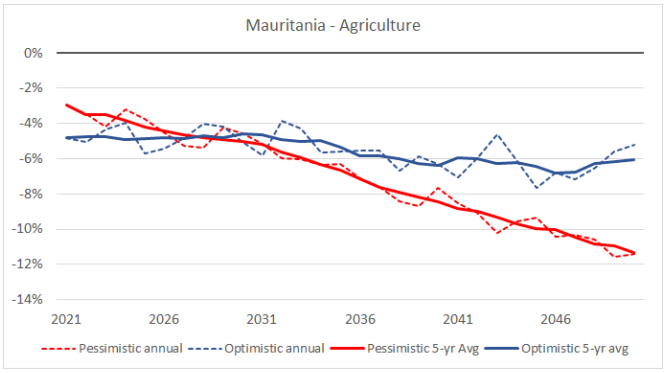
c. Mali

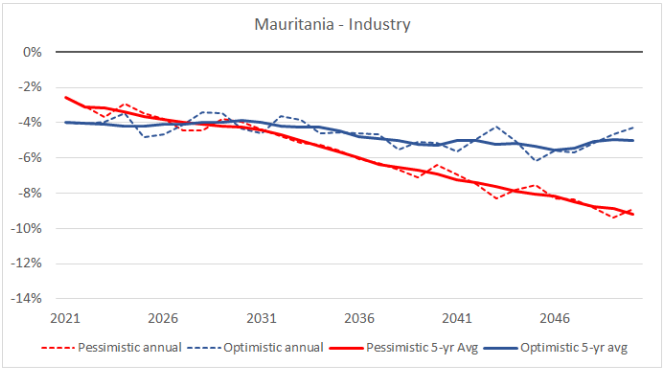


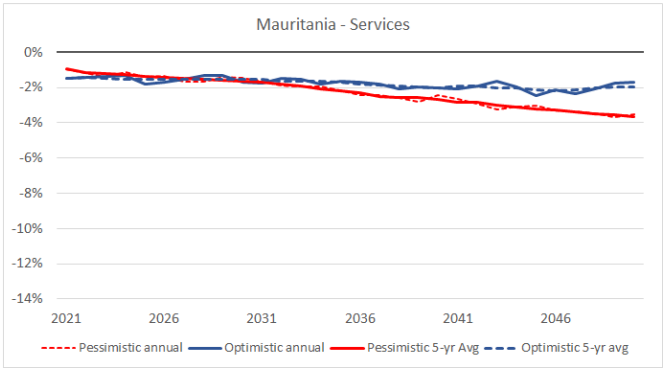




d. Mauritania



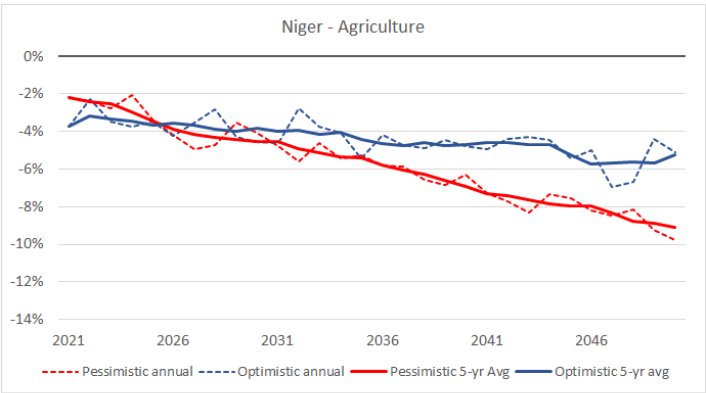


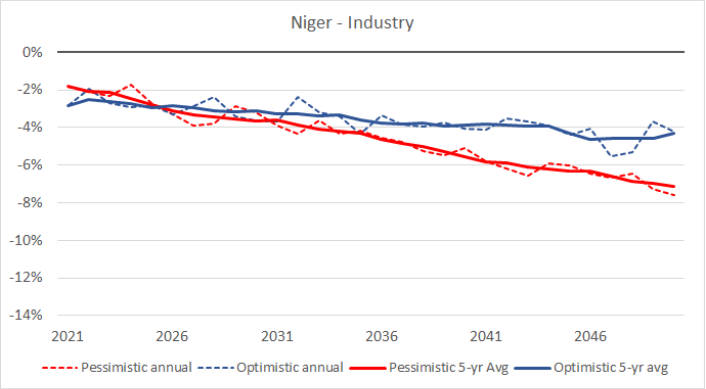


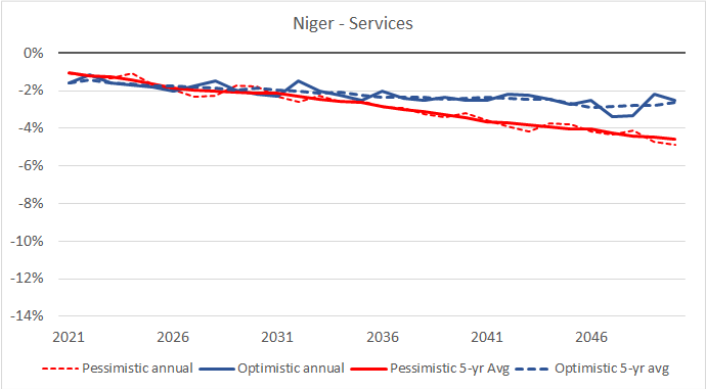
Source: IEc analysis for the World Bank
Notes: The figures show percent change in labor productivity by sector from changes in projected temperature, which reduce outdoor workers' performance, relative to a no climate change scenario. Given the large annual variability, five-year moving averages (the solid lines) are also shown.

Figure 1-10 Impact Channel #2: Heat shock on labor productivity for the climate optimistic (SSP1-1.9) and pessimistic SSP3-7.0) scenarios, NO adaptation

e. Niger



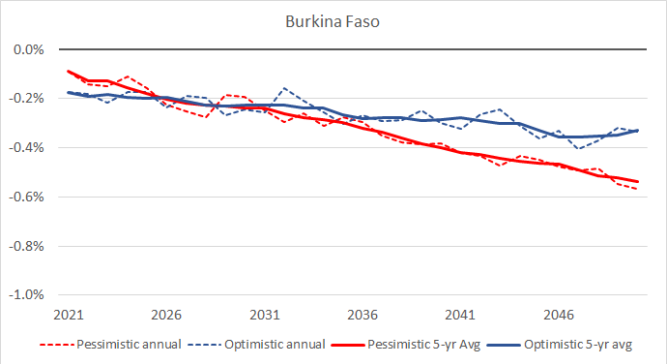




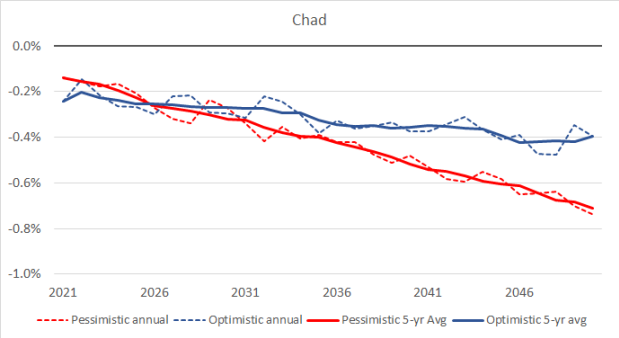
Source: IEc analysis for the World Bank
Notes: The figures show percent change in labor productivity by sector from changes in projected temperature, which reduce outdoor workers' performance, relative to a no climate change scenario. Given the large annual variability, five-year moving averages (the solid lines) are also shown.

Figure 1-11 Impact Channel #3: Heat-related human health-labor productivity shocks for the climate optimistic (SSP1-1.9) and pessimistic (SSP3-7.0) scenarios, NO adaptation

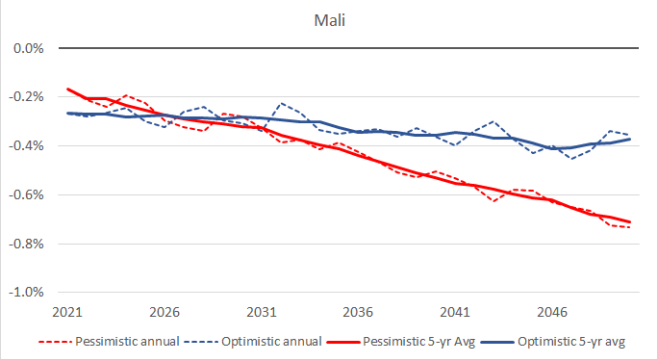
a. Burkina Faso



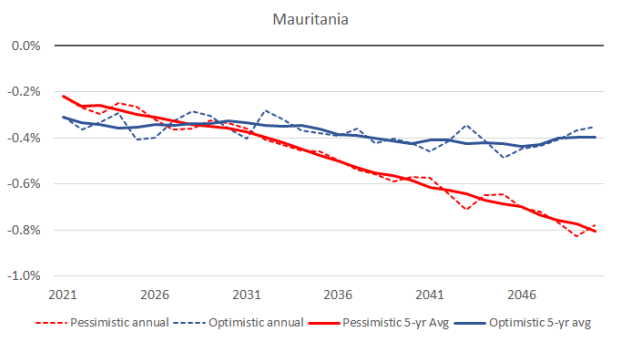
b. Chad



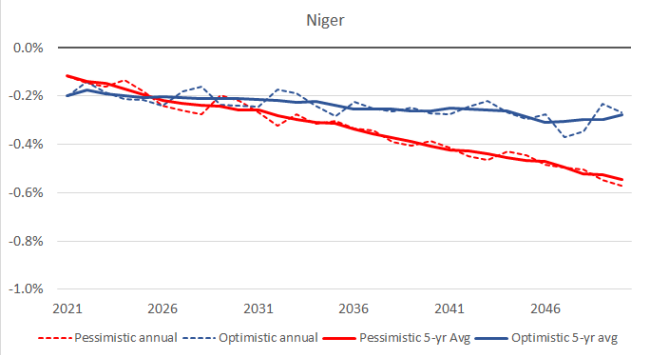
c. Mali



d. Mauritania



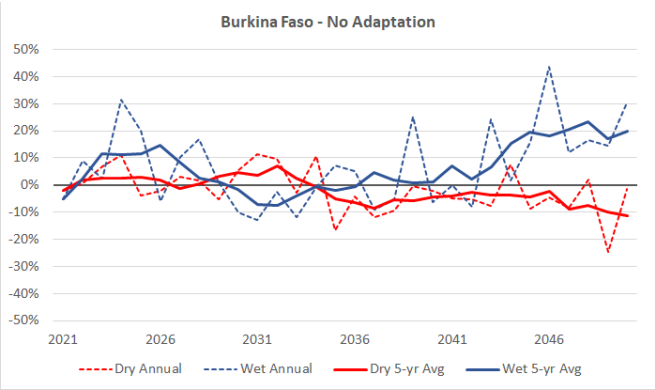
e. Niger



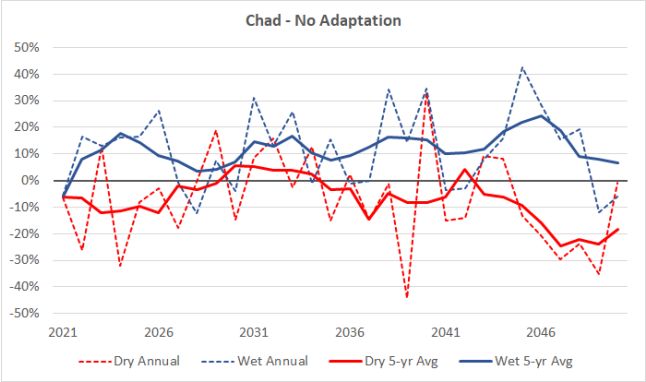
Source: IEc analysis for the World Bank
Notes: The figures show percent change in labor productivity from increases in mortality and morbidity due to increased temperatures, relative to a no climate change scenario. Given the large annual variability, five-year moving averages (the solid lines) are also shown.

Figure 1-12 Impact Channel #4: Livestock yield shocks, by dry and wet climate scenarios, NO adaptation

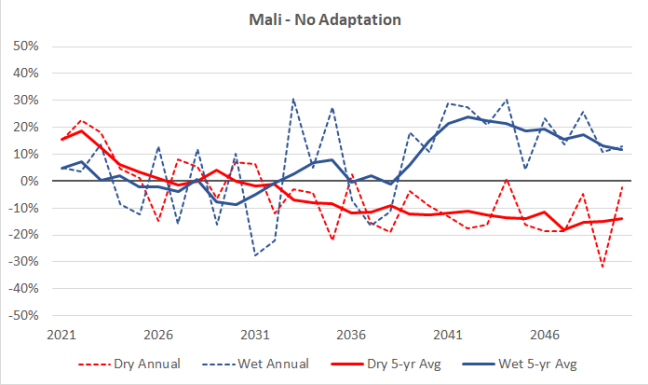
a. Burkina Faso



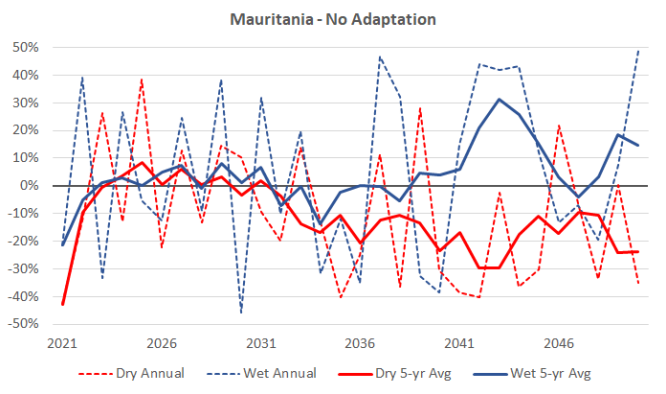
b. Chad



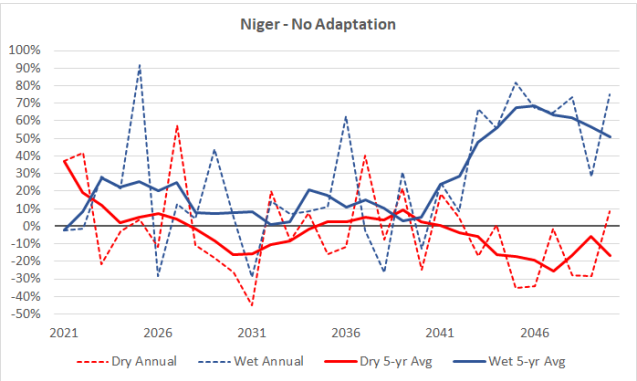
c. Mali



d. Mauritania



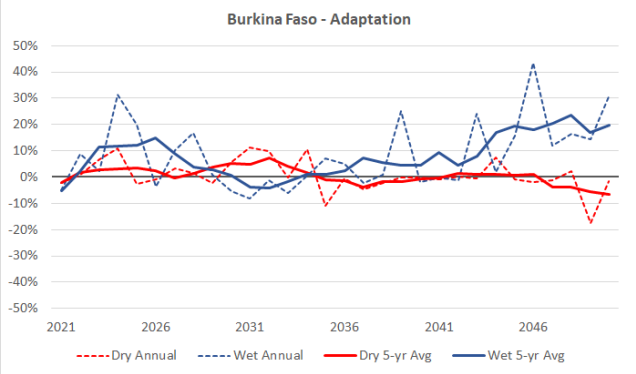
e. Niger



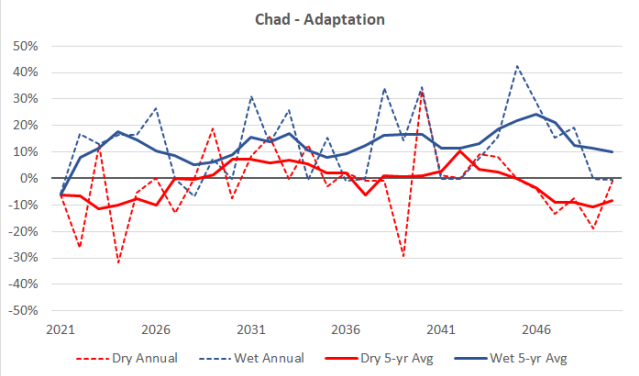
Source: IEc analysis for the World Bank
Notes: The figures show percent change in livestock revenues from changes in temperature and precipitation, which cause productivity losses from (i) heat stress on animals (ii) and reduced availability of pastures to graze. Given the large annual variability, five-year moving averages (the solid lines) are also shown.

Figure 1-13 Impact Channel #4: Livestock yield shocks, by dry and wet climate scenarios, WITH adaptation

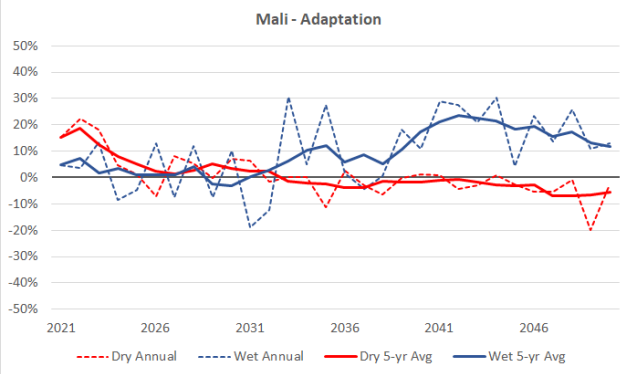
a. Burkina Faso



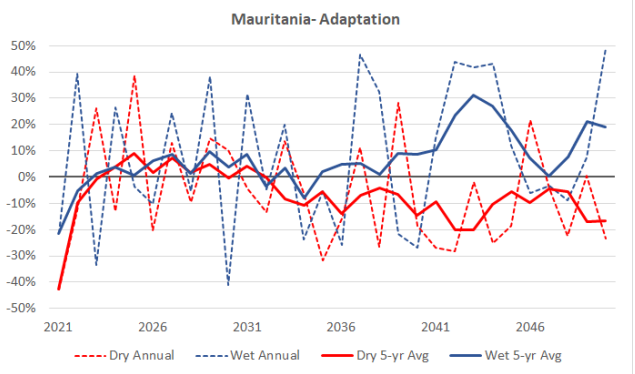
b. Chad



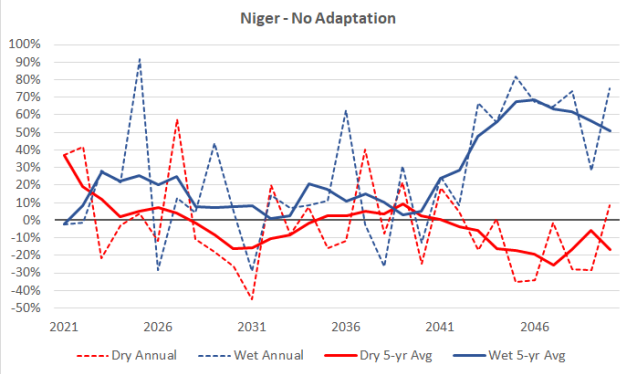
c. Mali



d. Mauritania



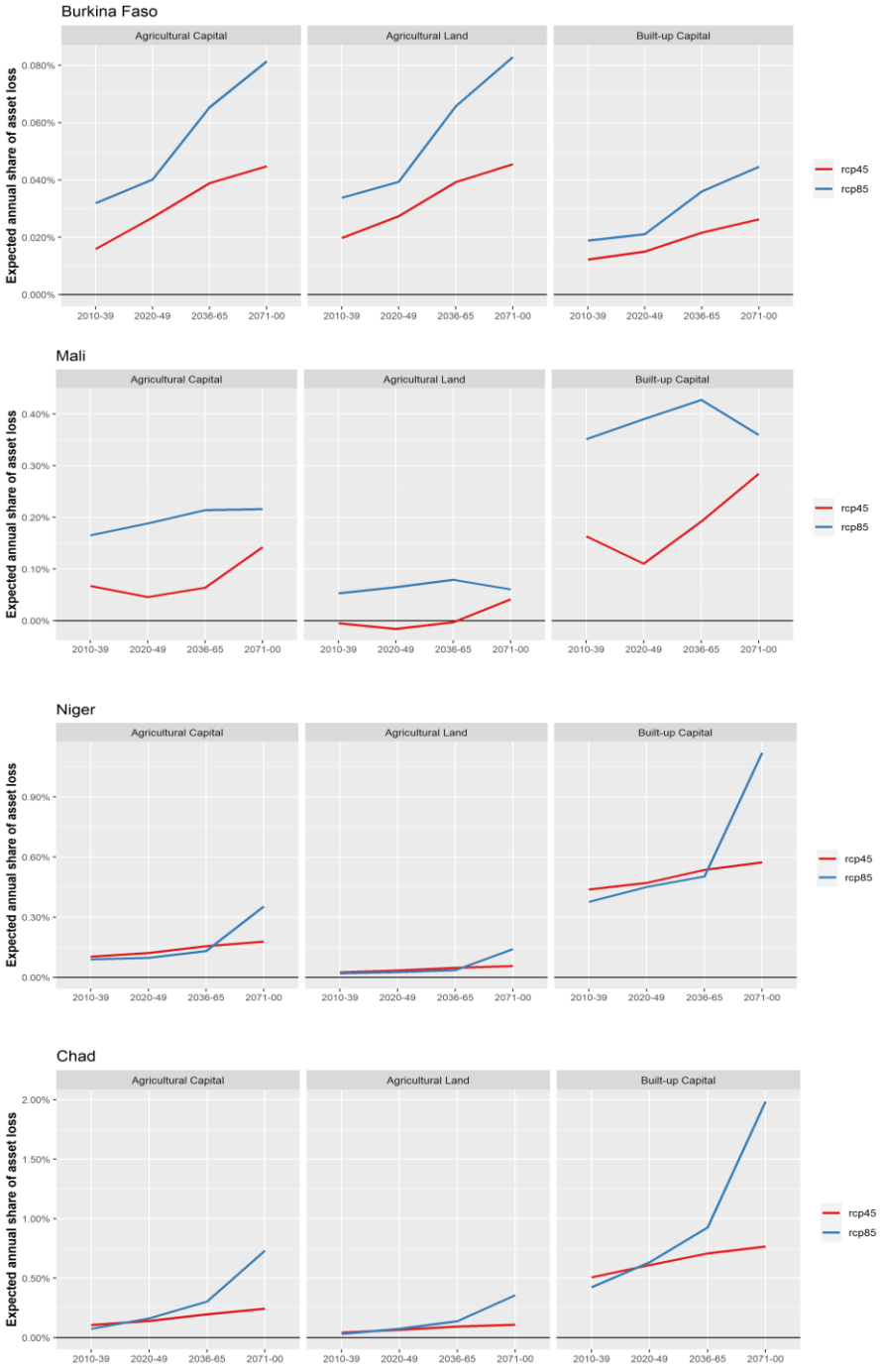
e. Niger



Source: IEc analysis for the World Bank

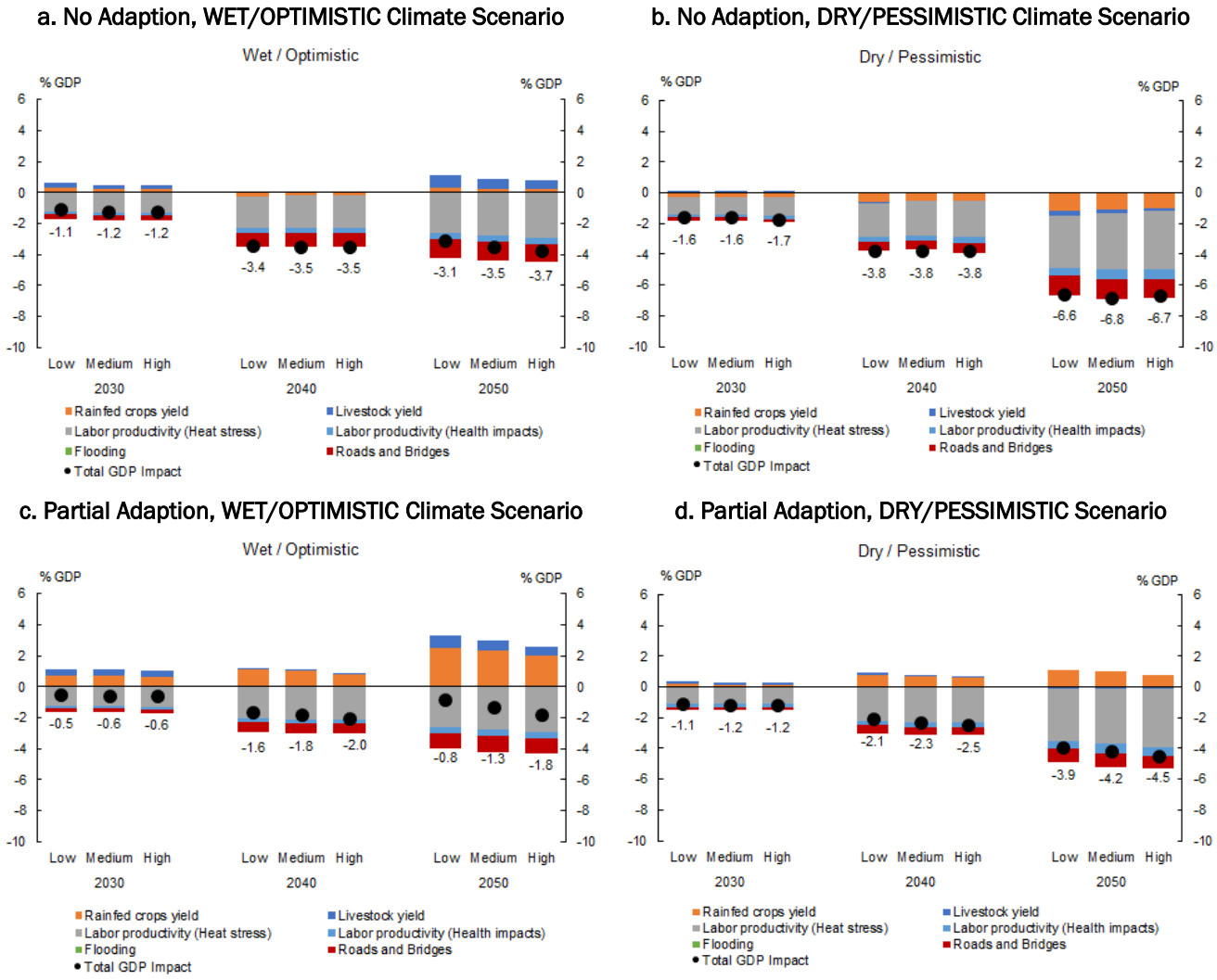
Note: The figures show percent change in livestock revenues from changes in temperature and precipitation, considering adaptation benefits from two interventions: (1) Purchasing crop residues from in-country crop production (largely maize) to use as animal feed, compensating the productivity losses of pastures; (2) Investment in establishing fodder banks (i.e., a system of forage cultivation with woody and leguminous species) that can be grazed by animals, compensating the productivity losses of pastures. Given the large annual variability, five-year moving averages (the solid lines) are also shown.

Figure 1-14 Impact Channel #5: Inland flooding shocks (% of assets damaged) for the RCP 4.5 and RCP 8.5 scenarios, NO adaptation



Source: IEc analysis for the World Bank
Notes: The figures shows the percentage of assets (three types: built-up capital (i.e., hard infrastructure like roads or buildings), agricultural capital, and agricultural land) that are expected to get damaged annually due to an increase in the recurrence interval of flooding events. Inland flooding shocks are based on available CMIP5 projections for RCP 4.5 and RCP 8.5 by era (2010-2039, 2020-2049, 2036-2065 and 2071-2100).

Figure 1-15 Impact on annual GDP of combined effects of climate change shocks from six impact channels for Burkina Faso

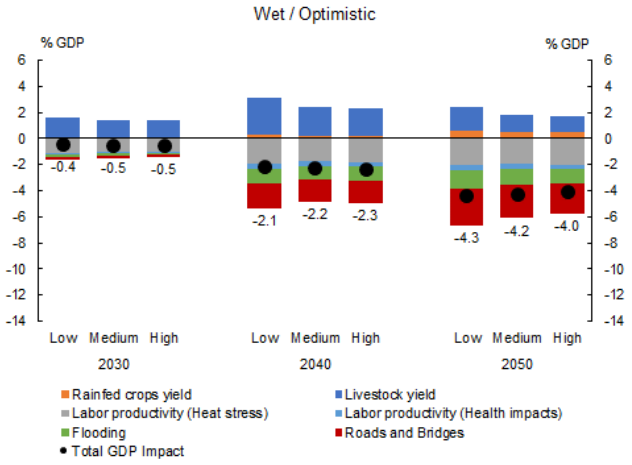


Source: IEc analysis for the World Bank, CC-MFMOD, May 2022

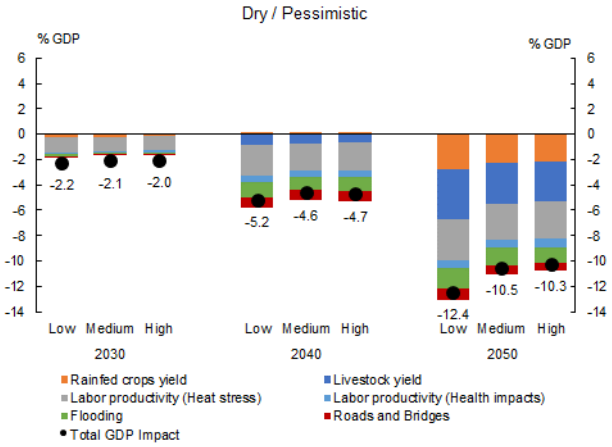
Notes: The figures show the combined effects of climate change shocks from six impact channels as deviation from the Baseline/No climate change real GDP projected under low, medium and high growth scenarios. Deviations are expressed as percent of Baseline/No climate change level of Real GDP projected under low, medium and high growth scenarios. The impacts are shown for the years 2030, 2040 and 2050. Figures A and B show the impacts with NO adaption, under a wet/optimistic climate scenario and a dry/pessimistic climate scenario. Figures C and D show the impacts with partial adaption to three of the six impact channels (rainfed crop yields, livestock yields and roads and bridges) under a wet/optimistic climate scenario and a dry/pessimistic climate scenario. The data labels refer to the Total NET GDP impact.

Figure 1-16 Impact on annual GDP of combined effects of climate change shocks from six impact channels for Chad

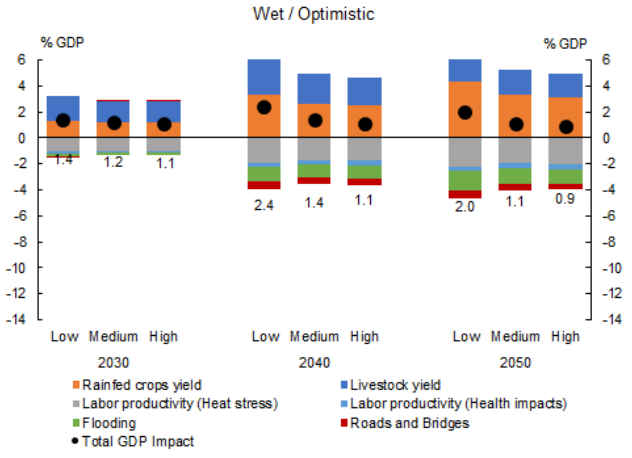
a. No Adaption, WET/OPTIMISTIC Climate Scenario



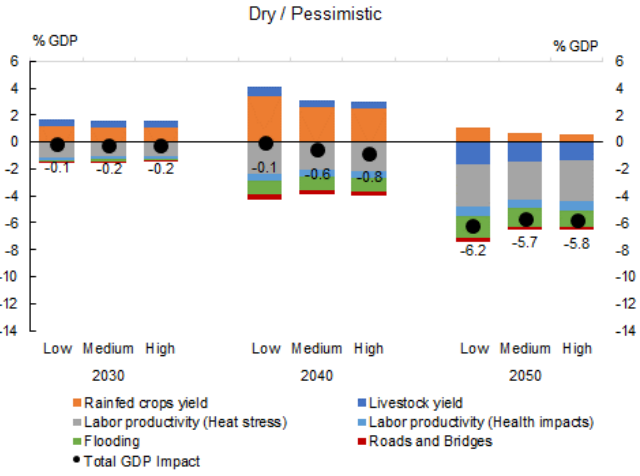
b. No Adaption, DRY/PESSIMISTIC Climate Scenario



c. Partial Adaption, WET/OPTIMISTIC Climate Scenario



d. Partial Adaption, DRY/PESSIMISTIC Scenario

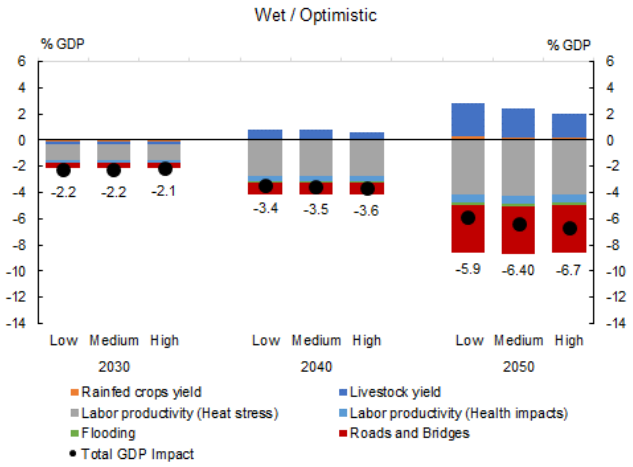


Source: IEc analysis for the World Bank, CC-MFMOD, May 2022

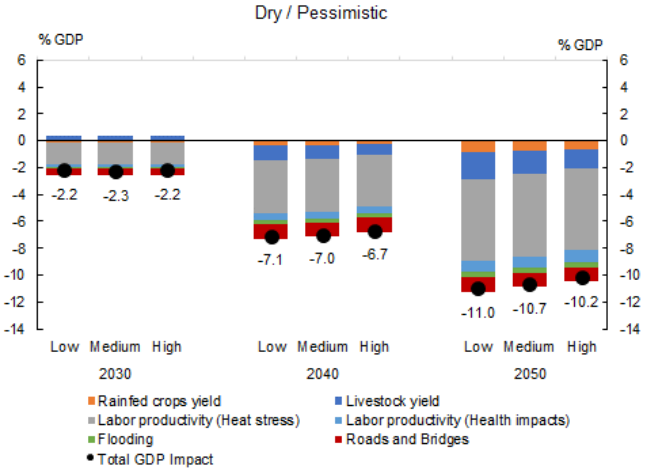
Notes: The figures show the combined effects of climate change shocks from six impact channels as deviation from the Baseline/No climate change real GDP projected under low, medium and high growth scenarios. Deviations are expressed as percent of Baseline/No climate change level of Real GDP projected under low, medium and high growth scenarios. The impacts are shown for the years 2030, 2040 and 2050. Figures A and B show the impacts with NO adaption, under a wet/optimistic climate scenario and a dry/pessimistic climate scenario. Figures C and D show the impacts with partial adaption to three of the six impact channels (rainfed crop yields, livestock yields and roads and bridges) under a wet/optimistic climate scenario and a dry/pessimistic climate scenario. The data labels refer to the Total NET GDP impact.

Figure 1-17 Impact on annual GDP of combined effects of climate change shocks from six impact channels for Mali

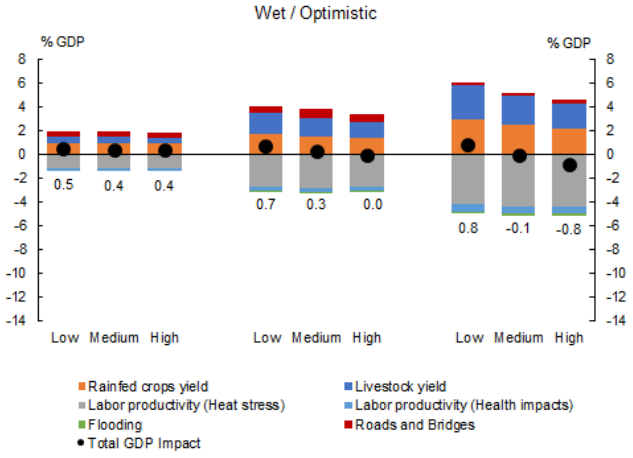
a. No Adaption, WET/OPTIMISTIC Climate Scenario



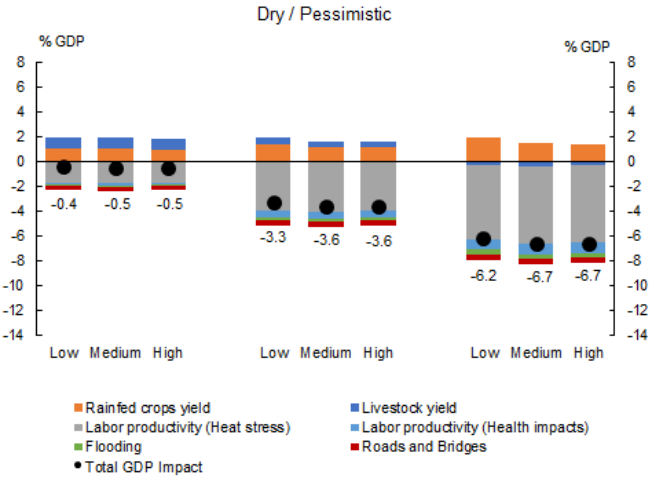
b. No Adaption, DRY/PESSIMISTIC Climate Scenario



c. Partial Adaption, WET/OPTIMISTIC Climate Scenario



d. Partial Adaption, DRY/PESSIMISTIC Scenario

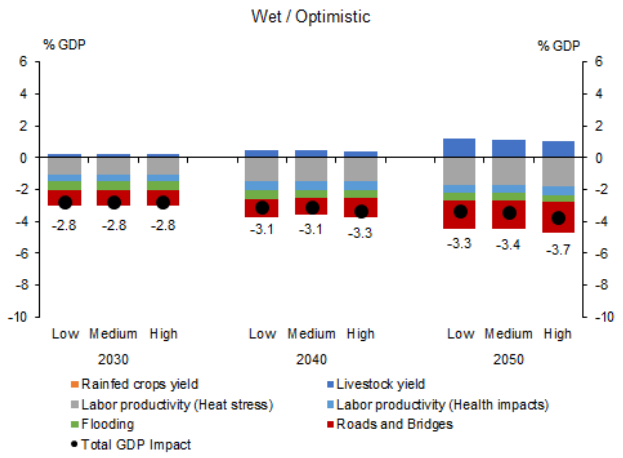


Source: IEc analysis for the World Bank, CC-MFMOD, May 2022

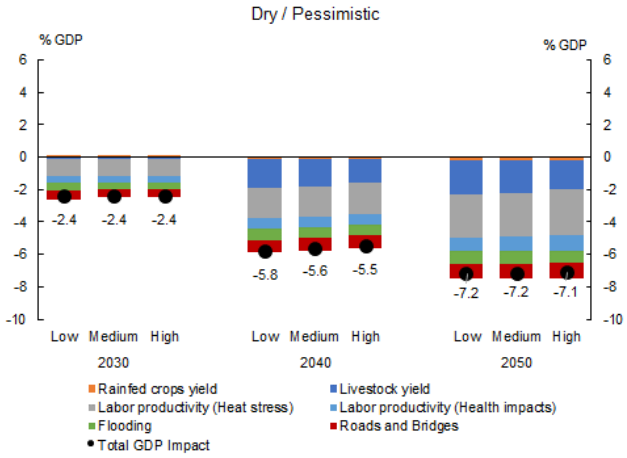
Notes: The figures show the combined effects of climate change shocks from six impact channels as deviation from the Baseline/No climate change real GDP projected under low, medium and high growth scenarios. Deviations are expressed as percent of Baseline/No climate change level of Real GDP projected under low, medium and high growth scenarios. The impacts are shown for the years 2030, 2040 and 2050. Figures A and B show the impacts with NO adaption, under a wet/optimistic climate scenario and a dry/pessimistic climate scenario. Figures C and D show the impacts with partial adaption to three of the six impact channels (rainfed crop yields, livestock yields and roads and bridges) under a wet/optimistic climate scenario and a dry/pessimistic climate scenario. The data labels refer to the Total NET GDP impact.

Figure 1-18 Impact on annual GDP of combined effects of climate change shocks from six impact channels for Mauritania

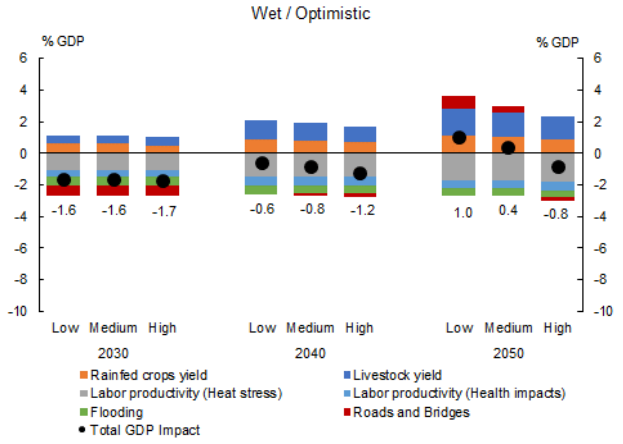
a. No Adaption, WET/OPTIMISTIC Climate Scenario



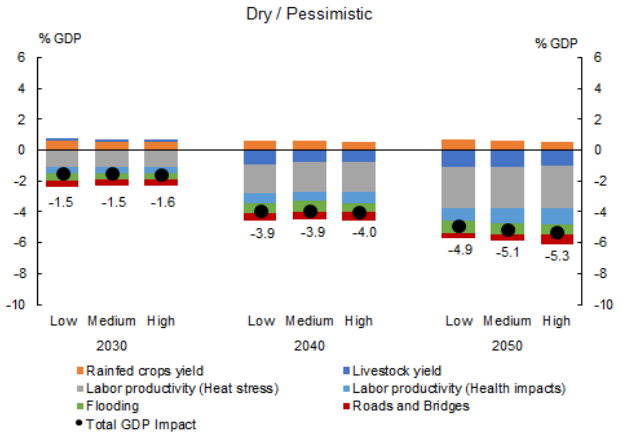
b. No Adaption, DRY/PESSIMISTIC Climate Scenario



c. Partial Adaption, WET/OPTIMISTIC Climate Scenario



d. Partial Adaption, DRY/PESSIMISTIC Scenario

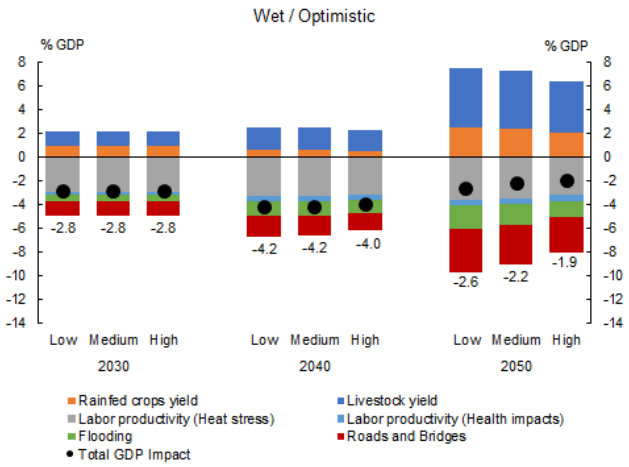


Source: IEc analysis for the World Bank, CC-MFMOD, May 2022

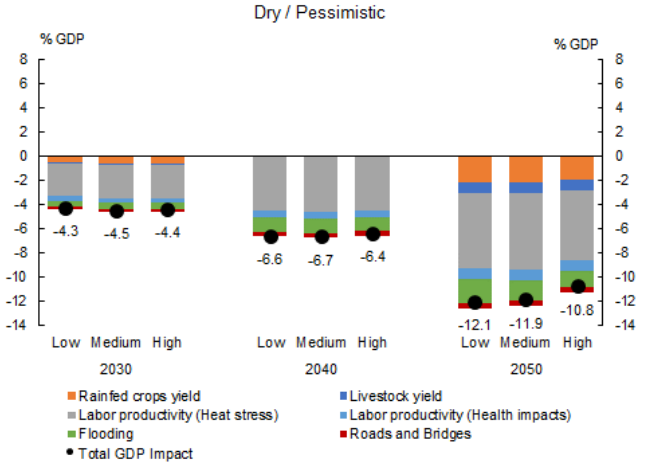
Notes: The figures show the combined effects of climate change shocks from six impact channels as deviation from the Baseline/No climate change real GDP projected under low, medium and high growth scenarios. Deviations are expressed as percent of Baseline/No climate change level of Real GDP projected under low, medium and high growth scenarios. The impacts are shown for the years 2030, 2040 and 2050. Figures A and B show the impacts with NO adaption, under a wet/optimistic climate scenario and a dry/pessimistic climate scenario. Figures C and D show the impacts with partial adaption to three of the six impact channels (rainfed crop yields, livestock yields and roads and bridges) under a wet/optimistic climate scenario and a dry/pessimistic climate scenario. The data labels refer to the Total NET GDP impact.

Figure 1-19 Impact on annual GDP of combined effects of climate change shocks from six impact channels for Niger

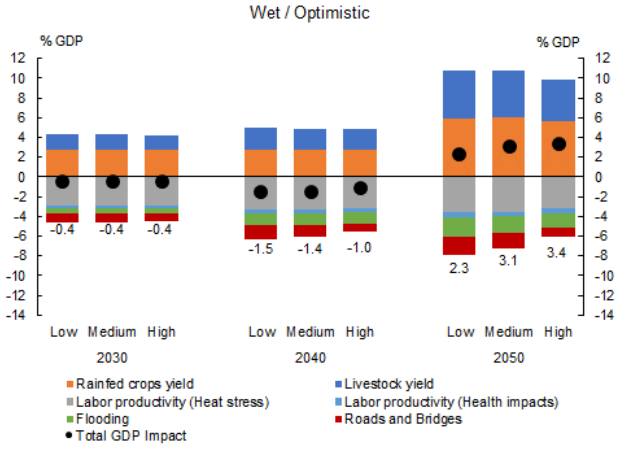
a. No Adaption, WET/OPTIMISTIC Climate Scenario



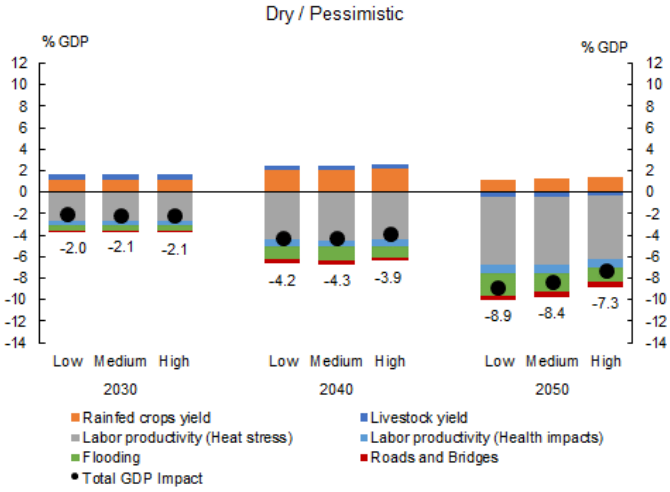
b. No Adaption, DRY/PESSIMISTIC Climate Scenario



c. Partial Adaption, WET/OPTIMISTIC Climate Scenario



d. Partial Adaption, DRY/PESSIMISTIC Scenario



Source: IEc analysis for the World Bank, CC-MFMOD, May 2022

Notes: The figures show the combined effects of climate change shocks from six impact channels as deviation from the Baseline/No climate change real GDP projected under low, medium and high growth scenarios. Deviations are expressed as percent of Baseline/No climate change level of Real GDP projected under low, medium and high growth scenarios. The impacts are shown for the years 2030, 2040 and 2050. Figures A and B show the impacts with NO adaption, under a wet/optimistic climate scenario and a dry/pessimistic climate scenario. Figures C and D show the impacts with partial adaption to three of the six impact channels (rainfed crop yields, livestock yields and roads and bridges) under a wet/optimistic climate scenario and a dry/pessimistic climate scenario. The data labels refer to the Total NET GDP impact.

2 Supplemental Notes

2.1 Thematic Supplemental Notes

2.1.1 Energy: Regional power integration

2.1.1.1 Mauritania

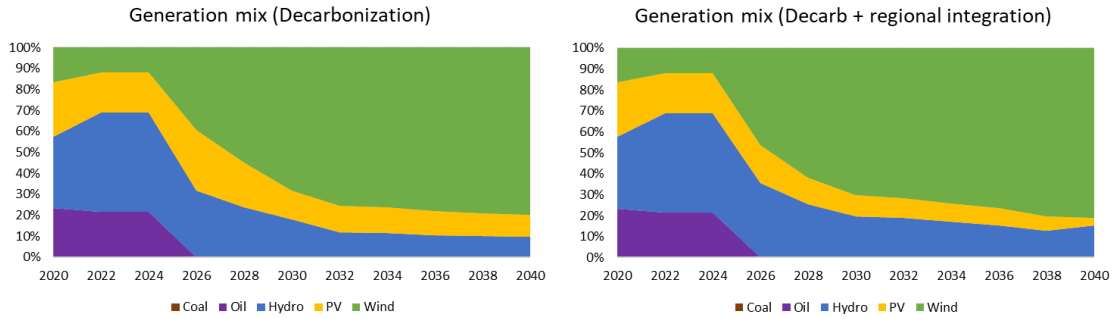
Context: Mauritania currently relies heavily on expensive imported fuel oil for generation, the power sector burdens the state with the need to finance generation investments and to provide operating subsidies to the state utility, and relatively few people have access to electricity, especially in rural areas. However, the country is well endowed with gas, wind and solar primary energy resources and is interconnected with Senegal and indirectly with Mali, which are members of the West African Power Pool (WAPP).

Opportunity: The Government aims to achieve universal access while providing low-cost reliable supply by harnessing domestic energy resources for electricity generation while also decarbonizing and stimulating growth. To do this it needs a financially viable sector that attracts private capital.

Regional power sector modelling shows that regional integration could help to achieve economies of scale in generation thereby reducing costs while decarbonizing the sector and reducing dependence on expensive imported oil through better integration of renewable generation (Figure 2-1). Furthermore, regional integration could allow Mauritania to earn revenues from the export of surplus generation from its world class wind energy resources.

Reducing generation costs and earning revenues from exporting surplus energy will improve the financial sustainability of the national utility, improving its credibility as an off-taker for privately financed independent power producers (IPPs). In addition, allowing access to neighboring power markets can reduce the market risk faced by IPPs. Finally, regional integration helps to provide the flexibility required by an electricity system with a significant share of generation from intermittent renewable energy.

Figure 2-1: Mauritania generation mix

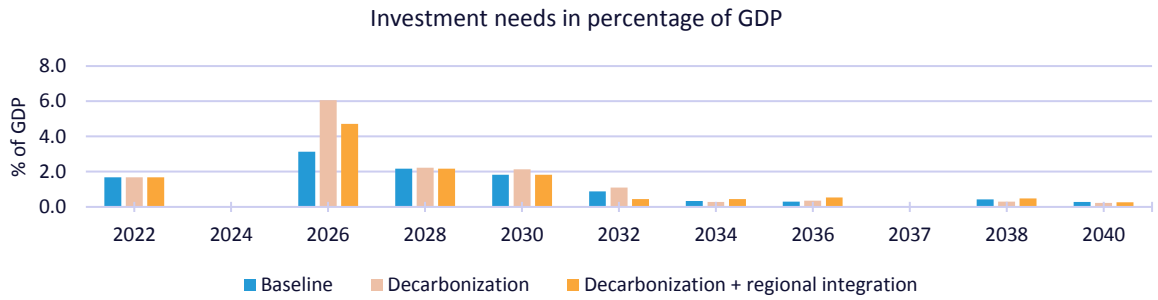


Source: World Bank
Note: the generation mix includes Mauritania's share of generation from regional hydro power stations developed by the Organisation pour la Mise en Valeur du fleuve Sénégal (OMVS)

Enablers and barriers: Mauritania already imports electricity from its share of the two OMVS hydro power plants Manantali and Felou, located in Mali. To deepen regional integration Mauritania will need to establish a regulatory, operational and commercial framework conducive to the integration of electricity markets (e.g., allow third party access to networks for regional trade), adopt the technical and commercial codes of the WAPP and the standardized contract templates for bilateral electricity trade, and update national least cost power sector plans that take into account regional options for exports and imports.

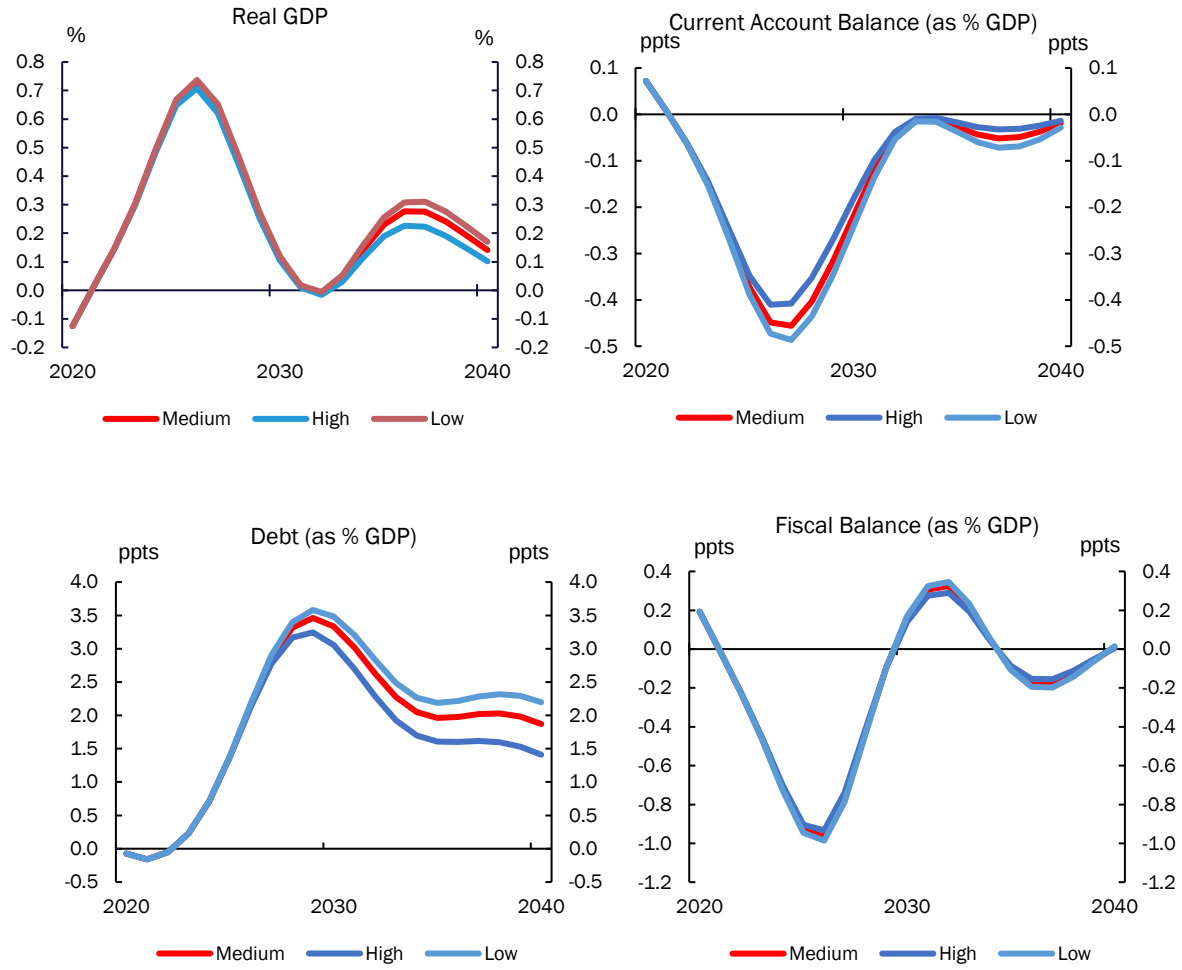
Investment needs and macro-fiscal impacts: Mauritania will need to invest to meet the growing demand for electricity, but at a different pace depending on the scenario. Investment needs for the country in the decarbonization plus regional integration scenario are lower than in the decarbonization scenario, showing the economic benefits of regional integration. The additional investments needed for decarbonization and regional integration scenarios compared to the baseline are relatively small and are expected to occur in the near term, in the mid-2020s.

Figure 2-2: Mauritania investment needs (a percentage of GDP)



GDP used is the medium growth scenario. Source: World Bank CC-MFMOD

Figure 2-3: Macro-fiscal response of Decarbonization plus Regional integration versus baseline (Mauritania)



Taking Baseline scenario as the reference scenario, the macroeconomic modeling simulates the impacts of government-funded changes in investment needs and cost of operations of the decarbonization plus regional integration scenario, under three development scenarios (Low, Medium, and High growth). These simulations do not take into account co-benefits (e.g. air pollution reduction). GDP is the percent deviation from the GDP in the Baseline. CAB, (Public) Debt, and Fiscal Balance (as % of GDP) are the difference in percentage points of GDP from the Baseline. Source: WB CC-MFMOD

The increase in public spending to meet investment needs for the decarbonization plus regional integration scenario compared to the baseline scenario will increase GDP by up to 0.8 percent but at the cost of an increase of public debt (3.5 percentage points of GDP above the baseline in 2030), with the impact on the fiscal balance as a share of GDP hovering near zero in the medium-term. The current account balance would decline slightly in the short term, by -0.5 percentage points of GDP, due to the increase in imports demand resulting from real investment needs. The CAB will return to the baseline in the medium term as investment needs fall and Mauritania benefits from exports. The overall macro-fiscal impacts are limited given that the additional investments needed for the decarbonization and regional integration scenario compared to the baseline scenario are relatively small.

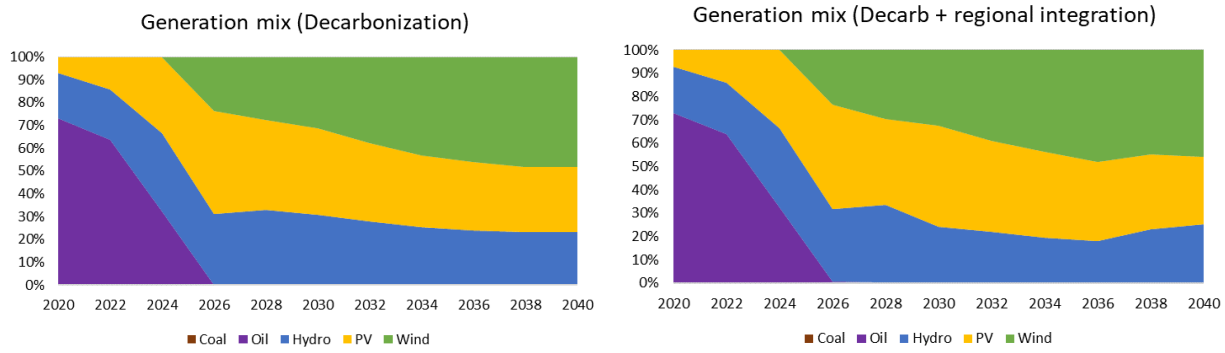
2.1.1.2 Mali

Context: Mali is a landlocked and fragile country with electricity low access rates that is vulnerable to security and natural crises. Despite high tariffs for electricity, costs are even higher due to a heavy reliance on expensive imported liquid fuels for generation, use of expensive rental generation and high

network losses, which leaves the national utility, EDM SA, in a precarious financial situation. Mali is interconnected with the power systems of Cote d'Ivoire and Senegal, and projects are underway to interconnect the country with Guinea and Burkina Faso.

Opportunity: The regional electricity market presents Mali with the opportunity to reduce its costs of supply while improving resilience to the effects of climate change on its hydro generation (changes to rainfall patterns) and electricity network (increasing wildfires). The adopted LCGP allows for 40% of total generation capacity to be imported by 2040. Regional integration has already allowed development of hydro projects such as Manantali, Felou and Gouina under OMVS, that would otherwise be too large to be developed to serve Mali alone. Further regional hydro projects are under development and planned. Regional power system modelling suggests that Mali could be a net importer of gas and hydro based electricity that will reduce its reliance on expensive oil-fired generation. In addition, the flexibility of the regional market would support the integration of renewable generation by allowing electricity to flow in different directions at different times depending on the relative costs of supply of Mali and its neighbors, for example, Mali could export surplus solar generation during the day and import cheap hydro and gas-based generation at night.

Figure 2-4: Mali generation mix



Source: World Bank

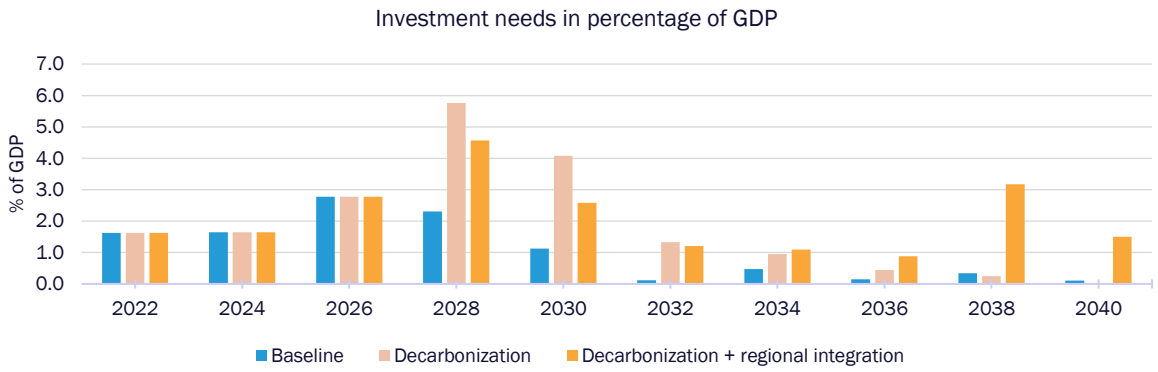
Enablers and barriers: To capture the benefits of regional integration, Mali should establish the national utility as a credible off-taker by putting in place a financial turnaround plan. This is partly circular since it entails cutting generation costs by using cheaper imports to displace expensive national generation and rental plants, reducing network losses and improving collections. It also entails strengthening the regulator and establishing a regulatory framework that safeguards the sector financial viability. Reducing costs and ensuring adequate revenues will allow the utility to meet its commercial obligations under import contracts and avoid new arrears accumulating.

These actions need to be complemented by a national planning framework that takes account of regional options for imports and exports, without compromising legitimate national security of supply objectives. As interconnectors to new countries are developed the increased diversity of supply may provide Mali with the assurance needed to rely even more on imports to reduce the costs of supply. Finally, a legal framework requiring competitive procurement of generation while allowing independent power producers would help to reduce generation costs and encourage private sector investors, thereby freeing up scarce state resources to be used elsewhere.

Investment needs and macro-fiscal impacts: Mali will have to invest much more to decarbonize its electricity supply, especially from the late 2020s. However, for the decarbonization plus regional integration scenario, this increase is smaller in the early years – one of the benefits of integration.

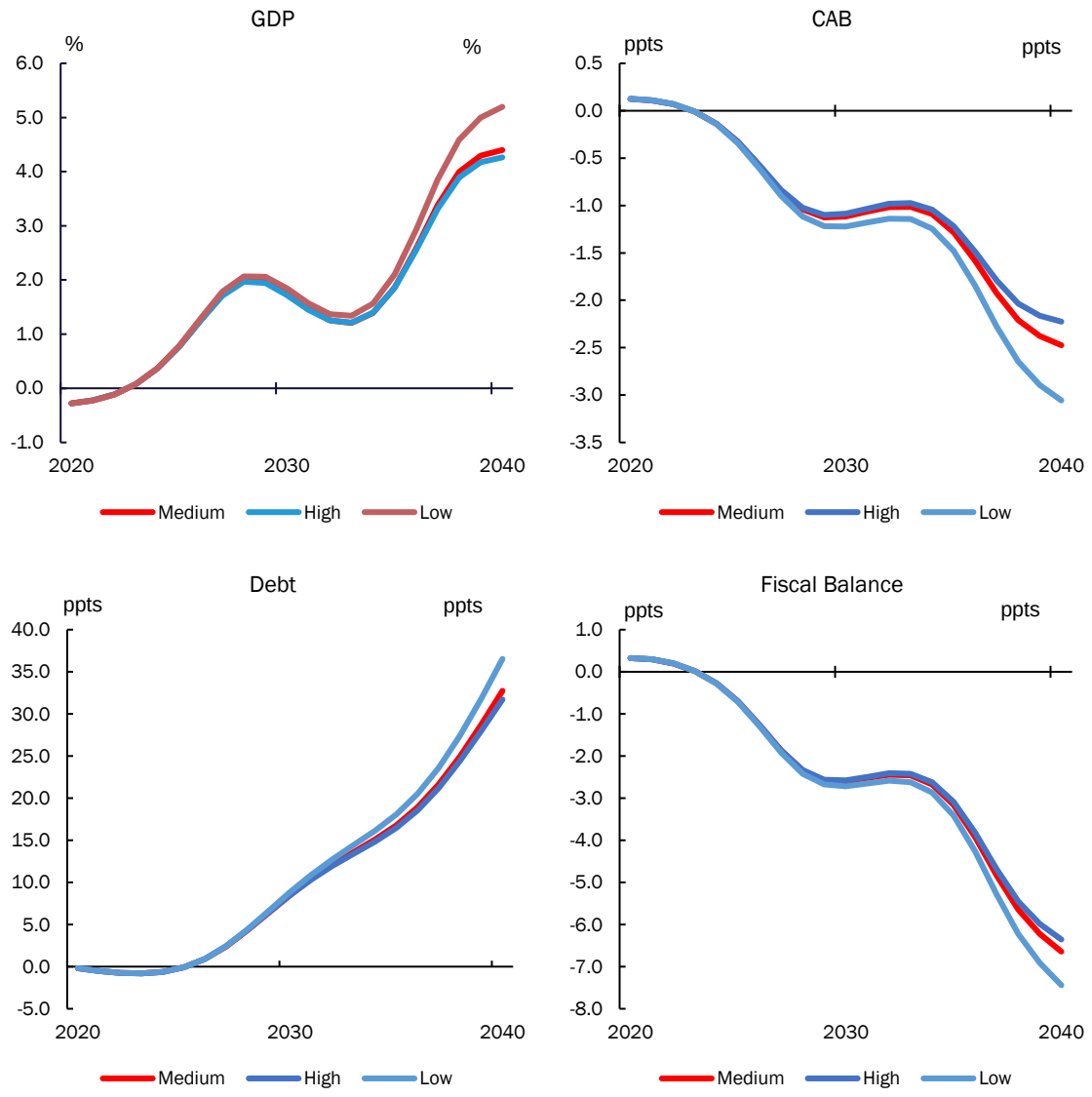
The higher public investment through to the 2040 required in the decarbonization plus regional integration scenario could boost aggregate demand, increasing GDP by up to 5 percentage points in 2040 compared to the baseline scenario. However, assuming that all the investment is financed through additional government borrowing, the fiscal balance will deteriorate and public debt would increase significantly by 32 to 37 percentage points of GDP by 2040. This scenario would not be fiscally sustainable and highlights the need for significant private sector investment. Finally, the increase in import-oriented domestic demand would put pressure on the current account, reducing it by 3 percentage points of GDP by 2040.

Figure 2-5: Mali investment needs (a percentage of GDP)



GDP used is the medium growth scenario. Source: World Bank

Figure 2-6: Macro-fiscal response of Decarbonization plus Regional integration versus baseline (Mali)



Taking Baseline scenario as the reference scenario, the macroeconomic modeling simulates the impacts of government-funded changes in investment needs and cost of operations of the decarbonization plus regional integration scenario, under three development scenarios (Low, Medium, and High growth). These simulations do not take into account co-benefits (e.g. air pollution reduction). GDP is the percent deviation from the GDP in the Baseline. CAB, (Public) Debt, and Fiscal Balance (as % of GDP) are the difference in percentage points of GDP from the Baseline. Source: WB CC-MFMOD

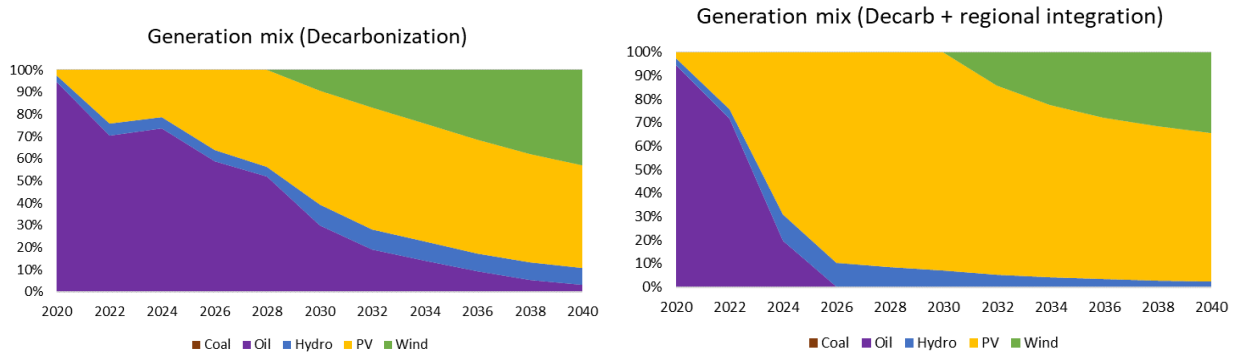
2.1.1.3 Burkina Faso

Context: Due to its landlocked nature, Burkina Faso faces exceptionally high costs for domestic power generation. Burkina Faso had barely 355 MW of installed capacity in 2019 (predominantly HFO-based) at an exorbitant cost of more than $0.20 per kilowatt-hour. Burkina Faso has high quality solar radiation and the potential to develop around 1GW of solar generation capacity, either for export or to meet domestic demand (complemented by battery storage). About 20 percent of Burkina Faso's population had access to electricity in 2019. While access is around 66 percent in urban areas, the rural access rates is estimated at about 3 percent only. Enhancing sector planning and transactional capacities is critical to foster energy sector transformation towards cleaner and cheaper sources.

Opportunity: Burkina Faso is a longstanding importer of electricity and has developed a good reputation for honoring payments. For many years, Burkina Faso has imported around half of its electricity from Cote d'Ivoire. Unlike other countries in the neighborhood, Burkina Faso has continued to honor power import bills despite continued financial stresses in the sector. Ongoing cross-border transmission projects have recently allowed Burkina Faso to diversify power imports by trading with Ghana. This new infrastructure will also allow it to become a transit country upon the completion of the North Core project allowing power from Nigeria and Niger to be transported westwards into Mali and southwards into Ghana and Togo.

The country stands to gain substantially from further development of regional power trade. Participating fully in emerging opportunities for regional trade would allow Burkina Faso to reduce its firm power generation capacity requirements and increase its capacity to develop large scale solar projects. Thanks to the North Core, the country could also become a major transit point and earn substantial wheeling revenues.

Figure 2-7: Burkina Faso generation mix



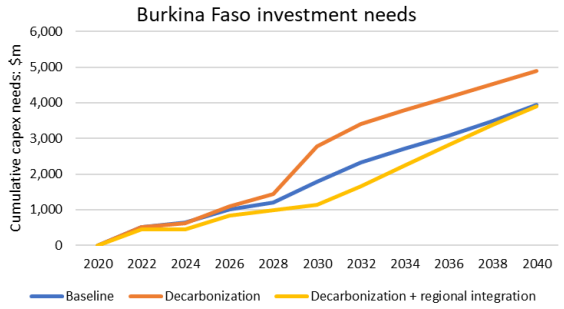
Source: World Bank

Enablers and barriers: For long term sustainability of the sector, Burkina Faso will have to improve its tariff setting methodology as current tariffs do not cover the system expansion costs (and while they cover operating costs, they fall short of fully covering fuel costs) as financial sustainability. To benefit from regional trade and potentially export solar power, Burkina Faso will need to develop a planning framework (between the MoE and the utility) and increase the capacity of technical staff.

Investment needs and macro-fiscal impact (fiscal and external sector): The overall investment needs to 2040 for the decarbonization plus regional integration scenario is nearly the same as the baseline scenario. In contrast, decarbonization alone increases overall investment needs, with a significant increase in the late 2020s.

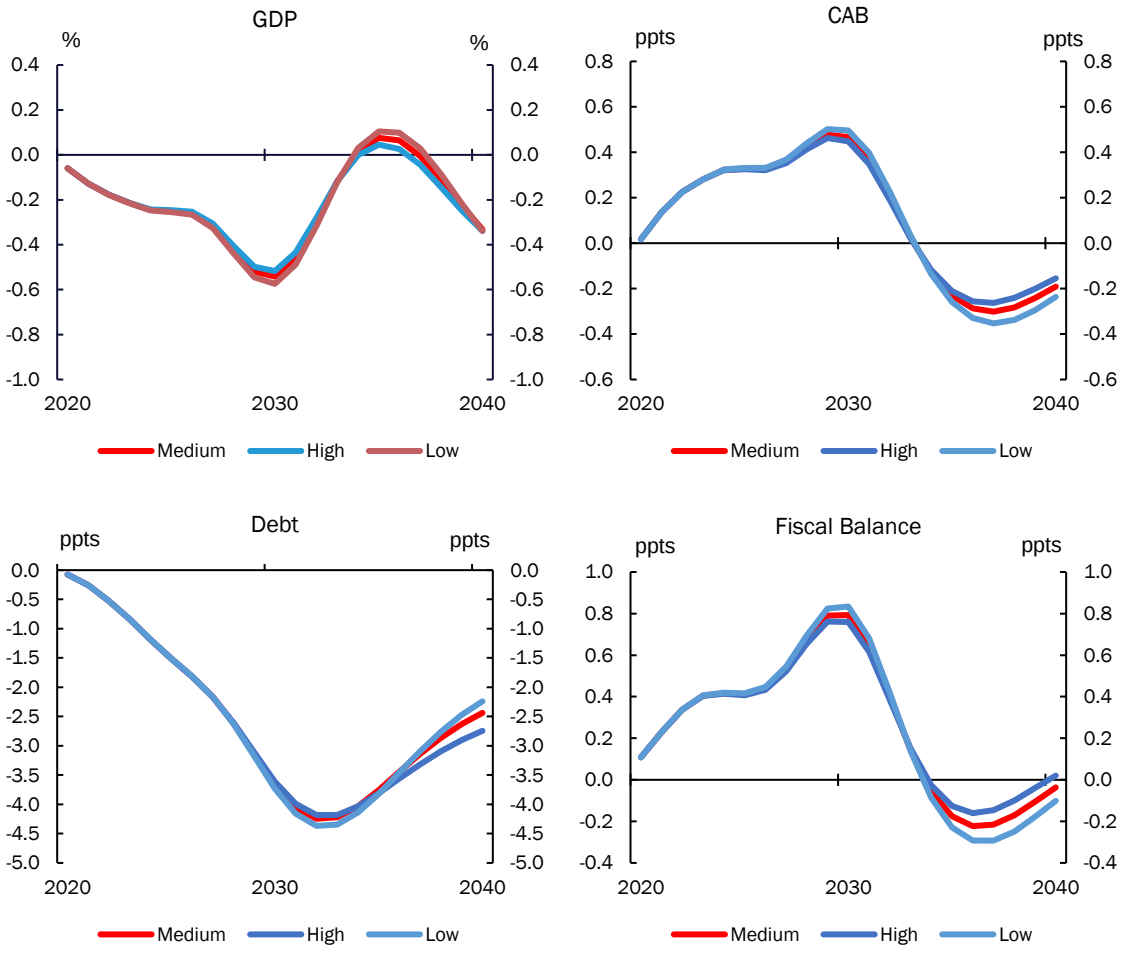
Compared to the baseline scenario, the decarbonization plus regional integration starts with a lower investment demand that become higher in the late 2030s. As a result, the relatively small impact on GDP ranges from -0.6 to +0.1 percent of GDP through the period. Both the current account and the budget balance increase in the short run, only to decrease in the medium-term when additional investment is needed. This postponement of investment needs results in a decrease in the debt-to-GDP ratio, close to 4.5 percent of GDP, which is partially offset in the 2030s. The overall macro-fiscal impacts are limited given that the additional investments needed for the decarbonization and regional integration scenario compared to the baseline scenario is limited.

Figure 2-8: Burkina Faso investment needs



GDP used is the medium growth scenario. Source: World Bank

Figure 2-9: Macro-fiscal response of Decarbonization plus Regional integration versus baseline (Burkina Faso)



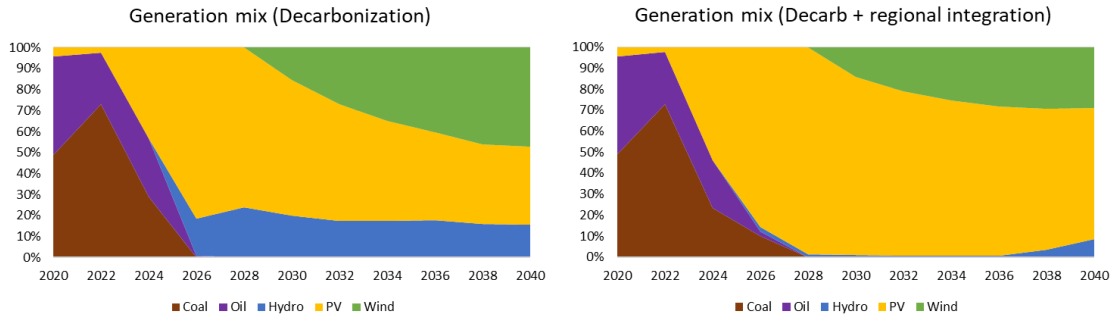
Taking Baseline scenario as the reference scenario, the macroeconomic modeling simulates the impacts of government-funded changes in investment needs and cost of operations of the decarbonization plus regional integration scenario, under three development scenarios (Low, Medium, and High growth). These simulations do not take into account co-benefits (e.g. air pollution reduction). GDP is the percent deviation from the GDP in the Baseline. CAB, (Public) Debt, and Fiscal Balance (as % of GDP) are the difference in percentage points of GDP from the Baseline. Source: WB CC-MFMOD

2.1.1.4 Niger

Context: Niger, another landlocked country, imports the bulk of its electricity needs from Nigeria under a longstanding agreement. Niger had about 300 MW of installed capacity in 2018 of which about two thirds is relatively expensive diesel-fired generation and one third relatively low-cost coal. However, Niger has long imported more than 70 percent of its electricity needs from Nigeria at a preferential rate as part of a bilateral treaty covering the transboundary waters of the River Niger. Only 19 percent of population had access to electricity services in 2019, 50 percent in urban areas and 12 percent in rural areas.

Opportunity: Nevertheless, Niger does have significant energy resources of its own. While domestic power plants are currently limited to fossil fuels, Niger does in fact have substantial potential to develop both solar, hydropower and also, in theory, more fossil fuels. With the completion of the North Core project, the country will become well connected with Sahelian countries to the West. The country stands to gain substantially from further development of regional power trade, potentially switching from being a power importer to a power exporter if the excellent RE resources were to be exploited. Additionally, through regional trade and the North Core, Niger could wheel substantial amounts of power coming from Nigeria (where the overcapacity is large) to Burkina Faso and Benin.

Figure 2-10: Niger generation mix



Source: World Bank

Enablers and barriers: Recently, Niger has put in place a modern institutional and legal framework, beginning with the liberalization of the power sector under the 2016 Electricity Act, which removed the monopoly of the majority state-owned company, NIGELEC, and opened the sector to private participation, particularly in generation and in rural electrification. In Niger, the tariff has covered utility costs (generation, operational, investment) since 2018, without direct State budgetary support. There are inefficiencies at the level of NIGELEC. Transmission and Distribution losses are high and vary between 20-25%. The main source of losses is the transmission line from Nigeria. In 2021, total losses were 19.68% with 12.67% in transmission and remaining in distribution.

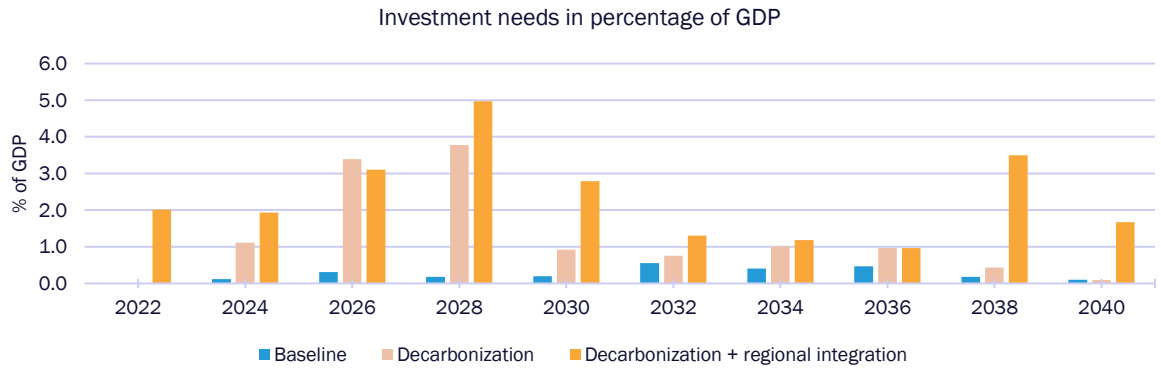
The high cost of generation is due to the high fuel costs associated with domestic oil-fired generation, as well as significant operational inefficiencies with very high system losses. These issues will need to be fixed to ensure that the country will have the capacity to invest in the public infrastructure necessary to increase trade and deploy VRE at scale. The North Core regional interconnector will help increase system efficiency and offer opportunities for increased imports, enable exports and facilitate RE development and integration.

In addition, to ensure an optimal use of Niger resources, it would be important to allow IPPs to sell directly to clients (outside Niger or large customers). Currently, NIGELEC has the monopoly on the transmission

and distribution. A legal framework requiring competitive procurement of generation allowing independent power producers is already in place. Competitive procurement based on least cost plan was mandated by a decree on IPPs in 2020 as part of the WB financed DPO. The grid code has also been established with modalities for third party access to the grid, consistently with the regional framework. ***Investment needs and macro-fiscal impacts:*** Niger will have to invest substantially more to decarbonize, more than threefold by 2040 of total investments compared to the baseline. This additional investment compared to the baseline peaks at 4.8% of GDP in 2028. For the decarbonization plus regional integration scenario, the increase is smaller at the end of 2020s but peaks in the late 2030s.

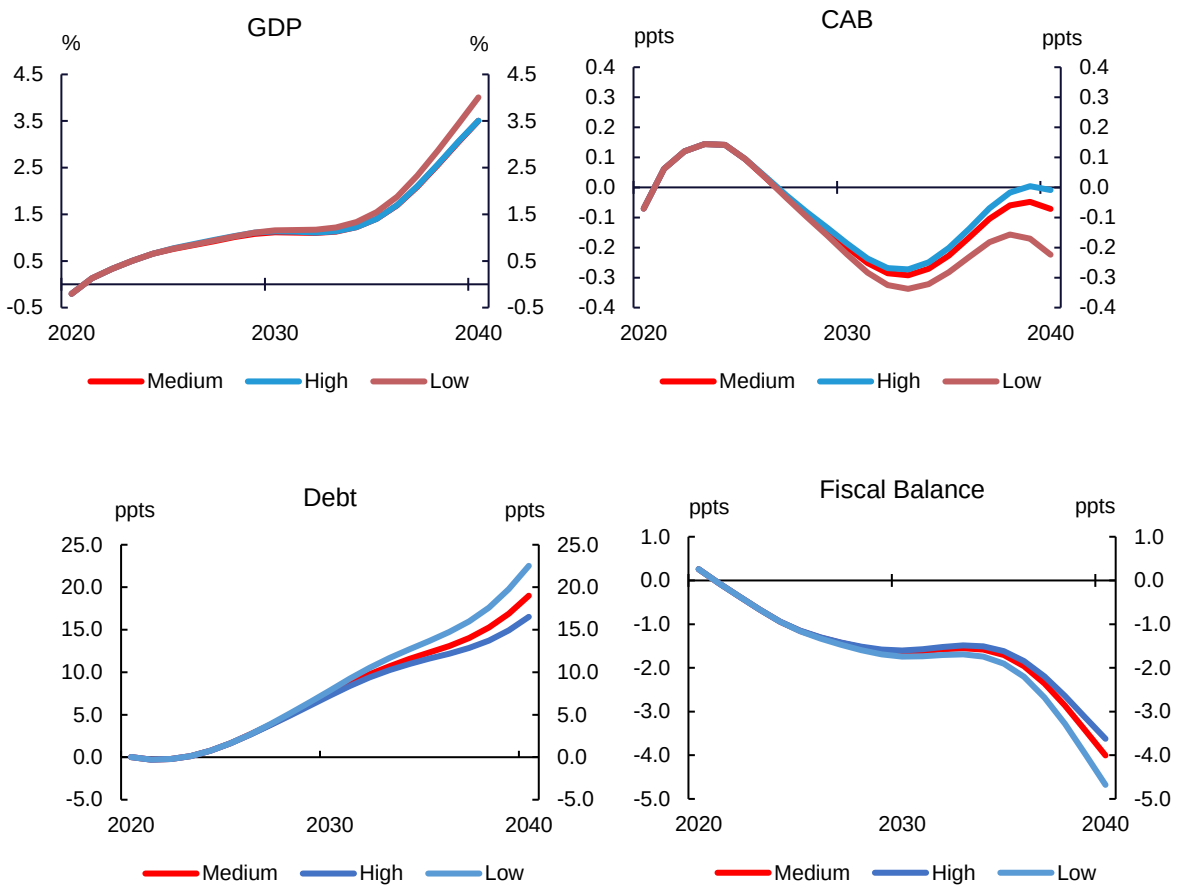
The higher public investment through to the 2040 required in the decarbonization plus regional integration scenario could boost aggregate demand, increasing GDP by up to 3.5 and 4.5 percent in 2040 compared to the baseline scenario. However, assuming that all the investment is financed through additional government borrowing the fiscal balance will deteriorate and public debt would increase significantly by 17 to 23 percentage points of GDP by 2040. This scenario would not be fiscally sustainable and highlights the need for significant private sector investment. The increase in imports from the investments would lead to a modest decline in the current account balance.

Figure 2-11: Niger investment needs (a percentage of GDP)



GDP used is the medium growth scenario. Source: World Bank

Figure 2-12: Macro-fiscal response of Decarbonization and Regional integration versus baseline (Niger)



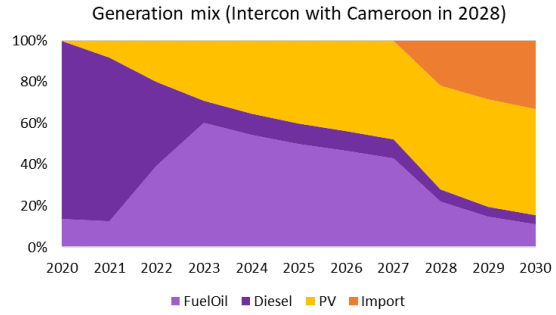
Taking Baseline scenario as the reference scenario, the macroeconomic modeling simulates the impacts of government-funded changes in investment needs and cost of operations of the decarbonization plus regional integration scenario, under three development scenarios (Low, Medium, and High growth). These simulations do not take into account co-benefits (e.g. air pollution reduction). GDP is the percent deviation from the GDP in the Baseline. CAB, (Public) Debt, and Fiscal Balance (as % of GDP) are the difference in percentage points of GDP from the Baseline. Source: WB CC-MFMOD

2.1.1.5 Chad

Context: Despite the endowment of fossil fuels and excellent solar resources, Chad has among the lowest electricity access rates in the world at 6.4 percent. Virtually all electricity is produced from hydrocarbons – diesel and HFO – that result in high production costs (exceeding $0.2/kWh) and negative environmental impact.

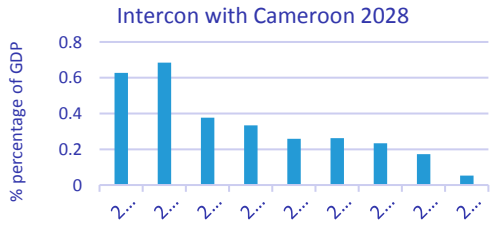
Opportunity: Unlike the other Sahel countries, Chad is not part of or connected to the WAPP and its grid is currently quite small, restricted to N'djamena. Therefore, in terms of regional integration its focus is to develop a planned interconnector with Cameroon and expand the domestic grid. It will allow Chad to import lower cost and cleaner hydro-based generation to support expansion of its main grid while displacing fossil fueled generation and improving the quality of grid supply. Interconnection with Cameroon will also help Chad to integrate greater quantities of intermittent generation from its world class solar resource. Indeed, Chad could one day export surplus solar generation to Cameroon during certain periods of the day.

Figure 2-13 Chad generation mix



Source: World Bank

Figure 2-14: Chad investment needs (a percentage of GDP)



GDP used is the medium growth scenario. Source: World Bank

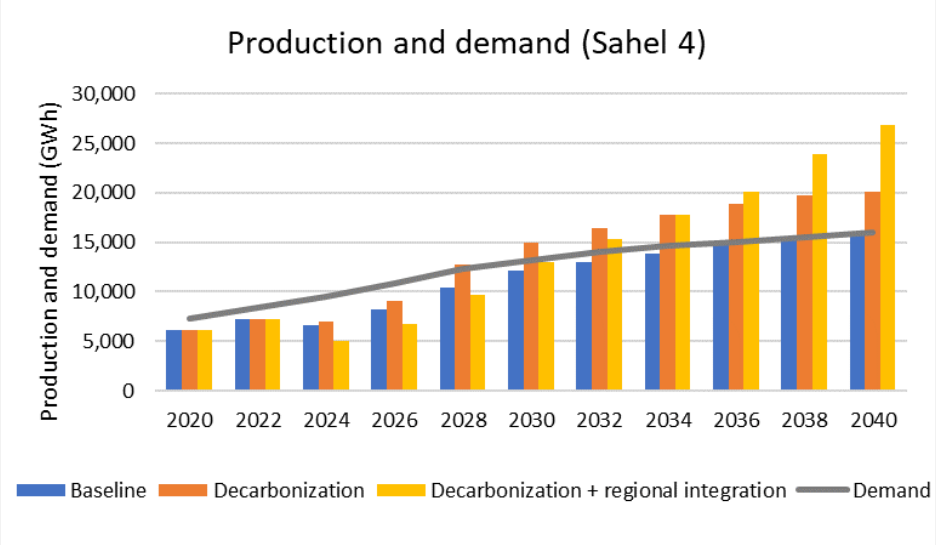
Enablers and barriers: To support imports from Cameroon and private sector participation in generation, Chad should ensure the financial viability of the national utility (SNE) by putting in place a legal and regulatory framework that allows the utility to recover its efficient costs. This in turn requires that the regulator (ARSE) is strengthened and the utility accounts are formalized, audited and published. To reduce the costs of supply, a national power system plan should be developed and updated on a regulator basis, and the legal framework should require competitive procurement of generation projects consistent with the plan. As the network is expanded it is also vital to ensure that customers pay for their electricity and a revenue protection program is put in place to reduce network losses and improve collections (currently 35% and 43%, respectively). ***Investment needs[11]:*** To meet growing demand due to higher electrification rates and increased economic activity, Chad will need to invest, about twice as much in the earlier years up to 2030.

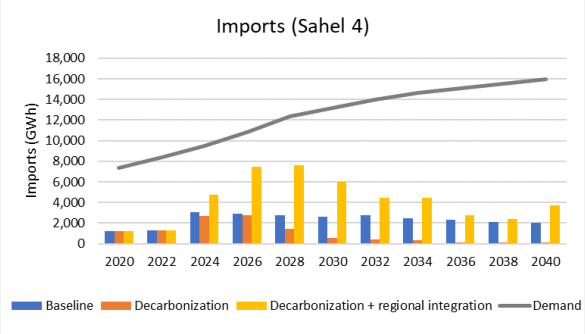
11 Different energy and investment scenarios are not available to assess the macro-fiscal impacts for Chad as has been done for the other G5 Sahel countries that are in WAPP

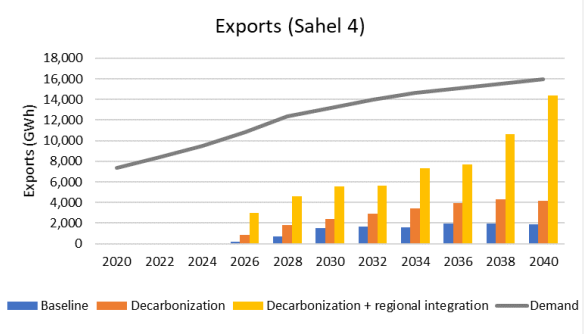
2.1.1.6 Regional power integration

2.1.1.7 Regional power integration - context, opportunities, enablers and barriers

Four of the five Sahel countries are either members of (Burkina Faso, Mali, Niger) or connected to (Mauritania via Senegal) the West African Power Pool (WAPP), which covers 14 countries from Nigeria to Senegal in an effort to create a unified regional electricity market. The planned interconnection of the WAPP region by 2025 combined with its abundant and diverse energy resources creates an opportunity for the G5 Sahel to use regional trade to reduce supply costs while also reducing carbon emissions by importing cheaper and cleaner electricity and displacing local expensive oil-fired generation. However, the benefits of trade are not limited to importing countries. Exporting countries also benefit by bringing much needed revenues to their power sectors. Trade also allows the development of resources that exceed what could be developed to meet the needs of a single country's power system, which is particularly important in the case of large hydro generation projects. Flexible trade supports the integration of greater quantities of renewable generation by helping countries to manage variability, whether seasonal variability in the case of hydro generation or more frequent variability in the case of wind and solar generation. Analysis using the Bank's power sector planning model for the WAPP region, the effects of deeper regional integration were analyzed and discussed below.





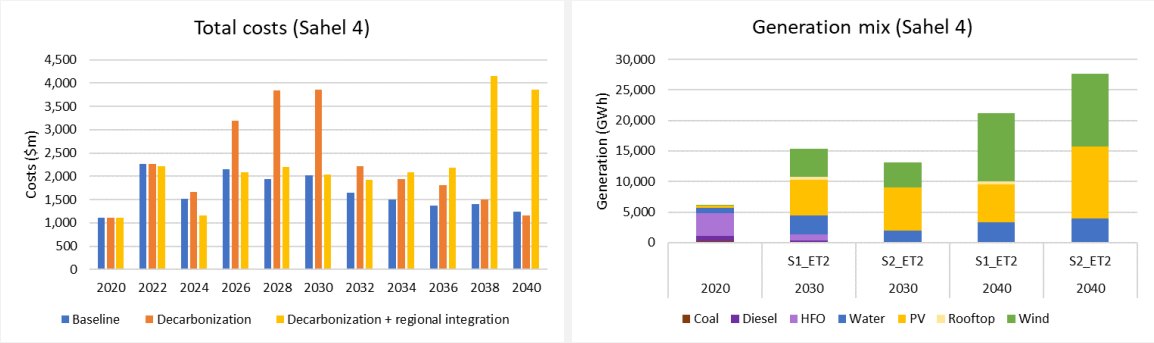


Note: Change in domestic productions, imports and exports. Imports and exports are summed across individual countries, which means exports from one country may be an import to another within the Sahel four, Source: The World Bank

For the Sahel four, the generally higher public investment needs entailed in the decarbonization and regional integration scenarios could generate a small positive impact on GDP but at the cost of a relatively small increase to debt-to-GDP ratio. The current account balance will deteriorate slightly due to higher

imports from investments but will recover in the medium to long-term once investments are made and exports increase.

Figure 2-15: Change in total costs and generation mix (Sahel 4)



Source: The World Bank. S1_ET2 = Decarbonization scenario; S2_ET2 = Decarbonization + deeper regional integration scenario
Note: Total costs comprise generation investment costs, operating and maintenance costs and fuel costs. Each year of the graph shows the sum of costs incurred over two years, for example, the costs shown for 2020 (US$ 1,117 million) comprise costs for 2020 plus costs for 2021

2.1.2 Landscapes

2.1.2.1 Changing Wealth of Nations

The World Bank's wealth accounts capture the value of assets in a country that generate income and support human well-being. Wealth accounts—including produced, human and natural capital— are useful complements to other economic indicators, such as GDP. The accounts provide a measure of capital stocks or the balance sheet of a nation, including assets not traditionally included in national accounts. Furthermore, disaggregated accounts show how countries are balancing their portfolio of assets, including whether GDP growth is accompanied by asset accumulation or depletion, and show the degree of asset diversification in a country (country profiles can be downloaded using this link). These economic indicators, therefore, can provide guidance for managing economies more sustainably over time, and allow for cross-country comparisons on economic performance and sustainable development.

CWON data regarding forest ecosystem services (ESs) that are relevant in the G5 countries in the presence of climate change were analyzed. The data cover the period 1995-2018 and pertain to asset value related watershed protection services, recreation services, and non-wood forest products provided by forests. Watershed protection services include benefits from forests on water quality / water quantity, often in the context of controlling water flow and pollution from erosion and other sources, enabling hydropower, avoiding disasters, or on crop yields by controlling weather impacts.

Figure 2-16 indicates that the forest ES value increased somewhat in Burkina Faso over this period, while in the other four countries it stayed constant or declined.

Figure 2-16 Forest ecosystem service values (1995-2018) (in constant 2018 USD)

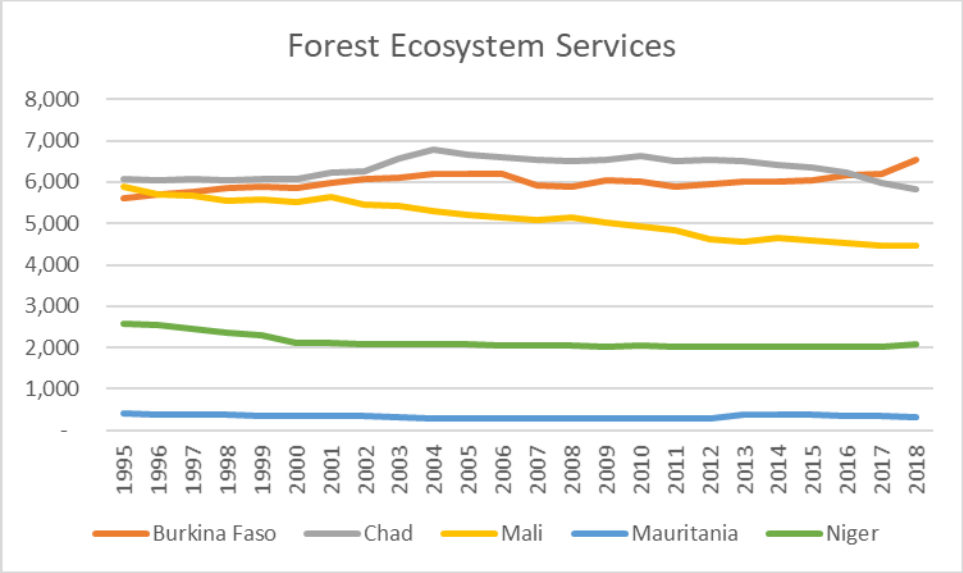


Figure 2-17 indicates however, that on a per capita basis the value declined in all countries, between 41% and 66%, as a result of the high population growth rate.

Figure 2-17 Per capita non-timber forest ecosystem service values (1995-2018) (in constant 2018 USD)

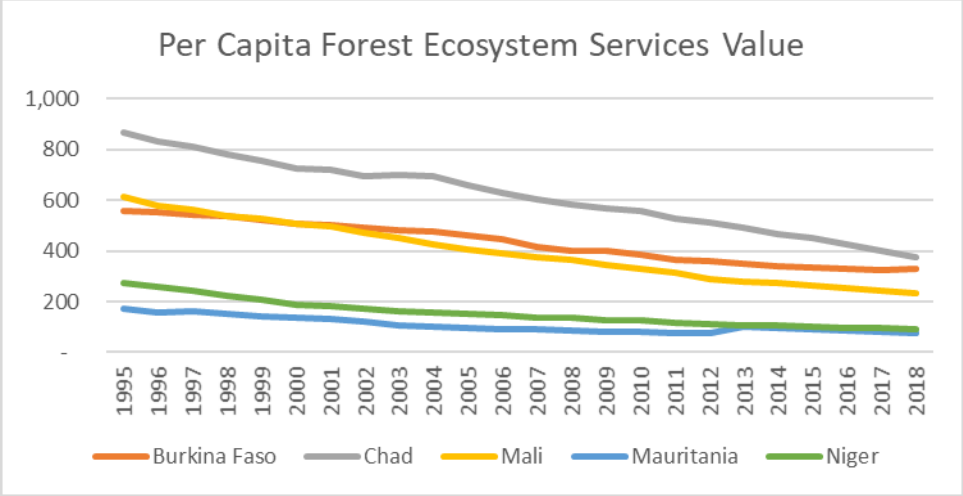
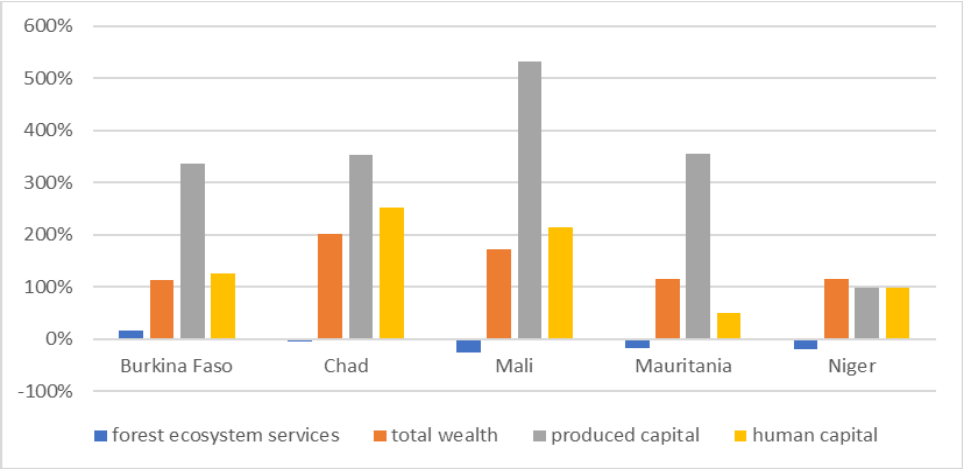
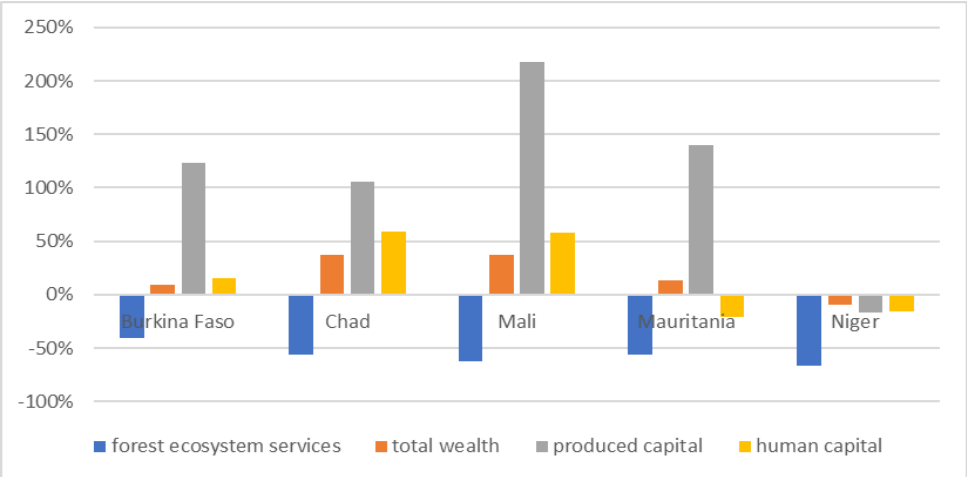


Figure 2-18 Change in forest service asset value compared with changes in total wealth, produced capital, and human capital (1995-2018)



By contrast, growth was mostly positive in other wealth categories, namely produced capital and human capital increased in all countries (Figure 2-18), suggesting that some of the growth of these wealth categories may have been at the expense of forest ecosystem wealth. On a per capita basis too, produced capital grew significantly in all G5 countries except for Niger and per capita human capital also increased, albeit by a smaller amount, except in Mauritania and Niger (Figure 2-19). The significance of these trends lies in the fact that with climate change these forest ecosystems services will be needed more for adaptation; but the apparent degradation of forests and their ability to provide these services does not bode well in this regard. In fact, the pressure on forest resources is likely to continue as climate induced agricultural yield decreases and the high population growth rate lead to an increased demand for cropland, thus further decreasing forests' ability to contribute to adaptation and resilience.

Figure 2-19 Change in per capita asset value of forest ecosystems services compared with changes in per capita total wealth, produced capital, and human capital (1995-2018)

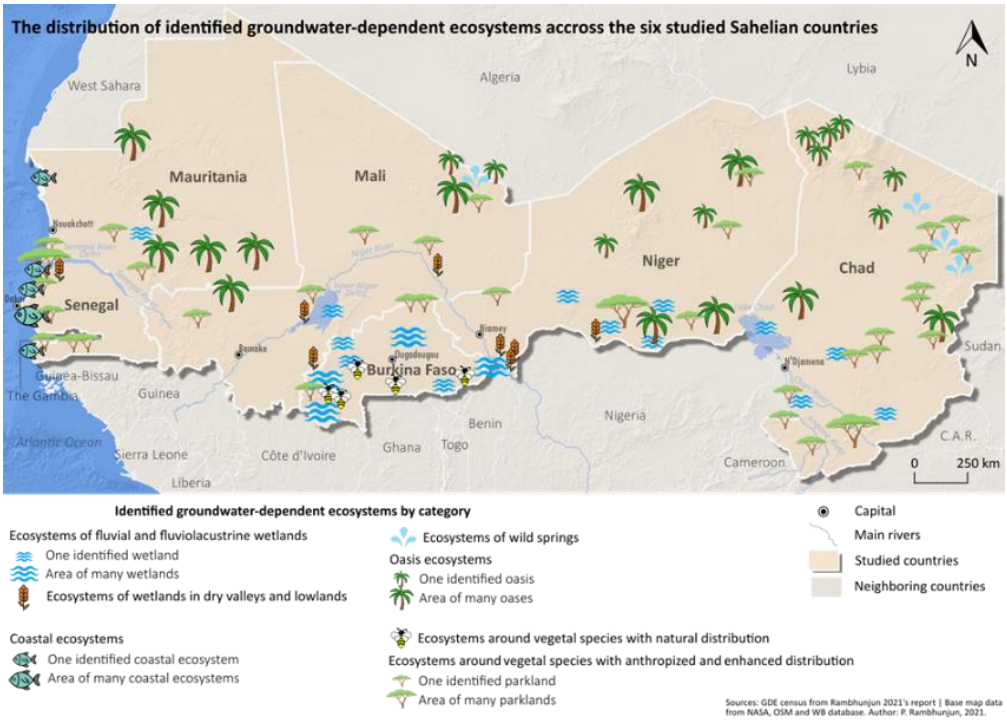


2.1.2.2 Water Sector in the G5 Sahel

Challenges and key issues in water sector

Over the last few decades, the SAHEL region has experienced strong seasonal and annual climatic variations. Climate variability is a major constraint on food security, health, environment, and poverty reduction in the region. Available water resources in the region are vulnerable to changes in temperature, and wind patterns. Almost all Sahelians feel the negative impacts of droughts and floods: the livelihoods of many, in particular subsistence farmers and nomadic herders, are highly dependent on rainfed agriculture. In addition, the gap between water demand and supply is widening in some countries, which is impacting the operations of utilities in the region. For instance, the per capita water availability in Burkina Faso has already dropped below the water stress threshold, and by 2040 Chad and Mauritania are also expected to reach similar levels of water stress. Climate variability together with structural constraints, such as rapid population increases, urbanization and water resources pollution, are further exacerbating the challenge of baseline water insecurity. Lack of investments, weak institutional capacity, lack of maintenance, and unequal water distribution hinder the use of water resources for productive uses and in turn hamper socio-economic development of the region. As a result, a large share of the population today is water insecure.

Figure 2-20 Groundwater-Dependent Ecosystems in the Sahel



In **Rural** areas of the G5 Sahel, over 34 million people (56 percent) lack access to basic water supply, while the sustainability of existing infrastructure is increasingly threatened by water scarcity and climate-related disasters such as droughts and floods. Poor access to sanitation makes contamination of water supplies likely during droughts and floods, with 59 percent of the rural population defecating in the open (almost 80

percent in both Chad and Niger),[12] contributing to malnutrition and stunting among children under five years of age and impacting human capital prospects. Furthermore, land is deteriorating and losing its fertility due to erratic rainfall patterns, inefficient farming practices and overgrazing. Insufficient rain means that crops fail or are destroyed, while livestock struggle to find water for drinking and sufficient pasture. Food production is consequently affected, and communities are exposed to environmental migration and marginalization. Today, in Burkina Faso, Mali, and Niger, 2.4 million people are struggling with food insecurity[13] and lack of pastoral lands and water shortages induce pastoralists to migrate toward agricultural areas, creating tensions among the communities. However, this need not be the case as the Sahel has comparative advantages: a lot of sunshine, major rivers, major groundwater-dependent ecosystems underpinning economic growth and abundant water resources during the rainy season that need to be mobilized and managed.

Urban centers are located both on riverbanks (Bamako, Niamey) and also further away from surface water sources, in which case they rely on long distance transfers from shared rivers (e.g. Ouagadougou, Dakar, Nouakchott). Rapid population growth combined with a changing climate[14] and economic instability in rural areas will continue to accelerate urban growth by driving people towards cities. This will put additional pressure on already fragile water services in host communities. While urban areas benefit from higher access to basic water supply than rural communities (86.6 percent), access within the household remains low. 49.2 percent of the urban population lacks access to basic sanitation,[15] hindering human well-being[16] and development. As cities are not equipped with the urban and water infrastructure planning mechanisms to successfully meet growing water demand, and climate change impacts the availability and reliability of water resources, a larger urban water deficit is likely to develop.[17] Moreover, low sanitation coverage and poor wastewater collection and treatment infrastructure in urban areas has led to untreated wastewater and fecal sludge discharge to the environment, polluting aquifers and rivers and worsening the water insecurity problem.

The main key facts in the water sector can be summarized as follows.

- Water is largely absent in regional development strategies; however, water security is vital for the socio-economic development, resilience, and security of the G5 Sahel. Three out of four jobs within the global workforce are water dependent.[18]
- Although there is no clear trend in water availability, some models project a decrease of water availability from precipitation of 1.9 percent under RCP 2.6 and no change under RCP 6.0.[19] Due to population growth, per capita water availability for the Sahel is projected to decline (76 percent for RCP 2.6 and 77 percent for RCP 6.0 by 2080, relative to year 2000).
- The majority of Sahelian economic activity relies on water-dependent ecosystems, essential to produce goods and services, including those related to climate resilience (water purification, flood

12 2020 data from WHO (World Health Organization) and UNICEF (United Nations Children's Fund) Joint Monitoring Programme for Water Supply, Sanitation and Hygiene (JMP).

13 WDI, 2020. Human Development Index

14 1% reduction in precipitation expected to fuel urbanization rate by 0.6%

15 2020 data from WHO (World Health Organization) and UNICEF (United Nations Children's Fund) Joint Monitoring Programme for Water Supply, Sanitation and Hygiene (JMP).

16 Kwasi, S., Cilliers, J., Donnenfeld, Z., Welborn, L., Maïga, I., 2019. Prospects for the G5 Sahel Countries to 2040. Institute for Security Studies

17 Strengthening Regional Water Security for Greater Resilience in the G5 Sahel. WBG, 2021.

18 World Water Development Report 2016

19 Climate risk profile: Sahel. UNHCR. PIK. https://www.unhcr.org/61a49df44.pdf

control, heat regulation). Main rivers in SAHEL are leveraged for hydropower generation and the production of water for irrigation and potable uses can be energy-demanding processes. For instance, in Burkina Faso and Mauritania, long distance water transfers are strategic water sources for the urban areas.

- With 36 million hectares cultivated (~10 percent of the total surface), the agriculture sector contributes between 30 and 40 percent of national GDP. It accounts for a staggering 25 percent of total employment in Burkina Faso, 50 percent in Mauritania, 68 percent in Mali, 75 percent in Niger and 80 percent in Chad. Pastoralism accounts for at least 25 percent of the GDP of G5 Sahel countries and 40 percent of agricultural GDP in the region on average.[20]
- By 2080, yields of strategic crops, such as maize (-9.8 percent), millet and sorghum (-7.6 percent) are projected to decrease compared to year 2000, under RCP 6.0. The severity of climate impacts will largely depend on irrigation capacities. However, while 38 percent of irrigation potential has been developed in the region, only half of the area equipped for irrigation is actually irrigated, corresponding to less than 1 percent of total agriculture land in the G5 Sahel.[21]
- Most of the irrigated areas depend on rivers (e.g., the Niger and the Senegal rivers), with groundwater irrigating less than 15 percent of the total irrigated lands.[22] There is significant groundwater potential in many parts of the region. Shallow alluvial ground water potential for irrigation in the G5 Sahel is between 3 and 4 million hectares.[23]
- Increasingly frequent and severe extreme events, such as droughts and devastating floods caused by heavy rains, are major climate change-related challenges in the Sahel. Floods are expected to shave off 5 to 14 percent of GDP in West African countries in the coming decade, given low levels of hard infrastructure and weak management capacity.[24]
- Safely managed WSS services both in urban and rural areas are crucial components of human capital, as they contribute to raising living standards, good health, and high labor productivity. Yet only 56.5 percent of the population in the G5 Sahel has access to basic drinking water services, while a mere 25.4 percent has access to basic sanitation services.[25]
- Rural areas in the G5 Sahel consistently show lower access levels to WSS. For example, in rural Chad, access to basic drinking water services is 37.6 percent compared to almost 74.2 percent in urban areas. Access to basic sanitation services is under 4 percent in rural areas versus almost 40 percent in urban areas.[26] In Niger, the economic losses from inadequate WSS are estimated to amount to more than 10 percent of the country's GDP.[27]

20 De Haan, C., 2014. "Estimating Livestock Dependent Populations in Mali: Methodological Note." World Bank, Washington, DC

21 FAOSTAT

22 Analyse des opportunités de développement de l'irrigation au Sahel à partir des eaux souterraines. World Bank, Working Document, 2016.

23 British Geological Survey Map

24 World Resources Institute, Global Flood Risk: Affected GDP in 2030 due to climate and socio-economic changes

25 2020 data from WHO (World Health Organization) and UNICEF (United Nations Children's Fund) Joint Monitoring Programme for Water Supply, Sanitation and Hygiene (JMP).

26 2020 data from WHO (World Health Organization) and UNICEF (United Nations Children's Fund) Joint Monitoring Programme for Water Supply, Sanitation and Hygiene (JMP).

27 Sadoff, C.W., Hall, J.W., Grey, D., Aerts, J.C.J.H., Ait-Kadi, M., Brown, C., Cox, A., Dadson, S., Garrick, D., Kelman, J., McCornick, P., Ringler, C., Rosegrant, M., Whittington, D., Wiberg, D., 2015. Securing Water, Sustaining Growth: Report of the GWP/OECD Task Force on Water Security and Sustainable Growth, University of Oxford, UK, 180pp.

- Water resources are complicated by regional politics: the Sahel region has the highest fraction of land globally in transboundary basins (90 percent of Niger and Mauritania's water comes from outside of their borders).
- Sector institutions responsible for water resources management and service delivery – such as river basin agencies and utilities – lack adequate human and financial resources to deliver on their mandate. Lack of coordination among decision makers hinders the development of coherent policies and the harmonized implementation of sectoral strategies.
- Several innovative sources of investment financing for the water sector have emerged during the last decades. These include new regional development banks, new UN-backed funds and the private sector. In addition, a number of bilateral cooperation agencies are now supporting investments in the water sector, as well as a few large international non-governmental organizations.

Deeper dives

2.1.2.2.1 Water Security

Climate projections for the Sahel are not conclusive and differ depending on climate models.[28] Yet, there is some agreement that, due to the population growth, per capita water availability for the Sahel is projected to decline (76 percent for RCP 2.6 and 77 percent for RCP 6.0 by 2080, relative to year 2000). This is despite the fact that the Global Change Analysis Model (GCAM)[29] shows slightly increasing overall water availability under RCP 2.6 and decreasing water availability under RCP 6.0 (see Figure 2-21). The decline, therefore, is not primarily driven by climate change, due to no clear trend with the precipitation regime change, but rather by socio-economic factors, such as increased agricultural production needs and increased water abstraction for irrigation, drinking water supply, domestic use and hydropower generation (see Figure 2-22).[30] The decline in water availability highlights the urgency to invest in diversifying water resources, increasing recharge and storage, and promoting the sustainable use of water to safeguard future consumptions.

28 Hulme, M. (2000). Climate perspective on Sahelian desiccation: 1973-1998. Global Environmental Change, 11(1), 19-29. ; Nicholson, 2013. The West African Sahel: A Review of Recent Studies on the Rainfall Regime and its Interannual Variability, ISRN Meteorology, 4.

29 The Global Change Assessment Model (GCAM) is a state-of-the-art integrated assessment model (IAM) designed to explore interactions among critical sectors of the economy, the human and physical systems, and to support policy-relevant decisions (Edmonds and Reilly 1985, Wise et al. 2009, Clarke et al. 2014). As a leading IAM, GCAM has contributed significantly to advance the scientific understanding of climate change as the IAM selected by the Intergovernmental Panel on Climate Change (IPCC) to model the representative concentration pathway (RCP) 4.5 (Thomson et al. 2011). GCAM is freely available as a community model and can be obtained through a widely used software repository (https://github.com/JGCRI/gcam-core).

30 Climate risk profile: Sahel. UNHCR. PIK. https://www.unhcr.org/61a49df44.pdf

Figure 2-21 Water availability in the Sahel in 2020 and 2100 under climate scenarios RCP 2.6 and RCP 6.0 (GCAM)

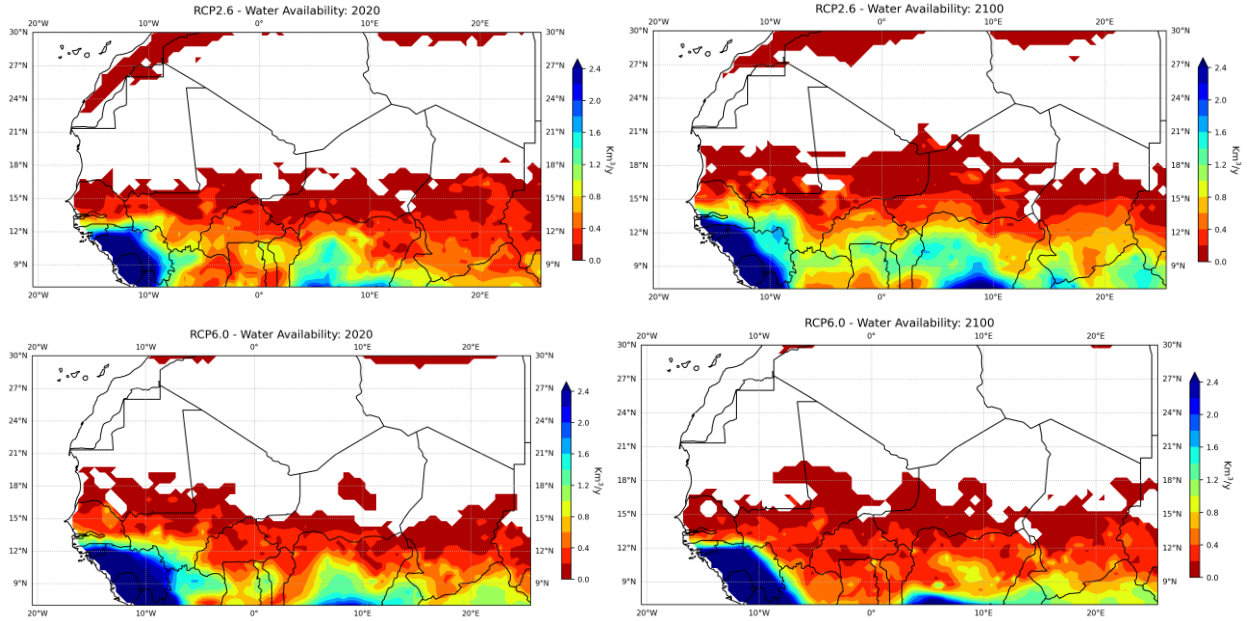
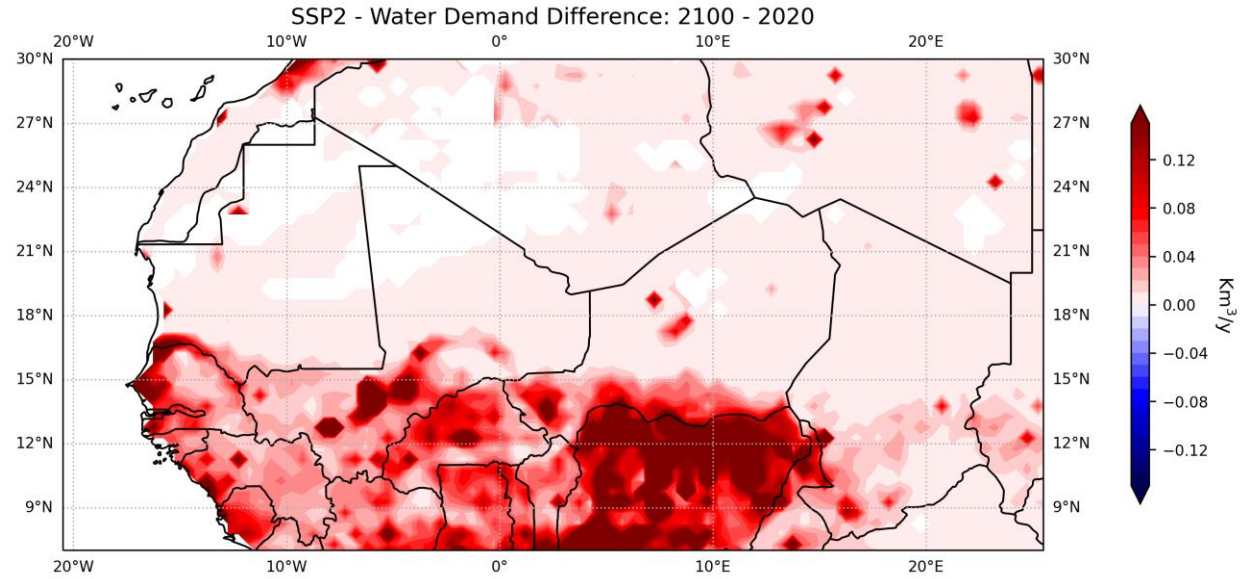


Figure 2-22 Difference in water demand in the Sahel between 2020 and 2100 (GCAM)



There are many options for increasing water storage in the Sahel, ranging from aquifer recharge to increasing soil water content, and to small, medium and large dams, with varying levels of complexities. The Bank may want to support small scale decentralized storage as a more climate-resilient and less socially and environmentally sensitive solution. In the Sahel, there is large untapped potential for water harvesting to increase water storage in aquifers through in-stream solutions, in soils through in-situ water harvesting, or in surface water reservoirs by harnessing runoff.

Investment opportunities

- Diversify water sources by mobilizing surface water and groundwater and exploring non-conventional water resources. Seek to align with circular economy principles, for example wastewater re-use, demand management and runoff capture.
- Multipurpose storage can significantly help increase regional energy access, improve flood and drought control, and secure access to water for different uses.
- The Bank is currently supporting the consultancy assignment "Mobilizing Water Resources through Watershed Interventions in the Sahel", whose objective is to develop practical guidance on how to implement small scale storage interventions in Western Sahel.

Policy recommendations

- Develop better information and support for resilient water storage infrastructure planning and improved water resources management, while recognizing the climate and water availability trends and risks from future uncertainties
- Improve water productivity via strengthening water governance and formalize a policy framework for IWRM (integrating urban and rural water supply and sanitation, irrigation, rainfed farming, pastoralism, fisheries, etc.[31]). Increase resources for and attention to water quality, to both monitor water resources and undertake interventions to reduce water pollution.[32]
- Expand the economic lifetime and water use efficiency (adaptation) of existing infrastructure by improving financial sustainability and the regulatory environment through policies such as the revision of national water tariffs. Encourage sector institutions to adopt programmatic approaches and improve their technical functions by offering the required funding for the sustainable management and use of water resources.
- Give priority to rehabilitation and consolidation of infrastructure, considering the large number of hydraulic structures to be rehabilitated (dams, hydro-agricultural development, water supply systems, etc.).
- Clarify the role and importance of (ground)water-dependent ecosystems in ensuring resilience to climate change and promote nature-based solutions while preparing water-related investments. Promote natural and nature-based solutions for flood prevention and coastal erosion protection, complementing other measures such as land use planning and built infrastructure.
- Strengthening the capacity of sector institutions for collaboration and for setting and achieving objectives is required, as well as promoting transboundary co-operation and knowledge. Development on transboundary waterways needs to be optimized at the basin scale. Benefit sharing opportunities should be considered, while continuing to promote transboundary co-operation and knowledge-sharing. This will require parallel work at the national level, and the regional level, and provide an opportunity to promote clean energy transitions where there is undeveloped hydropower potential.

31 Account for IDPs/refugees and pastoralists in developing water sector strategies.

32 In Niger, an integrated water platform approach is envisioned by the GoN's Integrated Water Resources Management (PANGIRE) program. The Bank supports the program through systematic and climate-informed planning of all water-related activities and investments at the commune level and basin level. The project builds on recent policy reforms and initiatives (particularly the PANGIRE) to implement a systematic approach to water security. The project takes a multi-sectoral approach, referred to as the 'water platform,' that recognizes the importance of decentralized, yet coordinated, decision making to sustainably manage water resources in Niger. The water platform places the commune – the foundational administrative division in Niger's decentralization reforms – at the center of water-related investments across multiple sectors. Sub-basin water platform institutions, meanwhile, will ensure the coordinated use and conservation of water resources across communes.

- Explore potential to increase hydropower development/use and innovative approaches like storing energy in water (solar pumping during the day and hydro at night).
- Partner with the private sector (PPP approach) for water security, in view of the decline in public aid to development, and the need to ensure the sustainability of investments.

2.1.2.2.2 Irrigation

In the Sahel region, agricultural production is projected to markedly increase (Figure 2-23) by the end of the century under the RCP6.0 to meet the needs of growing populations. However, the land area dedicated to crops slightly increases over the time[33] and crop yields may fall by 15 to 25 percent[34]. Climate change is likely to affect livelihoods and compound food insecurity in the Sahel and to cope with the growing food demand, it is vital to improve the land and water productivity in the region.

Adequate management of water resources and irrigation would enable cropping in dry seasons, secure harvest during drought periods, and potentially achieve higher yields. Thus, irrigation can contribute to improve the community's adaptation capacity to climate change through significant, potential increases in agricultural productivity.

In the G5 Sahel, over 600,000 hectares are presently equipped for irrigation. However, 40 percent of this area needs rehabilitation due to lack of proper maintenance, of which 90,000 ha for large scale schemes and 140,000 ha for small scale schemes. These figures correspond to less than **1 percent** of the total cropland,[35] making the region vulnerable to droughts and erratic rainfall. As a result, climate extremes generate an estimated annual loss of 1 to 2 percent of GDP in the G5 Sahel region, a loss that could be countered with the development of irrigated land in the region, where yields can be at least twice those of rainfed areas.

Investment opportunities

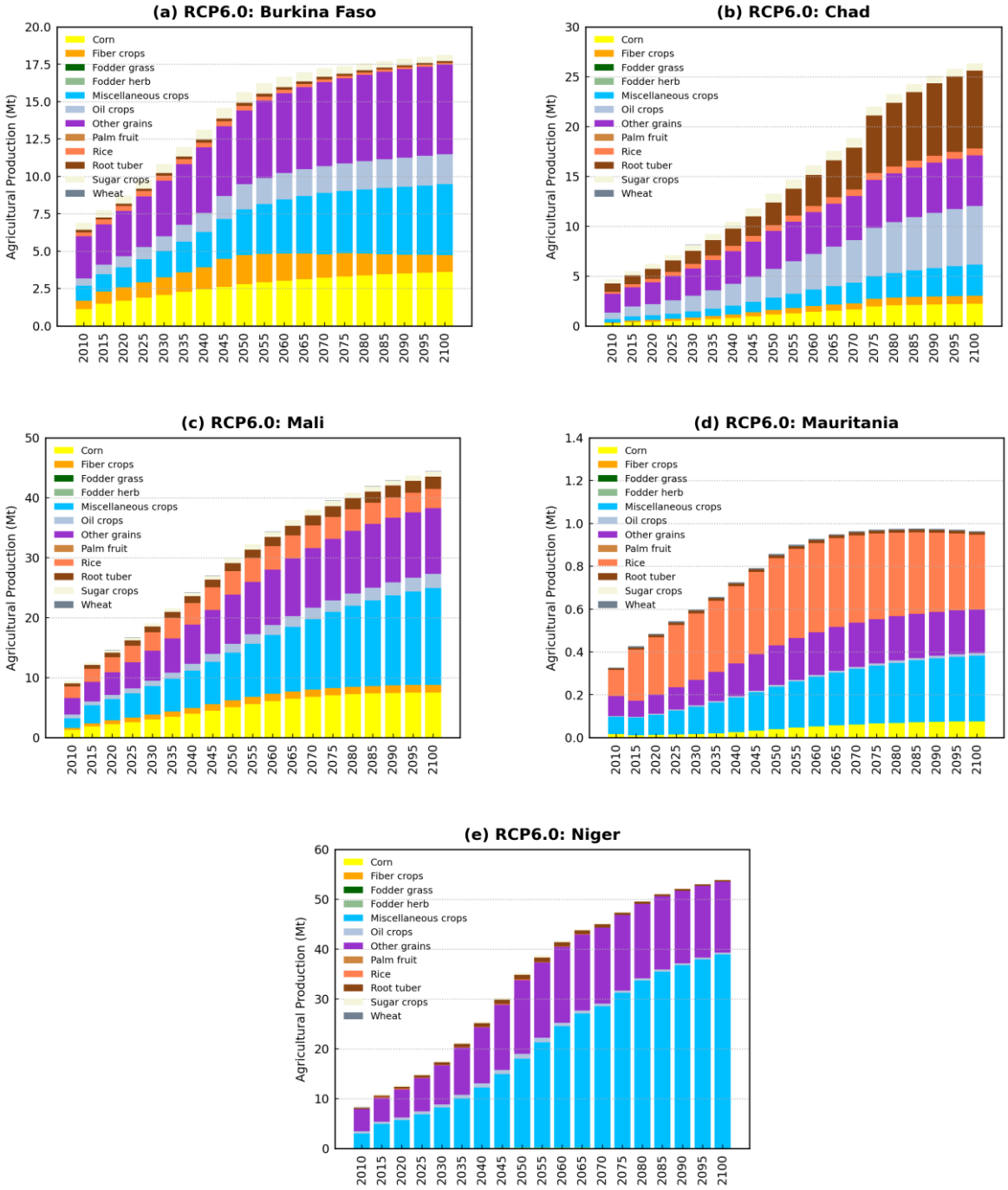
- Support in building climate resilient agriculture systems including switching to improved varieties in climate change sensitive crops, while weighing impacts on agro-biodiversity.
- Improving the productivity of agriculture via expanding irrigation, both large and small scale, will advance the resilience of communities to a changing climate and support more rapid and inclusive economic growth.

33 GCAM model for G5 SAHEL

34 Studies conducted by CILSS's Agrhymet on Sahelian countries showed that average yields of millet and sorghum will fall by 15 to 25 percent in Burkina Faso and Niger by 2080. Maize (15 percent) is vulnerable to climate hazards; however, rice yields will go up for both rainfed (2 to 10 percent) and irrigated crops (10 to 25 percent)

35 FAO AQUASTAT

Figure 2-23 Agricultural production by country under the RCP6.0 scenario



- In large scale irrigation schemes, Water Use Efficiency (WUE) is low and surface irrigation is the main applied irrigation technology. Financing will be preferably directed to rehabilitation of existing schemes that maximize WUE by minimizing losses during transport and distribution, as well as on farmer plots through efficient water conveyance and irrigation technologies.

- Promote low-cost irrigation options with low maintenance requirements and provide support and capacity building to ensure the ability of farmers to further operate the technology and maintain it.
- Controlled flood irrigation is a common practice in the Sahel region and is growing strongly in the wettest areas. However, existing infrastructure is confronted with increasing runoff water and needs physical improvements to better manage such extremes.
- The region has significant levels of groundwater. However, given the many problems commonly associated with deep groundwater use – including pumping emissions, cost recovery challenges, and over-exploitation risks – the World Bank should encourage use of shallow alluvial groundwater resources for irrigation.
- There is potential to improve the productivity of rainfed farmland by:
    - Promoting water saving equipment such as drip irrigation and smart irrigation systems and supported by extension services to encourage farmers to use sustainable and environment responsible techniques.
    - Better capturing runoff water for rainfed agriculture (e.g., water harvesting, supplementary irrigation).
- Developing financing mechanism, such as access to loans or credits, can support the accessibility for irrigation equipment.
- Investment potentials for the irrigation sector are: for the rehabilitation of large irrigation schemes, US$ 1.2 Billion (90,000 ha); for the rehabilitation of small-scale irrigation schemes, US$ 814 Million (140,000 ha); for the expansion of irrigation, US$ 12.4 Billion (915,000 ha) for large scale schemes and US$ 5.1 – 8.98 Billion for small-scale schemes (880,000 ha); to develop irrigation from shallow alluvial groundwater, US$ 2.4 – 14.1 Billion (more than 3 million hectares).
- Awareness raising about water-saving irrigation management is crucial to ensure a long-term responsible use of natural resources.

Policy recommendations

- Promote improved water productivity and energy efficiency by modernizing and refurbishing existing irrigation and drainage infrastructure and achieving water savings, as well as reducing energy consumption and emissions. Water savings can mitigate the negative impact of climate change on the amount of water resources available for irrigation and help overcome the constraint of water scarcity. Saved water resources can be partially or fully reused for the irrigation of additional agricultural land or for the needs of other sectors.
- Promote investments in small and on-farm irrigation systems that can improve the crop yields and support poverty alleviation and climate change adaptation via improving the resilience of smallholder farmers. Promote usage of renewable energy (solar) for pumping and reduce emissions.
- Clarify the role and importance of using shallow alluvial groundwater in irrigation to support communities with low access to surface water resources.
- Explore promoting the reuse of water from urban and industrial systems, which may represent an additional source of water for replacing unsustainable water abstractions for irrigation.
- Adopt reforms that target policy and legislation for effective scheme management and involve the beneficiaries in operations and maintenance.
- Structure private sector participation for irrigation sector investments, as a key partner for finance and innovation.

- For upscaling irrigation, consider user interests in water and energy management and engage in dispute settlement mechanisms to address potential conflicts between upstream and downstream users.

2.1.2.2.3 Water Services and Sanitation

In the G5 Sahel, 43.5 percent of the population, or over 37.5 million people, lack access to basic drinking water services, while 74.6 percent of the population lack access to basic sanitation services. The problem is especially critical in rural communities, where those numbers rise to 56.2 percent and 84.8 percent respectively.[36] Assuring access to clean water and sanitation services is critical to both economic growth and as a principal determinant of human capital outcomes, including early childhood survival, health, and educational attainment. Water supply, sanitation and hygiene (WASH) services improve people's resilience to water scarcity and reduce the threat of waterborne diseases such as cholera, schistosomiasis, and other diarrheal diseases, the incidence of which has been shown to increase as a result of climate change: heavy rainfall and high temperatures in particular.[37] With almost 60 percent of the G5 Sahel rural population practicing open defecation,[38] the region's water resources are at an increasing risk of contamination as climate change intensifies flooding. Permeable poorly managed latrines, leaking septic tanks, and the open dumping of untreated fecal sludge by sanitation workers further aggravate this threat. Heavy rains have also directly affected water infrastructure across the region. For example, more than 700 wells in Niamey were damaged or destroyed after heavy rainfalls in 2020, putting the population at risk of cholera and other water-borne diseases.[39] Finally, increasing temperatures will continue to increase the concentration of algae and bacteria in water resources, while the projected decline of water availability reduces water's pollutant dilution capacity.[40]

Beyond human capital considerations, water and sanitation services are critical inputs to economic growth. Investment in water and sanitation services generates a quantifiable, positive return on investment through saved medical costs and increased productivity: for urban basic drinking water: US$3 return for every US$1 invested; for urban basic sanitation: US$2.5 to US$1; for rural basic drinking water: US$7 to US$1; for rural basic sanitation: US$5 to US$1.[41] Investments in water and sanitation services are only becoming more critical as population and temperature increase, and more frequent droughts reduce surface and groundwater availability, aggravating pressures on existing water supply services in dry seasons and dry years.

36 2020 data from WHO (World Health Organization) and UNICEF (United Nations Children's Fund) Joint Monitoring Programme for Water Supply, Sanitation and Hygiene (JMP).

37 Levy K, Smith SM, Carlton EJ. Climate Change Impacts on Waterborne Diseases: Moving Toward Designing Interventions. Curr Environ Health Rep. 2018;5(2):272-282. doi:10.1007/s40572-018-0199-7

38 2020 data from WHO (World Health Organization) and UNICEF (United Nations Children's Fund) Joint Monitoring Programme for Water Supply, Sanitation and Hygiene (JMP).

39 USAID Bureau for Humanitarian Assistance (BHA), "USAID's Response to Flooding in the Sahel." 2020, [Online].

Available: https://storymaps.arcgis.com/stories/6b8ed21a7bca49268de26aecc21b456c.

40 Climate risk profile: Sahel. UNHCR. PIK. https://www.unhcr.org/61a49df44.pdf

41 Hutton et al. 2015

Investment opportunities

Given the huge gap in access to safe and sustainable WASH services in the region, the world's highest population growth rates (the population will have more than doubled by 2050[42]), increasing urbanization, and the impacts of climate change, WASH investments are particularly critical to human capital and economic development in the G5 Sahel. Investments to increase the coverage of WASH services should therefore be pursued, adhering to the following principles, as applicable:

- Use a resilient design process for infrastructure development to ensure robustness to threats of droughts and floods, which are expected to intensify with climate change.[43] This should include the development and enforcement of standards for construction quality, the incorporation of design under uncertainty methodologies, thorough water resources investigations to prevent seasonal or long-term over-abstraction – common problems in boreholes across many parts of the Sahel – while simultaneously protecting the region's scarce water resources.
- Prioritize the use of renewable energy, improve energy efficiency, and phase out diesel, when feasible, for water supply provision. Promote circular economy solutions and closed-loop systems, especially producing energy from waste and designing out inefficiencies in water and wastewater treatment plant operations.
- Support investments that reduce non-revenue water losses, including increasing metering for both household connections and standpipes to better encourage water conservation and enable more efficient tariff schemes. Such water conservation is particularly critical given that per capita water availability for the Sahel is projected to decline (76% for RCP 2.6 and 77% for RCP 6.0 by 2080, relative to year 2000),[44] and given the energy embedded in producing that water.
- Given the low functionality rates of existing WASH infrastructure across the region, prioritize rehabilitation activities and small-scale works that can improve the optimization of existing infrastructure and encourage the development and funding of O&M mechanisms.
- Develop the full sanitation value chain, including containment, emptying, transport, treatment, and reuse, to prevent the spread of human waste through flood events and the contamination of water resources. In the G5 Sahel, on-site sanitation is likely to continue to be the predominant and most economical solution to the sanitation crisis.
- Prioritize low-carbon fecal sludge management options and the upgrading of latrines to reduce GHG emissions. Scope opportunities for waste-to-resource innovations, such as the use of generated biogas for electricity generation, the production of fertilizer, and the re-use of treated wastewater for irrigation, industrial and other uses.
- In Mauritania, desalination plants may be pursued as a last resort where a lack of potable surface and groundwater are available, for example because of seawater intrusion. All measures should be taken in such projects to maximize the energy efficiency of desalination technologies to limit GHG emissions.

42 O. Diagana, "Opinion: The World Bank can only accomplish its mission of ending extreme poverty in Africa by prioritizing the Sahel region," The World Bank, 2020. https://www.worldbank.org/en/news/opinion/2020/12/16/the-world-bank-can-only-accomplish-its-mission-of-ending-extreme-poverty-in-africa-by-prioritizing-the-sahel-region.

43 The resilient design process should follow the principles outlined in the World Bank's Resilient Water Infrastructure Design Brief and Building the Resilience of WSS Utilities to Climate Change and Other Threats: A Road Map.

44 Climate risk profile: Sahel. UNHCR. PIK. https://www.unhcr.org/61a49df44.pdf

- Prioritize investments that support poor and vulnerable communities, including those in peri-urban and rural areas.

Table 2-1 Estimated investment needs (USD millions) to achieve universal water supply and sanitation coverage by target service level and year

Target	Total (Urban and Rural WSS)		Urban			Rural		
	Total Investment	Avg. Annual Investment	Total Water Investment	Total Sanitation Investment	Total Investment	Total Water Investment	Total Sanitation Investment	Total Investment
Universal basic by 2030	9,102	1,011	1,096	1,611	2,706	4,594	1,801	6,395
Universal basic (with 50% of currently unserved safely managed) by 2030	15,703	1,745	2,788	2,351	5,140	8,249	2,315	10,563
Universal safely managed by 2030	22,304	2,478	4,481	3,092	7,573	11,903	2,828	14,731
Universal basic (with 50% of currently unserved safely managed) by 2035	20,217	1,444	4,309	3,242	7,552	9,994	2,671	12,665
Universal safely managed by 2035	28,842	2,060	6,935	4,263	11,198	14,410	3,234	17,644
Universal safely managed by 2040	36,707	1,932	9,983	5,723	15,706	17,304	3,698	21,001
Universal safely managed by 2045	46,188	1,925	13,770	7,543	21,313	20,648	4,228	24,876
Universal safely managed by 2050	57,641	1,988	18,476	9,813	28,288	24,517	4,836	29,353

Table 2-2 Estimated investment needs (USD millions) to achieve universal coverage in water supply and sanitation by 2030 (with 50 percent of currently unserved population using safely managed services)

Country	Total (Urban and Rural WSS)		Urban			Rural		
	Total Investment	Avg. Annual Investment	Total Water Investment	Total Sanitation Investment	Total Investment	Total Water Investment	Total Sanitation Investment	Total Investment
Burkina Faso	2,586	287	340	568	908	1,227	451	1,678
Chad	4,956	551	838	398	1,236	3,012	708	3,720
Mali	2,549	283	831	721	1,553	735	262	996
Mauritania	1,268	141	441	447	888	279	102	380
Niger	4,343	483	338	216	555	2,996	792	3,789
TOTAL	15,703	1,745	2,788	2,351	5,140	8,249	2,315	10,563

Table 2-3 Estimated investment needs (USD millions) to achieve universal coverage in water supply and sanitation by 2040 (with currently unserved population using safely managed services)

Country	Total (Urban and Rural WSS)		Urban			Rural		
	Total Investment	Avg. Annual Investment	Total Water Investment	Total Sanitation Investment	Total Investment	Total Water Investment	Total Sanitation Investment	Total Investment
Burkina Faso	5,357	282	959	1,469	2,428	2,072	857	2,929
Chad	11,823	622	2,631	921	3,552	7,093	1,178	8,272
Mali	6,971	367	3,468	1,578	5,046	1,412	513	1,925
Mauritania	3,560	187	1,665	1,322	2,987	402	172	574
Niger	8,995	473	1,259	434	1,693	6,324	978	7,302
TOTAL	36,707	1,932	9,983	5,723	15,706	17,304	3,698	21,001

Policy recommendations

In addition to infrastructure investment, the World Bank should seek to leverage results-based instruments to establish and operationalize key policy, institutional, and regulatory (PIR) reforms required for improved sector performance, operational efficiency, and cost recovery, therefore maximizing the use of the region's scarce water resources, increasing resilience to climate-related threats, and making the sector more attractive to private financing:

- Finance country-specific sector diagnostics that identify the most critical bottlenecks to improved sector performance and climate resilience.
- Based on these diagnostics, support sector institutions in developing action plans for establishing and operationalizing necessary policy, institutional, and regulatory reforms.
- Leverage results-based instruments to incentivize the progressive and sustained implementation of these action plans or critical reforms.

- Support service providers in developing risk, resilience and emergency response plans to secure long-term resilience to climate-related and other threats in the provision of water supply and sanitation services.[45]
- Operationalize enhanced water quality monitoring to mitigate the increasing threats posed to water supplies from droughts and floods.
- Support educational institutions in delivering climate-informed trainings and capacity building to current and future water and sanitation professionals, including the development of young professionals' programs to facilitate the participation of youth and women.
- Operationalize an MIS system to monitor service functionality, institutional performance, energy and resource efficiency, and resilience to climate threats, therefore providing the required data to make climate-informed decisions in the sector.
- In rapidly growing urban areas, ensure demand management programs and appropriate water tariffication are in place to clearly communicate the value of water and avoid overuse.

Next Steps

Next steps in the modeling analysis through GCAM include scenario refinement consistent with potential CCDR interventions. A summary of proposed country development goals and climate-specific actions will be derived. These will be broad ranging recommendations for putting the country on a path to climate resilience (e.g., through revision of the country's NAP) and meeting its climate mitigation commitments (through revision of the country's NDC). Under this process, institutional and crosscutting enabling conditions for implementing effective adaptation and mitigation actions will also be proposed, including mechanisms for cross-sector coordination for climate action, bringing together various line ministries to work together under the leadership of the Ministry of Planning/Finance or other cross-ministerial coordination mechanism in charge of national climate action.

Measures of performance for different scenarios to be evaluated should be developed, assessed, and compared in agreement with indicators and judgment provided by in-country teams and Bank/Government staff. This performance will be quantified for each sector relative to the reference (baseline) scenario. For instance, a reduction in water demand, an increase (or decrease) in agricultural productivity, or shifts in primary energy matrix due to a policy intervention such as a country's NDC. For every intervention scenario run, the value of outputs (food, energy, water) can be obtained as output from GCAM, as well as equilibrium quantities and prices.

45 Plan development should follow the approach outlined in the World Bank's Resilient Water Infrastructure Design Brief, Building the Resilience of WSS Utilities to Climate Change and Other Threats: A Road Map.

2.1.2.3 Agriculture in the G5 Sahel

Challenges

The G5 Sahel has huge potential in Agriculture with abundant land and great irrigation potential. However, **yield potential** is low reflecting poor soils and a challenging climate. With 116 million ha of land having declining productivity and over 57 million ha showing early signs of decline46, the region is increasingly under pressure to meet estimated calorific requirements, Mauritania and Niger being the most severely affected. Most crops are produced in systems that also include useful trees, such as shea, baobab, locust-bean trees, and others. One could mention cereals for subsistence (millet, sorghum, maize, and other cereals including coarse/feed grains), and commercial crops (mainly cotton), as well as legumes (cowpeas, groundnuts) are produced under rainfed conditions, thus making them extremely vulnerable to climate.

Pastoralism plays an important role in the Sahelian socio-economic landscape. Even though animal production makes up 40% of agricultural GDP in the region on average47, veterinary personnel, material and equipment remain lacking. The sector is further weakened by insufficiently trained pastoralists and agro-pastoralists with little awareness on the importance of animal sanitary care. Adding to these challenges, the sector is climate sensitive; dry seasons become longer and adversely rainy season shorter and farmer – herder conflicts weigh heavily on the potential of the sector.

Fishing is an important livelihood activity in the Sahel, but both inland and coastal fisheries are suffering from overfishing and habitat degradation48. Inland fishing occurs along all major rivers and lakes of the region. Over the last thirty years, increasing demand for water supply has resulted in 25–60 % reductions in flows, causing increasingly low water levels.

Agricultural value-chains (VCs) are poorly linked to infrastructure. Agricultural sector continues to experience weak organizations, limited private investments in agro-processing and a limited regional integration. Agri-value chains including horticulture and animal resources are among the most perishable goods requiring specific conditions to unleash VCs development potential. National and regional trade in Sahel and West Africa in general remains strongly constrained by an uncertain environment characterized by a lack of basic infrastructures, the imperfection and weak market information systems, high level of transaction costs, and pervasive obstacles in regional trade linked to insufficient integration including non-tariff barriers (NTBs). Trade is predominated by informal practices, with limited transparency and visibility of prices along the VCs.

Deeper dives

2.1.2.3.1 Land suitability and crop yield

As the climate changes, shifts in land availability and suitability are anticipated49. In Chad, climate change will likely have a negative impact on yields of maize, millet and sorghum. Yields of rice, on the contrary, are projected to gain while yields of groundnuts are projected to decrease under a low emissions scenario and increase under a high emissions scenario by 2080. These projections vary from one country to another. In Mauritania, yields of maize are projected to decline, while yields of millet and sorghum, unlike in Chad are

46 Productivity Dynamics data is derived from NDVI product of MODIS/Terra Vegetation Indices 16-Day L3 Global 250m SIN Grid V006

47 De Haan, C. (editor). 2016. Prospects for Livestock-Based Livelihoods in Africa's Drylands. World Bank Studies. Washington, DC: World Bank. doi: 10.1596/978-1-4648-0836-4. License: Creative Commons Attribution CC BY 3.0 IGO

48 CLIMATE CHANGE RISK PROFILE WEST AFRICA SAHEL, Regional factsheet, USAID, 2017.

49 The State of the World's Land and Water Resources for Food and Agriculture – Systems at breaking point. Synthesis report 2021. Rome. https://doi.org/10.4060/cb7654en

projected to benefit from CO_2 fertilization. In addition to climatic risks associated with agricultural production and a decline in soil fertility which impede the use of improved seeds by farmers, there are several factors that impede the improvement of productivity such as high prices of agricultural inputs, the insufficiency of logistical and financial support, the poor organization of the sector, the lack of motivation by seed producers to enter the market. Also, insufficient agronomic knowledge remains a limiting factor. Besides that, insufficient agronomic knowledge or non-locally adapted varieties can lead to controversial effects and negative outcomes of this strategy

Investment opportunities

- **Gender sensitive smart agriculture investments.** Investment to increase horticulture irrigated areas together with postharvest facilities to reduce losses of produce will contribute to women and household income.
- **Climate-sensitive crop varieties.** Switching to improved varieties in climate change sensitive crops, yet carefully weighed against adverse outcomes, such as a resulting decline of agro-biodiversity and loss of local crop types. Crop-specific and location specific adaptation response should be considered.
- **Climate Information Systems.** Setting up of Climate Information Systems (CIS) to improve access to actionable climate information can help farmers to make informed decisions and thereby reduce the impact of climate risk. A comprehensive CIS-related project including capacity building and awareness raising campaigns can help to inform the various end-users along the value chain including farmers and rural communities about the great advantage of CIS.
- **Pest Management.** Setting up early warning systems for pest control.
- **Invest in crop production in line land suitability assessments.** Conducting regional (Sahel G5 at least) land suitability assessment to maximize economic potential in crop production and agricultural value chains.
- **Plant production from seed to fruit.** Creating a seed sector that covers the overall process for improved seeds from plant breeding and pre-breeding to seed propagation, marketing and advisory whilst focusing on farmers' needs. This should also include relevant trainings and awareness raising to ensure adoption by farmer groups.
- **Build on revisited traditional practices.** Setting up in-situ conservation projects, local seed banks, corporations with national or international gene banks and diversity fairs to safeguard seeds and institutionalize traditional practices.

Policy recommendations

- Develop policies towards sustainable land use intensification, as well as the rehabilitation of degraded soils and the necessary mechanisms to implement and evaluate these can help to promote the uptake of Integrated Soil Fertility Management (ISFM).
- **Integrated landscape approach**. Adopting a landscape approach empowers beneficiaries in implementing their local agenda in SLM and other integrated localized social development activities.
- **Strengthening research institutions** (climate smart innovation) and harnessing knowledge. Research institutions should be strengthened to continue generate climate smart and green technologies with potential for scale up. Research and impact evaluation for climate sensitive

investments will be important to inform policy decisions. Dissemination of the results can also improve the effectiveness of the proposed solutions and further strengthen the adoption rate

- **Foster partnerships and exchange.** Create a platform for bringing together and linking key partners in research, education, extension, service providers, input providers, and farmers to facilitate farmer mobilization and capacity development.
- **Access to finance.** Develop policies that incentivize credit and loan schemes and subsidy programmes for the production of organic inputs could address the issue of lack of access to equipment and input.

2.1.2.3.2 Pastoralism

The sector is highly climate sensitive. Dry seasons become longer and adversely rainy season shorter. And even where the total volume of rainfall has not decreased, it fluctuates more year on year and can come in short bursts (which can cause flash floods) rather than steadily throughout the season, thus affecting fodder availability, geographical distribution and even species diversity. Adding to climate factors, farmer – herder conflicts weigh heavily on the potential of the sector. Historically, pastoralists migrated their herds south during the dry season and north during the wet season and pastoralists benefitted from grazing cattle on crop residues and farmers used the cattle droppings as manure. In response to erratic rainfall and recurrent drought, pastoralists have altered their traditional migratory corridors in search of new seasonal watering holes and rangelands, resulting in conflicts with farmers[50].

As such, pastoralists and farmers need support to maximize adaptation and resilience.

Investment opportunities

- **Animal Health.** Invest in training pastoralists and agro-pastoralists and raise awareness on animal sanitary care and Good Manufacturing Practices of dairy and meat value chains. Investment in veterinary care, traceability,
- **Rangelands management.** Investment in water points and veterinary services as well support in downstream investments is required to sustain agro-pastoralism.
- **Invest in fodder value chain.** Invest in improved fodder production, including seeding, processing, storage, and marketing of fodder. Encourage the private sector to invest in animal feeds factories across the Sahel countries will increase livestock productivity and contribute to job creation. This investment is highly profitable as all countries are already investing in poultry and fish farming which the key sub-sectors that highly demanding of animal feeds.
- Pilot plots of sufficient coverage conducted for instance by local authorities can foster acceptance of farmers for improved varieties or new management techniques such as irrigated crop production.
- **Investment in the milk chain:** The Sahel region is the most cattle populated in Africa. However, investment in milk industry is very limited and not well organized. Intensification and promotion of animal feeds will lead to increased milk and meat productivity. It is important to invest in long shelf milk industry. This will reduce dependency to outside markets and instead create jobs for youth and women. The investment will consider the milk collection chain and logistics.
- **Investment in meat industry:** Sahelian countries has huge potential for meat production. Meat production is still at low lever and animals are instead sold on the legs. Private sector will be

50 Climate Change Risk Profile West Africa Sahel, Regional factsheet, USAID, 2017.

encouraged to invest in strategically located meat factories to take advantage of already existing regional market for meat.

Policy recommendations

- **Regional regulation on milk and milk products:** Ensure that regional standards are in place and implemented across all G5 Sahel countries.
- **Put in place Climate Change Investment facility** that support clean private sector climate smart initiatives such a smart milk collection centers and milk factories using solar energies as source of energies
- **Regulate pastoralism and land tenure in rural areas.** Develop and enforce rangelands management laws and regulations including rangelands management planning and assessment of underlying rangelands elements (ecological assessment, carrying capacity, grazing routes , socio-economic considerations, etc.)
- **Women empowerment** through awareness raising across gender can help to sensitize about the participation of women in decision making, which in turn presents an important opportunity to improve the sustainability of fodder management.
- **Change impacts and security and migration issues.** Adaptation measures can help to fight instability, conflict and terrorism, which are issues, that are often multiplied by climate change. Nevertheless, more research with regard to the complex interplay of climate change impacts and security and migration issues is needed, in particular between pastoralists and farmers.

2.1.2.3.3 Fisheries

Since the 1960s, Lake Chad has lost 95 % of its surface due to increased water use, changing rainfall patterns and rising temperatures which result in reduce fishery productivity, increasing disputes over access to water, fishery and land ownership[51], not to mention the impacts on water quality having negative consequences for the ecological integrity of aquatic systems. On the other hand, Mauritania's continental fisheries account for 10% of GDP and 50% of export earnings[52]. They are considering among the richest fishing grounds in the world and are the focus of national public investments and development, considering the sector's productive capacity and its contribution to food security[53]. It is estimated that Mauritania's fisheries are exploited 30-40% higher than the maximum sustainable yield adding to the additional risks that climate change brings, such as habitat and biodiversity loss, ocean acidification, extreme weather events, and sea level rise. However, not all of the changes will be negative. As sea levels rise, flooding of low-lying areas and salinization of groundwater and soil will create ideal conditions for aquaculture in many areas (MAB, 2009), while simultaneously rendering them unsuitable for regular agriculture. Inland fisheries

For the sake of avoiding double counting, investments and policy recommendations relating to inland fisheries are included under Water sector – section *Water Scarcity*

51 Climate Risk Profile: Sahel, UNHCR, PIK https://www.unhcr.org/61a49df44.pdf

52 Climate Change Profile West African Sahel © Ministry of Foreign Affairs of the Netherlands | April 2018

53 Programme Prioritaire Elargi du Président, comite technique, Septembre 2020.

Investment opportunities

- Invest in expanding relevant infrastructures including more ports, development of the infra for the value chain, expansion of fleet…
- Fish farming masterplan for Sahel: The fish farming masterplan for Sahel will identify potential investments required to transform fish farming, the cost and mobilize the public and private sector for financing

Policy recommendations

- Prioritize investment in adaptation to climate change as opposed to infrastructure investment.
- Develop national fisheries laws that provide the legal framework for fisheries and fish farmings

2.1.2.3.4 Agricultural value chains

Investment opportunities

- Develop climate smart and market-oriented value chains:
  - Invest in rice value chain: The G5 countries have a huge potential for irrigated rice production. All 5 countries import more than 50% of their annual rice consumption. Investment in rice value chain from water management and irrigation, production, postharvest and milling constitute a huge source of income the population. It will contribute to macro stability by substituting huge quantity of rice importation. This investment will mobilize public-private for irrigation infrastructure.
  - Increasing investments in Horticulture: Vegetables and fruits constitute a huge source of income in the rural areas. The commodities can be highly fragile to the climate if they are cultivated under rainfed system. Investments in horticulture require irrigation, postharvest facility for conservation and value addition. As the Sahel is urbanizing and becoming huge market for specific commodities such as milk, horticulture, rice and processed food, it will be important to mobilize small and medium enterprises together with farmers to take advantage of the new development. Investment in cold chain, horticulture wholesale markets will be catalytic to pull productivity in horticulture.
- **Export oriented value chains**: Horticulture, cotton, sesame, shea, moringa, hides and skins constitute key export-oriented commodities for the region. Investments across the value chain are required to increase productivity and value addition in the region. Rather than exporting raw material the private sector will encouraged to invest in semi-finished or finished products. Investments in processing factories, packaging and labelling will be required.
- **Climate smart agriculture investments with potential to mobilize the private sector**. Undertaking a reform agenda to mobilize climate smart and green investments in agriculture will be central to operationalize the CCDR in Sahel. This would include switching to improved varieties in climate change-sensitive crops, yet carefully weighed against adverse outcomes, such as a resulting decline of agro-biodiversity and loss of local crop types.
- Ameliorate the functioning of the agricultural value chain including functioning infrastructure and agriculture markets to make agricultural inputs available and accessible.

- **Regional momentum.** Development of regional value chains to improve commercialization of agricultural outputs (non timber forest products?)
- **Crop and livestock insurance:** Sahel countries are challenged by seasonal crop failures due to pest and climate conditions among others. Most of G5 countries deliver input subsidies to farmers. Crop failure leads to loss of farmers' investment and public subsidies. Crop/livestock insurance protect farmers and Government support against climate change and other shocks.
- **Investing in country and regional strategic food reserves:** The region deals with repetitive food crisis every year due its climate conditions. However, response systems in place are always reactive. The crisis response hampers development efforts that Sahel countries are making. Investing in early warning systems and country food reserve will help to proactively respond to the crisis while allowing the countries to remain on a good developmental trajectory.
- **Investment in digital agriculture:** Drones, MIS, E-agriculture, e-voucher.

Policy recommendations

- Develop policies that incentivize the private sector to engage in value chain activities, namely supplying seeds, registering fertilizers, investing in technology.
- **Strengthening public-private dialogue** will be central to help mobilize private investment in the agricultural sector
- Reduce the cost of land titling by implementing a large-scale land titling investment program
- Institute contract farming and other land use models including cooperative land use and corporate land use to allow domestic and international private sector to invest in Agriculture
- Strengthen sanitary and phytosanitary standards
- Develop policies that incentivize credit and loan schemes and subsidy programmes for the production of organic inputs could address the issue of lack of access to equipment and input and also access to market.
- **Aligning with GAP.** Regulate trade, namely export requirements to elevate quality of the products.
- **Policy and legal framework for warrantage.**
- **Crop insurance policies and legal framework:** Undertake reviews and assessment on crop and livestock insurance and propose policies and legal framework that help private companies to invest in crop insurance in Sahel
- **Put in place observatory for priority value chain**: Example being the ECOWAS Rice Observatory. This helps streamline and coordinate efforts around key and strategic value chain. It helps organize players across the value chains, producers, millers and importers while facilitating to access to finance and technologies.

2.1.2.4 Landscapes - Sectoral Policies, Investments, and Institutional Arrangements

1. Introduction

1. Successful development through climate action in the G5 Sahel will yield a fast and inclusively growing climate-resilient region. Climate risks will be accurately identified, assessed, and addressed through a comprehensive multisectoral suite of policies and investments built on proactive government leadership and strong participation by the private sector, civil society, local communities, and individual citizens. Cutting-edge technologies and digital and financial tools will be deployed

through effective institutions and organizations able to design and implement bankable, high-impact, sustainable interventions in multiple contexts.

2. Seizing the opportunity to bring this vision to fruition and unleash the region's immense development potential entails strengthening and leveraging existing resources, capacities, and partnerships. It also means creating fresh coordination platforms, financing instruments, and targeted initiatives that address not only long-standing climate-related development challenges, but also newly emerging risks linked to the interaction of climate change with other drivers of vulnerability and hardship in the Sahel, such as conflict and COVID-19. Key sectors must realize important outcomes linked to adaptation, resilience, mitigation, and disaster risk management, overcoming major challenges and constraints through effectively implemented policies and investments.

2. Essential Sectoral Outcomes

3. Agriculture, water, and environment are strongly impacted by climate change from a landscape perspective and therefore the sectors within which most landscape-scale development through climate action must occur. Given recent trends and current conditions in the G5 Sahel, what are the major climate resilience-boosting and inclusive growth-enhancing outcomes within and across these priority sectors?
4. *Agriculture*. The agriculture sector must contribute to reduced GHG emissions while registering major sustained increases in productivity through expanded sustainable land management practices, enhanced availability and adoption of climate-resilient production technologies and practices in cropping, livestock, and fishing systems, expanded access to finance and financial risk management services, and effective preservation of agrobiodiversity. Given the prominence of livestock in rural livelihoods, effectively stabilized and expanded availability of and access to sustainable livestock feed and water resources and improved livestock health are vital. Overfishing and degradation of fish habitats must cease. Increased access to markets based on improved infrastructure and market information systems is critical to value chain development for expanded livelihoods. Efficient and effective research and extension systems are critical, alongside effective disaster early warning, preparedness, and response systems.
5. *Water*. Per capita water availability must increase, water insecurity must drop, and sustainable water sources must diversify and expand. Flood prevention and erosion protection must be enhanced, including through nature-based approaches. Transboundary water resources and basins must be effectively managed. In rural areas, the potential for large-scale and small-scale irrigation must be fully exploited, including improved water harvesting and modernized and refurbished irrigation and drainage infrastructure. Water-use efficiency must improve. In urban areas, capacities for low-energy water treatment, water supply and sanitation, wastewater treatment services must expand, with access for women prioritized. Contamination of surface and groundwater resources and pollution of aquifers and rivers must be curtailed.
6. *Environment*. Reduced GHG emissions must be accompanied by sustainable livelihoods based on effective exploitation of natural endowments of space, solar energy, minerals, water resources, biodiversity, and cultural heritages. Deterioration of the natural resource base and loss and fragmentation of forests, savanna and woodland areas must be arrested. Nature-based solutions for managing and restoring landscapes, forests and watersheds must expand. Green technologies, green businesses, and clean energy infrastructure must increase. An effective and reliable centralized environmental information systems is vital.

3. Challenges and Constraints

7. There are several impediments to achieving these sectoral outcomes. Some are cross-cutting, most are sector-specific.
8. *Cross-cutting.* Economic growth is not keeping pace with population growth and urbanization. Development gaps across the region are therefore vast, with huge financial requirements for climate action coming on top of massive existing unmet development funding needs. The delivery model for development is functioning poorly due to weak, unstable, and overburdened public institutions. Climate action is adding complexity and capacity requirements. Multiple policies and strategies remain unimplemented or poorly implemented. Conflict and COVID-19 are destabilizing or destroying hard and soft infrastructure, generating a surge of vulnerability and dependence due to displacement and forced migration, diminishing public revenues, and diverting resources away from intended purposes.
9. *Agriculture*. Rainfall is increasingly erratic and poorly distributed, with extreme droughts and floods more widespread and frequent. Productivity in major cropping, livestock, and fishing systems is stagnant or falling due to lack of climate-resilient and climate-smart technologies and management practices, high pest-related production losses, and declining agro-biodiversity and loss of local varieties and breeds. Large-scale and small-scale irrigation potential is under-exploited. Food production deficits are leading to low stocks, high demand, and high prices. Agricultural research and extension systems are poorly resourced. Trained veterinary and fishery personnel, materials, and equipment are lacking, leading to poor animal health and over-exploitation of fish habitats. Rangelands and watering points are increasingly depleted, spurring irregular interaction and competition between pastoralists and farmers for land and water in remote areas. Farmer organizations are weak. Women have unequal access to productive resources and technologies. Within and across borders, trade is highly informal and opaque. Market and value chain infrastructure, organization, and information capacities are weak, leading to limited private sector investment.
10. *Water*. In rural areas, agriculture, pastoralism, and other economic activities remain reliant on highly vulnerable water-dependent ecosystems. Surface and ground water sources are largely uncontrolled and their potential mostly unseized. Declining pastoral lands and water shortages are leading to increased migration by pastoralists to agricultural areas. In burgeoning urban areas, there is a widening gap between water demand and supply, alongside lack of urban planning mechanisms to successfully meet growing water demands. Water utilities are characterized by low throughput, low efficiency, lack of investment, weak institutional capacity, and poor maintenance. Access to water supply and sanitation services is therefore low and unequal, with strong negative impacts on women, and with remote rural areas significantly deprived. Water treatment infrastructure and access to basic drinking water services are inadequate. Aquifers and rivers are increasingly polluted from uncontrolled discharge of untreated wastewater and fecal sludge, with strong impacts on urban slums. Sectoral strategies are poorly harmonized and implemented. Major water sources straddle borders but there is limited attention to water in regional development strategies.
11. *Environment*. There is rapid degradation of natural capital due to lack of capacities for design and implementation of environmental conservation measures at landscape scale and low understanding and limited capacity to apply nature-based solutions to deterioration of landscapes, forests and watersheds. Despite their pivotal role in natural resource management, women face major impediments to accessing and controlling natural capital. Financing mechanisms for adaptation, resilience, and disaster risk management are uneven across the region. Environmental and social

impact assessment regulations covering climate and disaster risk and climate resilience are similarly patchy, leading to poorly functioning or inoperative regulatory systems and regulatory vacuums regarding climate and disaster risk assessment and climate resilience. Financial and technical capacities and databases in regulatory bodies are thin, especially for climate analysis, including for early warning systems for climate risks and projections at national and subnational levels.

4. Policy Responses

12. Viewed together, the desired outcomes, challenges, and constraints point to five broad areas for system-transforming policy action in each of the core sectors: (1) *promoting system innovation* – in all three sectors, the quantity and quality of climate-resilient technologies and practices must increase dramatically; (2) *increasing system depth and coverage* – in all three sectors, the availability of and access to sustainable natural capital must increase significantly, alongside robust expansion of resilient livelihood options; (3) *enhancing system efficiency and sustainability* – in all three sectors, costs and impediments to action and coordination in the face of climate hazards must drop sharply; (4) *boosting system equity and inclusion* – in all three sectors, marginalized groups and areas must not be left behind in efforts to expand and strengthen climate-resilient livelihoods; and (5) *strengthening system coherence, transparency, and accountability* – in all three sectors, huge gaps in the structure and functioning of vital climate action decision making and implementing institutions and organizations must be filled.
13. Many of the policy actions are highly recognizable. Given the chronic nature of some of the challenges, this is to be expected. Several policies would be novel to the G5 Sahel region. Together, the set of policy actions comprise a comprehensive framing of the normative requirements for climate-enhanced development in the region.
14. The value proposition of climate action-enhanced development springs from its fundamental multi-sectoral imperative, expressed partly through existing policy actions and partly through new ones. One cross-cutting theme is therefore the need to focus on filling policy gaps and promoting country-driven capacity development in the short and long term. Energy fuels and regulates economic activity; meeting energy needs, safely, efficiently, and sustainably drives to the core of climate action. A second cross-cutting theme thus is energy efficiency and access. Climate change generates impacts with strong spatial and temporal expressions. Hence, a third cross-cutting theme is regionality and collective action across national borders, and regional specificity between rural and urban areas within national borders.
15. Sector-specificity is greatest in the policy actions seeking to promote system innovation and increase system depth and coverage (Table 2-4Table 2-6). Some sector-specific actions can be expected to generate impacts in other sectors, both positively and negatively. The main potential tradeoffs are between agricultural productivity growth and livelihood promotion, on one hand, and protection and conservation of biodiversity, landscapes, forests, and watersheds, on the other. Some challenges and constraints cut across sectors and thus require cross-sectoral policy responses (Table 2-7). In such cases, sector-specificity is at the level of investments.
16. Among the nine cross-cutting policy actions (Table 2-7), three are especially critical: digital tools and platforms, financing instruments, and women and other disadvantaged groups. Digital tools and platforms are already fundamental to climate action in many parts of the world, allowing for assembly and analysis of large volumes of the multi-faceted data and information required for informed decision-making on climate issues. The best of these tools and platforms must be drawn into the mainstream in the G5 Sahel at national and regional levels.

17. The inherent, ubiquitous, and varied risks generated by climate change in the G5 Sahel entail an expansion and deepening of risk management tools and structures. Financial instruments that allow for enhanced risk mitigation, transfer, and coping solutions at micro, meso, and macro levels are pivotal and must be aggressively developed and applied in the region.
18. Given their prominent roles in the provision of food, energy, and water in households and communities, women in the G5 Sahel interact constantly and deeply with natural resources. Climate-enhanced development will succeed only to the extent that women have greater access, agency, and control of natural capital. Comparable requirements must be met for today's youth and disabled groups, who comprise large segments of both rural and urban populations.

5. Investment Targets

19. Assuming an initial five-year implementation horizon, Table 2-4, Table 2-5, and Table 2-6 present indicative annual and overall investment targets within and across the three core sectors, based on estimated costs of investments under the policy action areas set out in the previous section. The sector-specific investments are largely "hard" investments that aim to establish and strengthen the physical foundations of effective climate action, whereas the cross-cutting investments are mainly "soft" investments that seek to expand institutional scope for climate action. The "hard" investments are more costly and visible than the "soft" ones, but not only are "soft" investments typically more complex than "hard" ones, they are vital to realization of the full impacts of "hard" investments. Both kinds of investments must therefore be prioritized for effective climate action, with deliberate measures to overcome tradeoffs and seize complementarities between productivity growth and conservation across landscapes.

6. Institutional Arrangements

20. Implementation is where climate action-enhanced development differs most significantly from "normal" development. This raises both challenges and opportunities.
21. The stakeholder groups are largely the same – i.e., national and subnational government agencies, multilateral and bilateral development partners, regional bodies, international and domestic civil society organizations, local and international private companies, local communities, and private individuals. But due to the complexity of climate action and the urgent imperative to act, there are profound differences in the demands and expectations of these stakeholder groups, both individually and collectively.
22. As noted in the presentations of policy responses and investments, some policy actions and associated "hard" investments are highly sector-specific, whereas others are inherently multi-sectoral and "soft." Both kinds are vital and complementary, meaning that sets of policy measures and investments must be carefully combined over space and time. Effective implementation rests on pragmatic prioritization and focus based on the principles of proportionality (directing resources toward the greatest needs) and feasibility (aligning goals with available resources and capacities). The challenge is that in all G5 Sahel countries and across all sectors, needs are immense and surging, and resources and capacities are limited and shrinking. Governance and accountability systems are inadequate, leaving room for fraud and corruption. A fundamental reimagining of stakeholder roles is warranted.
23. Even as their leadership and accountability for climate action are affirmed and strengthened, an intentional reconsideration of the weight and content of responsibility resting on G5 Sahelian governments is appropriate. The delivery model must recognize and overcome huge technical, organizational, institutional, and policy gaps in overburdened public sectors. These gaps must be

systematically identified, assessed, and filled. Given the urgent need to fill these gaps, in some especially complex or novel policy action areas (e.g., development of renewable energy assets or nature-based integrated landscape management), governments might deliberately delegate oversight and leadership roles to capable stakeholders, while retaining accountability through institutional and information management innovations. Further, the stakes are sufficiently high that, in partnership with relevant stakeholders, governments in the region must assess the viability of all public development agencies and initiatives, with the principal criterion for continued support being relevance and impact in the climate action-enhanced development agenda. Identified nonviable agencies and initiatives would be placed on time-bound reform programmes following which continued support would be contingent on performance against transparent targets. Such a process requires strong stakeholder engagement and input, especially from non-state actors.

24. But climate change is marching on in the region. Other actors must be deliberately encouraged, incentivized, and facilitated to support implementation in the immediate term, aiming in the first instance to take existing national and regional strategies and policies in the prioritized action areas to full implementation. Where relevant and feasible, new implementation platforms must be developed with great urgency. Especially important are measures that enhance scope for public-private partnerships involving national, regional, and international actors that can effectively accommodate and respond to the wide spatial reach and sharp immediacy of the unfolding impacts of climate change within and across the three core sectors.
25. Public sector implementation capacity must be boosted in all G5 Sahel countries. But gradual enhancement is an unaffordable luxury. Reliance on domestic public resources or expanded support from traditional donors is not viable. The needs and investment priorities of the private sector – from smallholder farmers at one end to large multi-nationals at the other – must be clearly articulated and either accommodated or incentivized toward desired changes, aiming to catalyze significant new investment from this vital source. Targeted support for the emergence, facilitation, and capacity development of private sector climate investment forums and platforms will be paramount.
26. The G5 Sahel has long been a priority for climate action at global level. That will not change. Successful climate action in the G5 Sahel has huge implications not only for prospects that the people of the region will benefit from its huge natural endowments of space, solar energy, minerals, water resources, biodiversity, and cultural heritages, but also for prospects that climate change mitigation and adaptation will succeed at a global level.
27. A key recognition is that significant financing and implementation capacity for climate action exists outside the G5 Sahel, including in donor countries, multilateral development and humanitarian agencies, and the international private sector. Within the region, private investors – from smallholder farmers at one extreme to large multi-nationals at the other – have considerable untapped knowledge and capabilities for climate action. Several national and regional commitments and initiatives provide political and policy space for scaled multi-stakeholder action within and across the prioritized sectors.[54] A major opportunity facing national and regional leaders thus is to work with partners to develop sets of climate action-enhanced development business cases that allow the region to attract and deploy the large-scale funding and expertise required to exploit this powerful set of capabilities and attributes.

54 Examples include: the Great Green Wall – https://www.greatgreenwall.org/about-great-green-wall; the Sahel Resilience Project – https://www.africa.undp.org/content/rba/en/home/projects-and-initiatives/ResilienceSahel.html; and the African Initiative for Combating Desertification to Strengthen Resilience to Climate Change in the Sahel and Horn of Africa http://aicd-africa.org/archives/3562

28. Finally, for all stakeholders, given the range and depth of the climate-driven crises facing the G5 Sahel, climate action-enhanced development must be approached as an emergency activity. Several principles and approaches of emergency planning and action must be taken on board by the region's development actors. These include: strategic use of "no regrets" investments driven by rapid risk assessments; development and deployment of contracting and procurement systems that allow for quick, targeted, large interventions that include significant strategic and operational contributions from the international and domestic private sector; prioritization of operational feasibility and impact potential to facilitate learning-by-doing; development and application of comprehensive but practical analytical and decision-support platforms similar to the widely implemented Integrated Food Security Phase Classification (IPC) to build consensus on triggers, thresholds, scale, location, and duration of action[55]; and development and rollout of "essential packages" of short-term and long-term climate action interventions suited to major prevailing conditions in the G5 Sahel's rural and urban areas, and which together provide immediate relief from the impacts of climate shocks while addressing underlying drivers of vulnerability.[56]

55 https://www.ipcinfo.org/ipcinfo-website/ipc-overview-and-classification-system/en/

56 "Essential packages" are common in healthcare, aiming to provide comprehensive sets of tools and guides that enable programs to address patient needs in integrated and holistic ways. They are especially useful for defining priority health services in fragile settings, where needs often exceed available resources. https://www.who.int/health-cluster/about/work/task-teams/EPHS-working-paper.pdf?ua=1

Table 2-4 Illustrative policy action areas and policy actions in the agriculture sector

Policy Action Area	Policy Actions1/	Cross-Sectoral Impact2/	
		Water	Environment
Promoting system innovation	Enhance capacities of agricultural research and extension systems to develop and deliver energy-efficient climate-resilient technologies and practices	+	+
	Strengthen farmer and trader organizations and increase their engagement in energy-efficient climate-resilient agricultural technology development and dissemination	+/-	+/-
	Boost private sector investment in energy-efficient climate-resilient agricultural technology development and dissemination	+	+
Increasing system depth and coverage	Expand irrigated cropland through energy-efficient small-scale and large-scale approaches	+	+/-
	Preserve, regenerate, and expand rangelands and forage, water resources, watering points, and veterinary services	+	+
	Expand cropping and livestock market and value chain infrastructure and services, including market information systems	+/-	+/-

1/: Farmers refers to crop farmers, pastoralists, and fishermen.

2/: "+" = impact is clearly positive; "+/-" = impact is dependent on design and implementation of interventions

Table 2-5 Illustrative policy action areas and policy actions in the water sector

Policy Action Area	Policy Actions	Cross-Sectoral Impact*	
		Agriculture	Environment
Promoting system innovation	In rural areas, promote transfer and adaptation of scalable energy-efficient technologies and practices for resilient: groundwater and surface water mobilization and management; small- and large-scale irrigation; flood prevention and control; water-use efficiency in crop, livestock, and fish production; water harvesting and storage; domestic water supply and sanitation	+	+
	In urban areas, promote transfer and adaptation of scalable energy-efficient technologies and practices for resilient: groundwater mobilization and management; domestic and industrial water supply and sanitation; flood prevention and control; water treatment and purification; domestic and industrial water-use efficiency and water quality monitoring		+

	In both rural and urban areas, increase the use of nature-based solutions to enhancing resilience, reducing deterioration, and boosting conservation of water resources	+	+
Increasing system depth and coverage	In rural areas, leveraging public and private capacities, expand, rehabilitate, and maintain infrastructure for and access to: groundwater and surface water; low-cost and low-maintenance irrigation and drainage technologies and services; water supply and sanitation services; flood prevention and control	+	+
	In urban areas, leveraging public and private capacities, expand, rehabilitate, and maintain infrastructure for and access to: water supply and sanitation services, wastewater management, water treatment and purification, flood prevention and control		+
	In both rural and urban areas, increase capacity and improve mechanisms for mobilizing, managing, and conserving water resources, aiming to bridge gaps between demand and supply	+	+

** Note: "+" = impact is clearly positive; "+/-" = impact is dependent on design and implementation of interventions*

Table 2-6 Illustrative policy action areas and policy actions in the environment sector

Policy Action Area	Policy Actions	Cross-Sectoral Impact*	
		Agriculture	Water
Promoting system innovation	Support development and diffusion of technologies and approaches to enhance conservation (reduce degradation and over-exploitation) of landscapes, forests, and watersheds, and strengthen associated livelihoods	+/-	+
	Develop and implement regulations that improve incentives for design and application of nature-based solutions to deterioration of landscapes, forests, and watersheds, including integrated landscape management to maximize biodiversity co-benefits and minimize tradeoffs	+/-	+
	Support sustainable development and use of renewable energy assets	+	+
Increasing system depth and coverage	Expand access to conservation-enhancing technologies, approaches, and livelihood opportunities	+/-	+
	Expand affordable access to sustainable renewable energy assets	+	+
	Increase technical, financial, and organizational capacities of environment regulatory and impact assessment bodies and platforms at national and regional levels	+/-	+

** Note: "+" = impact is clearly positive; "+/-" = impact is dependent on design and implementation of interventions*

Table 2-7 Illustrative cross-cutting policy action areas and policy actions

Policy Action Area	Policy Actions
Enhancing system efficiency and sustainability	• Support design and application of digital tools and platforms for planning, design, implementation, and monitoring of climate action measures at micro, meso, and macro levels • Support design and application of modern financial instruments and approaches for sustainable management of natural resources and enhanced climate risk management, adaptation, and resilience at micro, meso, and macro levels • Improve structures and processes for climate disaster preparedness and response, including strengthened early warning and integration with social protection systems
Boosting system equity and inclusion	• Support increased engagement of women, youth, and people with disabilities in planning, design, implementation, and monitoring of climate action measures, aiming to boost their access to and control of key natural resources and associated services • Prioritize needs of vulnerable communities in remote rural areas • Prioritize needs of vulnerable communities in urban slums
Strengthening system coherence, transparency, and accountability	• Promote development and application of sectoral and cross-sectoral performance standards, indicators, benchmarks, and targets for climate-resilience • Increase data availability and analytical capacity for evidence-driven, results-based climate policy and regulation development and implementation at national and regional levels • Strengthen stakeholder complaint and feedback structures and processes within multi-sectoral climate action coordination mechanisms

2.1.2.5 Urban, Disaster Risk Management, Resilience and Land G5 Sahel Policy Package

Problem Statement

Over the last two decades, the Sahel region has become increasingly fragile, with waves of conflict and disasters (primarily climate induced), destabilizing the region. Currently, all G5 Sahel countries (Mali, Niger, Burkina Faso, Chad, Mauritania) are facing erratic rainfall patterns and increasing intensity and frequency of droughts and floods due to climate change, which has impacted agricultural production and increased food insecurity, thereby posing additional threats to livelihoods in the region. In this context, rural-urban migration has become a major contributor to urbanization as poorer populations head to cities to seek refuge and hope to improve livelihoods.

Sahelian urbanization is largely uncontrolled and is driven by the rural-urban migration[57] as well as some endogenous growth. In areas experiencing conflict or growing insecurity, cities are also seen as refuges and play a critical role in building community resilience as well as local economic development.

Urbanization in the Sahel is also characterized by primary cities hosting a growing share of the population, smaller towns, which are more numerous and spread out, hosting an equal share of the population[58]. Population growth has been faster in larger cities compared to smaller ones, resulting in a situation where the eight largest cities concentrate almost 40% of the urban population and the remaining 60% are distributed in numerous smaller cities with population levels below 100,000 inhabitants. These smaller cities are scattered across the region, distant from each other and display little agglomeration effects. Consequently, the majority of Sahelian cities are not sufficiently large to create market potential or generate

57 Sahel: The Urban Link, WB ASA FY 2022.

58 Sahel: The Urban Link, WB ASA FY 2022.

economies of scale. In addition, while Sahelian cities have experienced rapid population growth, population densities remain low6. Cities have almost doubled in size in terms of their built-up area since 1985, however, urban growth patterns suggest that new city dwellers are settling in poor-quality settlements with poor access to infrastructure and services. Urban infrastructure expansion has been limited and unable to meet the demands of the growing urban population. These informal and unplanned urbanization characteristics and patterns point to are driven by a lack of resources and weak urban planning capacity at the local level.

This points to the **need for policy and investment programs towards both types of cities to support resilient urban development in line with climate change adaptation and mitigation measures.**

Even though Sahelian cities' current GHG emissions are low, significant action is needed now before carbon-intensive urbanization patterns are locked in for generations, requiring massive investments to reverse.

Unsustainable urban sprawl, low densities and fragmented urban forms, which differ from a city to another not only increase the cities' carbon footprints but also push up the cost of service delivery, preventing cities from achieving agglomeration economies and delivering jobs and productivity gains. Optimizing cities' spatial and morphological structures may be the greatest source of energy savings and lower transport GHG emissions. Higher compactness will also reduce the needs of land and physical infrastructure and service connections (e.g. denser cities need fewer kilometers of asphalt roads and shorter electricity lines and water pipes concrete).

Low population density in Sahel is, therefore, an opportunity to set urbanization on a resilient low-carbon path before it is too late. Strategic urban planning—that favors denser, more compact, connected and mixed-used urban growth and translates into enforceable resilient land-use planning and construction practices —is a priority. Compact urban growth would not only bring down Sahelian cities' carbon footprint but could help preserve land for agriculture, an important jobs sector and a critical component towards alleviating the deteriorating food security situation. Compactness could be developed through structural investments promoting urban regeneration – upgrading dense informal settlements in strategic areas, developing efficient urban mobility (adequate roads to cater for increasing collective transport demand), and using green belts to limit sprawl as part of a broader nature-based solutions strategy that would target climate risks such as heat waves and flooding, taking into account that cities will be impacted differently by climate change depending on where they are located. Capacity building to design, implement, and enforce appropriate urban plans will also be needed.

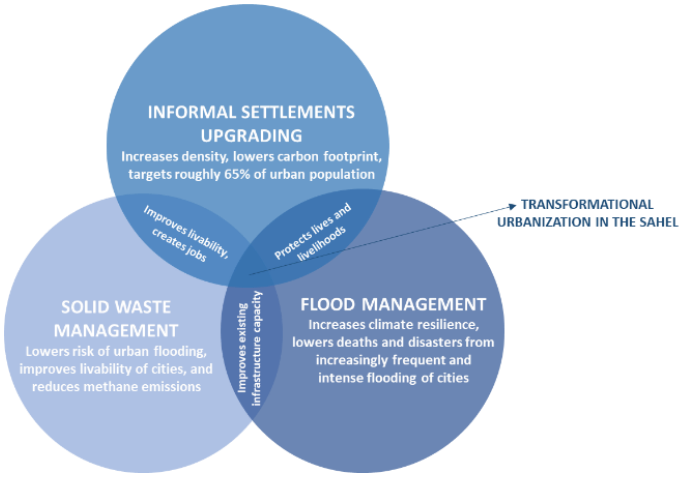
However, **simply creating greater compactness by densifying existing built-up areas could lead to congestion and a further deterioration in livability** standards **under the current circumstances of flooding and inadequate wastewater and sanitary coverage.** Therefore, an integrated solution is needed to support densification while concurrently boosting the quality of life by providing essential basic services.

The Sahel is becoming increasingly flood-prone; floods have increased by a factor of 5 since 1990s and in the last decade floods have accounted for 65% of disaster events and caused 24% of disaster deaths, with Niger and Chad being the hardest-hit in recent years. As floods become more frequent and intense, **deaths and damages from urban flooding are intensified by unplanned and informal urbanization: 65% of the urban population in the Sahel lives in informal settlements with inadequate drainage and deficient solid waste management (SWM) systems**. Indeed, solid waste dumped in the existing drains is a major cause of flash floods in urban areas. Left untreated or openly burned, **solid waste is a major contributor to methane and other greenhouse gases and affects the health of communities**. Between now and 2030, **Sahelian**

countries are expected to more than triple their waste generation, pointing to the need to prioritize SWM. Informal settlements upgrading is particularly urgent as built-up areas are projected to peak around 2030.

Approach to Solution

To achieve transformational impact and avoid lock-in effects, **a programmatic approach that links large scale structural investment program with technical assistance and policy interventions is needed at a national and multi-city scale**. The program would combine multi-year massive investments in the following three areas - **informal settlements upgrading, solid waste and flood management** - along the design and implementation of national strategies and regulatory frameworks.



Recommended Investment Programs

Informal Settlements Upgrading

Informal settlements upgrading at scale will require a programmatic approach with prioritization of dense informal settlements either exposed to risk or close to the city center as a way of fostering a less emissive urban form, better urban mobility (access to jobs/markets), and improved service delivery (access to water/SWM).

To achieve a transformational impact on urban resilience, massive informal settlements upgrading programs would integrate flexible resilient planning with a phasing and sequencing of investments. Projects should aim to start with easier to implement investments, such as drainage and road paving, public places' upgrading, and water kiosks, while planning in parallel and to avoid delays[59], more complex interventions in the areas of sanitation, public lighting, electricity access and markets' rehabilitation.

The indicative investment packages for cities would be prioritized depending on local needs. These investments could include paved roads and streets, bicycle/pedestrian paths, street lighting, vending platforms, solid waste collection and settlement sorting, storm water drainage, water and sanitation systems, and public and green spaces. Wherever possible, the investment package should adopt labor-intensive public works to support job creation, with a particular focus on youth as well as vulnerable groups, such as women, IDPs, refugees etc.

59 Using simple digital tools such as Open Street Map to facilitate rapid and efficient planning.

Housing opportunities should be provided in parallel to limit new informal settlements through a programmatic rather than a site-level approach. This can be done using a renewed 'sites and services' approach, i.e. the provision of serviced plots, including the relevant public spaces and equipment, while setting up well-designed and controlled self-building schemes by the small builders' sector.[60] Support to existing public housing companies to develop serviced plots during a second phase would mature the market and open up room for private sector developers in a third phase. Resilient building standards should be adopted and enforced.

Programs should take into account the local specificities of tenure systems and encourage flexible, scalable and creative solutions to secure land tenure (collective rights, acquisitive prescription, etc.). Successful informal settlement upgrading programs in other countries have benefited from an "adoptive" approach to planning (e.g. in Kenya an in-situ upgrading approach adopted a gradual move to full standards to minimize displacement). Programs should also consider neighborhood approach to land tenure regularization to support densification in Sahelian cities and avoid formalizing ownership in hazard-prone zones.

Solid Waste Management

To achieve structural and impactful transformation in the SWM sector, large national programs that entail a multi-year initiative should be adopted. A phased approach could be considered, with the engagements starting with the 2-3 largest cities, and a longer program over 5-10 years expanding to other cities in subsequent phases. The local experience can feed into the development/update of national level SWM strategy and management plan. Subsequent phases would benefit from this strategy and would entail rollout into other cities. Joint inter-municipal agreements at the secondary city level could help avoid duplication of investments.

The multi-year national SWM program could become a mechanism to provide municipalities with financial and technical assistance to develop critical infrastructure needed for the provision of adequate SWM services from waste collection and recycling to disposal. Household waste collection could be done at the neighborhood level and by local entrepreneurs to reduce costs[61], through the development of a bottom-up community managed, solid waste management system that is sustainable Initiatives to reduce the amount of dumped waste should also be identified[62]. An awareness program should be developed to influence behavioral change and to increase public participation for better waste management, recycling, and composting with community participation, as no matter what measures policymakers in Sahel deploy to collect, recycle, and process waste, they will never achieve such objectives without a fundamental shift in public behavior toward reducing littering and increasing recycling.

National waste management authorities should be established to implement the program, either as independent agencies or within a single ministry; these entities would be the leading authorities for the sector and the sole point of contact on regulatory and strategy for municipalities' matters during their planning processes. The responsibility for waste collection would remain the role of municipalities[63].

60 Successful experiences in Haiti show that with proper support these self-building schemes can be very efficient in LICS.

61 Beneficiaries of services often pay providers directly Burkina Faso: Improving Solid Waste Service Delivery, Farouk Mollah Banna, World Bank, Korean Green Growth Trust Fund

62 plastic recycling, traditional composting activities, research to identify mechanisms to reduce the quantity of sand and dust from solid waste, source separation of recyclable and material to organic and inorganic waste, informal collectors incentivization to keep waste segregated, etc.

63 Burkina Faso: Improving Solid Waste Service Delivery, Farouk Mollah Banna, World Bank, Korean Green Growth Trust Fund

Flood Management

Large investment programs to manage frequent and intense urban floods in the Sahel should combine hard infrastructure measures (drainage systems and flood defenses), nature-based solutions, and softer approaches (land use planning, early warning systems, community engagement and awareness) with relevant TA provided to authorities.

The design of flood management systems should be data-driven as performance in this sector relies heavily on flood hazard data and forecasting capabilities. It is important to remember that the infrastructure investments need to be designed/developed carefully as they can transfer flood risk from one area to another, making the latter more flood prone. A good understanding of water basin hydrology through modeling is needed in order to plan adequate investments. Land use planning should be actively used as a mitigation and adaptation tool as it is performed in several countries.[64] Cities should also invest in early warning systems and emergency response capacity.

Once the risk assessment and prioritization of cities/neighborhoods are done, investments will include flood control infrastructure, construction of drainage and canals, recontouring of low-lying flood plains, and stormwater systems. SWM, sediment management, and watershed management are important complimentary investments that ensure the sustainability of the infrastructure constructed.

While new investments are essential to increase flood resilience, effective flood management may also require a rehabilitation and upgrading of existing infrastructure, such as roads and informal settlements. These upgrading/rehabilitation investments would help prevent the failure of existing infrastructure in the face of the increasing frequency and intensity of floods. Community engagement and awareness must go hand-in-hand with investments in new infrastructure and the rehabilitation of existing infrastructure to prevent dumping SWM in drains. Adequate funds must also be available to support timely and regular maintenance of the drainage infrastructure. Whenever possible, a combination of green/gray infrastructure should be favored over gray-only infrastructure. It is also critical to mainstream concepts of resilience into urban planning, such as avoiding settlements in flood-prone areas and enhancing capacity to design and implement land use plans.

Key Barriers to Resilient Urban Development

Regardless of the scale of investments, transformational impact cannot be achieved in the Sahel under the current low capacity and weak governance circumstances. Cities are key actor of any potential transformation not only due to their roles in urban planning and development, but also because of their understanding of local needs. Moreover, in marginalized fragile areas, local authorities are often the closest and most trusted level of government. However, within the current institutional framework and unfinished decentralization process, competencies are transferred to cities without corresponding financial, human and technical resources which are required to exercise the powers assigned. Moreover, lack of appropriate regulation frameworks and standards at the national level, unclear institutional mandates, and weak coordination between national and local governments, do not allow local authorities to perform their duty.

64 Cities and Flooding: A Guide to Integrated Urban Flood Risk Management for the 21st Century, World Bank, 2012.

The lack of clear and transparent regulations and standards is also a major hurdle to private sector participation. Capacity issues create a vicious cycle wherein the lack of resources contributes to urban sprawl, which further increases the cost of service delivery, which, in turn, puts even more financial pressure on local governments.

The major constraint to rapid and impactful development in the urban sector is the low absorption capacity in the G5 Sahel countries: capacity enhancement can only happen at a slow pace. Substitution by private or external stakeholders will not by itself solve the problem.

Recommended Policy Responses

To resolve this dilemma policies recommended are aiming at supporting a gradual increase in the capacity of central and local governments, while delegating all activities that can be performed to urban operators and/or the private sector without hampering authorities' legitimacy. This change should entail as first steps, while implementing the programs: (i) the building of a shared forward-looking vision of strategic resilient urban planning through successful participative approaches[65] including local and national stakeholders as well as communities to develop awareness, (ii) identification and support of climate champions among cities to show-case and replicate the pathway, (iii) sector strategy design, regulatory frameworks improvement and development of appropriate standards in the three identified intervention areas (informal settlement upgrading, flood management, and SWM) with mandates' clarification and strengthening of coordination under ministries' leadership and through a results based approach (iv) improvement of cities' financial capacities through simplified inter-governmental fiscal transfers making allocations more predictable and responsive to local needs; and (v) through hiring and/or training staff who can mainstream resilience expertise through extensive TA in each of the sectors.

Prioritization and scoping of the investment program will be needed. During the first years of implementation, it will be key to facilitate ownership, producing a situation analysis for each of the sectors. Open data policies and data standards development with support from the private sector to strengthen data-driven policy making may facilitate the process. Thus, scoping informal settlements and prioritizing them by climate risk and economic potential (to facilitate densification) will be essential. This could be done while identifying settlements in areas with fewer land constraints as "quick wins" to facilitate better targeted implementation. The situation analysis in SWM will provide information on the main characteristics of the waste management system and, most importantly, identify the problems and challenges faced by the sector, and aspects which require particular attention and improvement.[66] In flood management, a key step is the development and operationalization of information and knowledge management systems that support data collection and key assessments (e.g. city risk profiles, flood models, feasibility studies) ensuring these are updated to current basin and climate circumstances and utilize the latest technology, build towards a collective vision, and are connected to institutional commitments that enable resilient urban planning and support the prioritization of future investments

To promote resilient urban planning, after the first phase of sensibilization, strategic planning tools such as energy and climate territorial plans and nature-based strategies, could facilitate the mainstreaming of mitigation and adaptation issues into public policy, urban planning and land use plan. To ensure impact on GHG emissions, strategies should integrate urban and mobility planning.

65 Such as the approach successfully implemented by Ateliers de Cergy in several cities in Africa, a 10 days workshop gathering experts from similar countries to share urban resilient approaches and start the design of a forward looking vision with the local stakeholders.

66 Bridging the Gap in Solid Waste Management | Governance Requirements for Results, World Bank.

It will allow to incorporate resilient urban planning principles in each of the sectors, for example, in informal settlement upgrading, preserving and introducing green spaces to limit heat waves and floods, using materials allowing soil permeability in road paving, ensuring drainage systems development, etc. In the solid waste sector, it means reducing waste production through the whole waste management chain: prevent, reduce, re-use, recycle, recover and only then, finally dispose of waste.

Given their soberness and their ability to reduce disaster risk and heatwaves, capturing carbon and improving living conditions through nature-based solutions should be incentivized and supported. Central governments could consider financial incentives to support the development of green/green-gray and resilient infrastructure over traditional gray-only and non-resilient infrastructure. In the flood management sector, nature-based solutions (green infrastructure) combined with the traditional investments (gray infrastructure) would make the overall investments more effective and sustainable. To reduce undesired waterflow while increasing water capture, solutions such as urban river restoration and management, erosion management, greening of upstream and flood prone areas, recycling rainwater, development of ponds / retention basins, increasing soil permeability, and development of appropriate pavements to prevent street flooding could be implemented. In addition to these investments, capacity building programs on risk evaluation, risk-sensitive planning, disaster preparedness and response capabilities are needed.

Delegation of implementation processes to urban agencies / private sector, would help achieve impact from the first 5 years phase of the programs, while building capacity at the local level. This option implies a strong dedicated TA to allow national/local authorities to play their role as project owner. Cities will need to establish detailed specifications to frame the design and manage the contracts aimed at informal settlement upgrading. The national/ local authorities could delegate in some areas serviced land development to public or private developers. Urban operators could be strengthened or created to implement informal settlement upgrading.

In Solid Waste Management, clarifying the regulatory framework will be key to facilitate private sector participation. To overcome the potential challenges of contracting private companies, the programs could (a) provide TA to enhance the financing mechanism and the regulatory framework, (b) co-finance infrastructure and social programs that are unlikely to be financed by the private sector (dumpsites closure, livelihood programs for waste pickers), and (c) consider a financial guarantee to attract reputable firms to the SWM sector. Successful experiences of setting up guarantee systems for local banks to finance waste collection by private operator in multiple cities could be studied (such as in Cameroon).

Lastly, urban communities should be at the center of these programs to ensure sustainability. Strong engagement by civil society and communities will be supported at every stage of the urban projects, from design to implementation. It will help create a real-time feedback loop on local realities and allows focus on areas and services that best support people. Community awareness campaigns and community engagement should also be incorporated to develop climate awareness, for example sharing the link between dumping waste in drainage canals and flash floods and establish early warning systems. New participatory approach to help meet the challenge of fostering community projects ownership, such as Urban Labs, may be proposed.[67]
It also means adopting Labor-intensive approaches to create jobs through community-based outfits in construction and waste collection. Though often temporary, these jobs increase youth employment and

67 Urban Labs, tested in Sahel by AFD in Ouagadougou, support communities in inventing and testing urban micro-projects with social, cultural, and environmental impact. An urban operator facilitates in partnership with local authorities identification and implementation of micro-projects, which may be temporary or eventually upscaled. Projects can promote better use of unoccupied space during land-use studies or construction such as urban improvements, development of new uses for renovated spaces (such as sports trail or playgrounds in restored river banks), etc.

economically engage refugees and IDPs (driven by climate or conflict) and can be life changers with relevant training support. It also entails supporting the informal sector, particularly in informal settlements (e.g. water carrying, solid waste collectors, vendors). Policies that support a gradual conversion to more secure or formal employment and opportunities could be identified.[68]

Indicative Program Costs

Table 2-8 Indicative analysis of investment needs for resilient urbanization in the G5 Sahel

INDICATIVE ANALYSIS OF INVESTMENT NEEDS FOR RESILIENT URBANIZATION IN THE G-5 SAHEL						
	5 year program			10 year program		
	Urban Population Targeted (# of people in urban areas)	Urban Population Targeted (% of total urban popualtion)	Investment Needed (US$)	Urban Population Targeted (# of people in urban areas)	Urban Population Targeted (% of total urban popualtion)	Investment Needed (US$)
Informal Settlements Upgrading	18,956,955	55%	**4,085,742,347**	23,715,491	55%	**5,643,329,081**
Solid Waste Management	25,850,393	75%	**1,276,840,963**	32,339,306	75%	**1,763,604,537**
Flood Management	22,403,674	65%	**2,535,385,292**	28,027,398	65%	**3,501,937,307**
TOTAL INVESTMENT NEEDS			**7,897,968,602**			**10,908,870,925**

- Estimates of Indicative Investment Needs: **US$ 7.8 billion for a 5-year program and US$ 10.9 billion for a 10-year program**, representing periods from 2023-2027 and 2023-2032 respectively.
- These estimates are based on population estimates (as indicated in Chapter 1), per capita unit cost estimates from relevant Bank-financed projects (details below), and a conservative 2% annual inflation added to cost estimates.

An Important Note on Investment Cost Estimates

The exercise of determining cost estimates for the Cities investment program is not without its challenges. It is difficult to come up with precise investment outlays due to the fact that the general cost of investment programs is driven by site specific information. Therefore, in the absence of specific sites chosen at this stage, these investment estimates remain indicative at best.

Another challenge is to use per capita investment costs from relevant Bank-financed projects in other countries in AFR and applying them to the G-5 Sahel countries. While such a method may hold reasonably well for estimating the cost of an informal settlements and solid waste management programs, it does not translate well for flood management, which is highly location specific. However, given the need to determine indicative estimates these per capita unit costs have nevertheless been applied to estimate investment needs for the G-5 Sahel countries.

68 For example, a charette process with multi-sectoral teams (including city officials, planners, transport engineers, landscape architects etc.) and local citizens resulted in the transformation of Msimbazi River basin in Tanzania, leading to dramatic climate risk reduction and resilient redevelopment of previously-affected neighborhoods.

While efforts were made to develop per capita unit costs based on average costs from multiple projects, the analysis finally relies on per capita unit cost estimates from the most relevant project. This is because of the wide variation in project cost numbers (driven by local specificities as well as size of the ISU, SWM, and/or FM components within the larger projects) that rendered the averages difficult to apply to derive sensible investment estimates.

These assumptions can be fine-tuned once specific cities and sites within these cities where investments would be made can be determined. Depending on the resources at that stage, costs can be estimated based on data gathered locally and pre-feasibility studies. Otherwise, costs from relevant Bank-financed projects can be applied with adjustments made for the local context.

At the moment, in order to provide the aforementioned investment estimated, the following sub-section gets into the details of the cost assumptions that have been applied.

Investment Cost Assumptions

- Informal Settlements Upgrading
  - Assumes US$ 157 per capita unit cost from the Kenya Informal Settlements Improvement Project (cost estimate from 2011 (project approval year)). The number includes the cost of upgrading the informal structures as well as making associated investments in improving roads and drainage in the informal settlements. Given that this number is from 2011, a conservative 2% inflation is applied annually.
  - The investment estimates assume that 55% of the urban population across the G-5 Sahel countries could benefit from informal settlements upgrading.
  - Based on the aforementioned assumptions, the investment estimates for informal settlements upgrading comes up to US$ 4.1 billion for a 5-year program and US$ 5.6 billion for a 10-year program

- Solid Waste Management
  - Assumes US$ 43 per capita unit cost based on the investment component and target beneficiaries of the Senegal Municipal Solid Waste Management Project focusing on the entire waste chain from collection to landfill. A 2% conservative annual inflation is applied to the per capita unit cost starting 2020 (project approval year)
  - The investment estimates assume that 75% of the urban population across the G-5 Sahel countries could benefit from informal settlements upgrading.
  - Based on the aforementioned assumptions, the investment estimates for solid waste management come up to US$ 1.3 billion for a 5-year program and US$ 1.8 billion for a 10-year program

- Flood Management
  - Assumes US$ 102.50 unit cost from a range of projects in AFR. Of the US$ 102.50, US$ 100 is estimated as the per capita unit cost of structural measures (mainly primary drainage) and US$ 2.50 is estimated as the cost of non-structural approaches like EWS. A 2% conservative annual inflation is applied to the per capita unit cost starting 2022 (year of publication of this analysis). It should be noted that costs for flood management are highly location specific and, therefore, more site-specific analyses may need to be done for investment planning.

- The investment estimates assume that 65% of the urban population across the G-5 Sahel countries could benefit from informal settlements upgrading.
- Based on the aforementioned assumptions, the investment estimates for flood management come up to US$ 2.5 billion for a 5-year program and US$ 3.5 billion for a 10-year program.

2.1.3 Cities

2.1.3.1 Policies and Recommendations for the Path Forward

SUMMARY

3) Cities

In cities, rapid and uncontrolled urbanization has led to growing informal settlements, with low-income, communities finding themselves in areas that are highly vulnerable to floods and other climate change related risks such as droughts and poor access to potable water, heat waves, etc. due to the general lack of resilient urban planning. To increase vulnerable communities' resilience, large scale investments are urgently needed to better manage flood risks and other natural hazards, to upgrade informal settlements; to expand basic public services such as water, sanitation, solid waste management and to improve connectivity in transportation. The ultimate goal is to create climate-resilient cities.

A two-pronged approach will be needed to address the challenges in the Sahel. First, in recognizing the fiscal challenges of national and local governments after the COVID pandemic and the food and fuel price crisis of 2022, low-cost initiatives could help deliver some "quick win" results and build trust with local communities. This is an important step as these low-cost initiatives would set the foundations and pave the way for transformational changes when anchored into bigger programs. Second, a massive intervention, particularly on informal settlements upgrading, will be essential to deliver on the promise of urbanization by building resilience and delivering the benefits of sustainable cities. The two programs' highlights are included below.

The low-cost measures governments can start taking now could include:

- Identification of critical infrastructure bottlenecks and vulnerable hotspots to climate shocks – especially floods and droughts – some of which can be tackled with practical lower-cost measures, especially maintenance of existing drainage, roads, and waste collection infrastructure

- Community engagement and information in three areas: (i) support for household and community actions to prepare in advance for climate shocks, including dissemination of national warning systems trusted by the community; (ii) information to reduce or avoid encroachment in high-risk areas subject to increasing climate shocks such as floods and landslides; (iii) mobilization to improve flood evacuation capacity of creeks and canals, such as inadequate waste disposal and infilling.

- Enhanced drought resilience for non-networked water, including advanced drafting of emergency plans to provide water to vulnerable communities, increasing the supply through private water kiosks and vendors and avoid storage levels from being depleted.

- Protect existing nature buffers like wetlands, creeks, and water catchments areas upstream of urban centers. These green spaces are rapidly disappearing in the G5 Sahel cities. Preserving them requires a much lower cost than recuperating the land and restoring the ecosystem to provide resilience services.

Simultaneously, work can begin on massive resilient informal settlements upgrading programs that would entail the following four main interventions:

- First, ensure that incoming low-income communities do not settle into flood-prone areas by promoting flexible resilient urban planning and climate change strategies, that can also help limit

urban sprawl which increases the cities' carbon footprints, and drives up the costs of delivering services[69],

- Second, improve the resilience of these communities whether in terms of vulnerability to floods or access to basic services like safe and sustainable drinking water and sanitation using a bottom-up approach; in this regard, solutions should be sought from different stakeholders: public agencies, private sector, social entrepreneurs, NGOs;
- Third, upgrade informal settlements through large scale multi-sectoral investment programs centered on public spaces upgrading including road paving with drainage, developing public plaza and green spaces, providing sanitation and solid waste management (SWM) services, etc.
- Forth adapt regulatory frameworks to allow for the bottom-up approach and connect local service delivery systems to national sector strategy and infrastructures (landfills, water infrastructure), develop flexible standards and appropriate design in informal settlement upgrading, flood management, provision of water and SWM. At the same time, strengthen local government capacity, raise awareness among communities, and open room for private sector participation.

2.1.3.2 Cities: Urbanization and provision of basic services

As described in Chapter 1, cities in the Sahel are growing rapidly and uncontrollably, driven by migration from rural areas and natural increase. Since 1985, the built-up areas have doubled, mostly in the form of informal settlements, sometimes in risk-prone areas, due to lack of resources and planning capacity at the local level. More frequent and intense floods in the Sahel impact the majority of the Sahelian urban population that lives in informal settlements with inadequate drainage and weak solid waste management (SWM) systems. Solid waste dumped in the existing drains triggers flash floods in urban areas. Moreover, 23.5 percent of the urban population, also highly concentrated in informal settlements, lacks access to basic drinking water services, while 49.2 percent lacks access to basic sanitation services.[70] This population is at high risk of cholera and other water-borne diseases. Permeable poorly managed latrines, leaking septic tanks, and the open dumping of untreated fecal sludge by sanitation workers further aggravate this threat. Heavy rains have also directly affected water infrastructure across the region.[71] To achieve a transformational impact on urban resilience, while boosting urban population's quality of life by increasing access basic services, an integrated solution is needed.

Massive informal settlements upgrading programs would need four main interventions in the areas of risk prevention, service delivery, investments in relevant infrastructures, and regulatory frameworks and policy reforms.

1. Manage climate risks through resilient urban planning and land use planning:

To facilitate risk management, the following policies and investments could be promoted:

- Increase the capacity of central and local governments to build a shared vision of strategic resilient urban planning. That can include supporting climate champions in cities, hiring staff with resilience expertise, and improving cities' financial capacities.

69 growth pattern can even touch off a vicious cycle: the lack of resources contributes to urban sprawl, which further increases the cost of delivering services. That puts even more financial pressure on local governments, and contributes to more urban sprawl, mostly in the form of informal settlements

70 2020 data from WHO (World Health Organization) and UNICEF (United Nations Children's Fund) Joint Monitoring Programme for Water Supply, Sanitation and Hygiene (JMP).

71 For example, more than 700 wells in Niamey were damaged or destroyed after heavy rainfalls in 2020, putting the population at risk of cholera and other water-borne diseases. USAID Bureau for Humanitarian Assistance (BHA), "USAID's Response to Flooding in the Sahel." 2020, [Online].Available: https://storymaps.arcgis.com/stories/6b8ed21a7bca49268de26aecc21b456c.

- Develop systems to collect data and risk assessments (water basin hydrology through modeling, scoping informal settlements by climate risk). Open data policies and data standards development with support from the private sector may facilitate the process.
- Promote resilient urban planning using tools like energy and climate plans and nature-based solutions and mainstreaming of climate mitigation and adaptation into public policies. To better control urban sprawl, strategies should mix urban and mobility planning, which combined with land use planning (including zoning) will also help manage the impact on GHG emissions.
- Develop a public and green space policy to prevent future settlements in risk-prone areas, improve land use planning for future development, facilitate rapid upgrading and improve quality of life[72]. For example, preserving or adding green spaces in informal settlements can reduce the impacts of heat waves and floods while also capturing carbon and improving living conditions.
- Support service providers in developing risk, resilience, and emergency response plans to secure long-term resilience to such climate-related and other threats. This should include the operationalization of enhanced water quality monitoring to mitigate the increasing threats posed to water supplies from droughts and floods.

2. Improve community resilience through increased basic services delivery in informal settlements

To manage the impact of drought and flooding for low-income population in informal settlement, flexible bottom-up solutions for basic service delivery should be developed, while supporting economic activities through the informal sector when formal sector development generates delays:

- Provide access to safe and sustainable drinking water services by leveraging water kiosks and, where feasible, household connections. Water supply investments should reduce non-revenue water losses through increased metering to better encourage water conservation and enable more efficient tariff schemes.
- Given that on-site sanitation will be the primary solution to the sanitation access gap, provide access to safely managed sanitation services through investments in the full sanitation value chain.
- Reduce waste production by preventing, reducing, re-using, recycling, composting, recovering materials considering the full waste value chain as well from pre-collection of waste to its treatment. Develop an awareness program to influence behavioral change and increase community participation for better waste management, as a fundamental shift in public behavior toward reducing littering and increasing recycling.
- Initiate a bottom-up community managed, SWM system to collect household waste at the neighborhood level by local and possibly social entrepreneurs to reduce costs.[73] Identify initiatives to reduce the amount of dumped waste.[74]
- Establish guarantee systems for local banks to finance waste collection by local private operators.
- Increase low-income communities' resilience through job creation using labor-intensive approaches through community-based outfits in construction and waste collection. Though often temporary, these jobs increase youth employment and economically engage refugees and IDPs (driven by climate or conflict) and can be life changers with relevant training support.

72 Lessons learnt from the Karachi Neighborhood Improvement project -
public spaces are classified into 3 main categories: (i) streets and sidewalks;(ii) public open spaces like markets, parks, playgrounds, plaza s, squares, urban forests, and waterfronts; and (iii) public buildings such as community centers and libraries.

73 Beneficiaries of services often pay providers directly in Burkina Faso: Improving Solid Waste Service Delivery, Farouk Mollah Banna, World Bank, Korean Green Growth Trust Fund. In Kenya Taka Taka Solutions Nairobi is a social enterprise implementing affordable waste collection services for 1200 households.

74 Plastic recycling, traditional composting activities, research to identify mechanisms to reduce the quantity of sand and dust from solid waste, source separation of recyclable and material to organic and inorganic waste, informal collectors incentivization to keep waste segregated, etc.

3. Invest in large-scale systematic informal settlements upgrading

Tackling fragility coming from informal urban growth would require complementing these bottom-up solutions with large-scale investments in informal settlement upgrading, to boost access to water and other services, provide better housing and improved transportation. Effective sanitation, SWM, wastewater treatment, and flood management must be put in place.

- Phase and sequence investments, beginning with informal settlements that have the highest climate risk or present the highest economic potential through densification. Projects should aim to start with easier to implement investments prioritizing public spaces including road paving with drainage, public plazas and green spaces, and water facilities. More complex interventions should be prepared in parallel to avoid delays[75] in the areas of sanitation, SWM, public lighting, electricity access and markets' rehabilitation.
- Invest in the full sanitation value chain, including containment, emptying, transport, treatment, and reuse, to prevent the spread of human waste and associated disease. Circular economy and closed-loop solutions, such as producing energy from waste, should be promoted. The same applies to the SWM sector.
- Provide housing opportunities in parallel to limit new informal settlements through a programmatic rather than site-level approach. This can be handled using a renewed sites and services approach, i.e. the provision of serviced plots while setting up well-designed and controlled self-building schemes by the small builders' sector.[76] Support existing public housing companies to develop serviced plots on a second phase, which would open room for private developers for a third phase.
- Develop large investment programs to manage frequent and intense urban floods combining hard infrastructure measures (drainage systems and flood defenses), nature-based solutions, and softer approaches (land use planning and early warning systems) with relevant support provided to authorities. Urban river restoration, erosion management, greening of upstream and flood prone areas, permeable pavements, and other "green" infrastructure can prevent street flooding throughout informal settlements.[77] Other NBS like rainwater harvesting and recycling can also be considered.
- Infrastructure investments, such as in water supply, sanitation and SWM, shall incorporate resilient design principles to ensure robustness to droughts and floods.
- Start engagements with the 2-3 largest cities and develop a longer program over 5-10 years expanding to other cities in subsequent phases, taking into account the differences in needs of primary vs. secondary cities.[78]
- Engage local urban communities at every stage of the projects, from design to implementation and maintenance. This will create a real-time feedback loop to sharpen the focus on areas and services that best support people and give voice to the vulnerable. The engagement should also include establishing early warning systems and creating campaigns to boost climate awareness. Participatory approaches, such as Urban Labs, are already showing encouraging results.[79]

75 Using simple digital tools such as Open Street Map to facilitate rapid and efficient planning.

76 Lessons learnt from site and services experiences shows that NGOs specialized in housing support could be integrated into the program. Successful experiences in Haiti show that with proper support self-building schemes can be very efficient in LICS. In Sahel.

77 For example, a charette process with multi-sectoral teams (including city officials, planners, transport engineers, landscape architects etc.) and local citizens resulted in the transformation of Msimbazi River basin in Tanzania, leading to dramatic climate risk reduction and resilient redevelopment of previously-affected neighborhoods.

78 Urbanization in the Sahel is characterized by primary cities hosting a growing share of the population, smaller towns, which are more numerous and spread out, hosting an equal share of the population (Sahel: The Urban Link, WB ASA FY 2022).

79 Urban Labs, tested in Sahel by AFD in Ouagadougou, support communities in inventing and testing urban micro-projects with social, cultural, and environmental impact. An urban operator facilitates in partnership with local authorities identification and implementation of

4. Adapt regulatory frameworks

Better national strategies and regulatory frameworks must be designed and implemented both to allow for bottom-up service delivery to improve current conditions in informal settlement and to manage and guide future growth. Clear and transparent regulations and standards will also have the benefit of improving private sector participation, with detailed specifications from authorities to frame the design and manage the contracts.

The local experiences in basic services provision, such as water distribution and solid waste collection can feed into the national level sector strategy and management plan, connecting critical infrastructures that will be developed for the provision of adequate SWM, water, sanitation and flood management services. Given challenges in service quality and sustainability, water supply and sanitation sector institutions should be supported in developing action plans for establishing and operationalizing necessary policy, institutional, and regulatory reforms, including the development and funding of O&M mechanisms. Urban agencies could be created or supported to accelerate informal settlements upgrading in a second phase.

5. Indicative Investment Needs

Indicative investment needs estimates based on similar investments in other AFR countries point to a need of US$7.8 billion for a 5-year program and US$10.9 billion for a 10-year program.[80]

Table 2-9 Indicative analysis of investment needs for resilient urbanization in the G5 Sahel

INDICATIVE ANALYSIS OF INVESTMENT NEEDS FOR RESILIENT URBANIZATION IN THE G-5 SAHEL						
	5 year program			10 year program		
	Urban Population Targeted (# of people in urban areas)	Urban Population Targeted (% of total urban popualtion)	Investment Needed (US$)	Urban Population Targeted (# of people in urban areas)	Urban Population Targeted (% of total urban popualtion)	Investment Needed (US$)
Informal Settlements Upgrading	18,956,955	55%	**4,085,742,347**	23,715,491	55%	**5,643,329,081**
Solid Waste Management	25,850,393	75%	**1,276,840,963**	32,339,306	75%	**1,763,604,537**
Flood Management	22,403,674	65%	**2,535,385,292**	28,027,398	65%	**3,501,937,307**
TOTAL INVESTMENT NEEDS			**7,897,968,602**			**10,908,870,925**

micro-projects, which may be temporary or eventually upscaled. Projects can promote better use of unoccupied space during land-use studies or construction such as urban improvements, development of new uses for renovated spaces (such as sports trail or playgrounds in restored river banks), etc.

80 These numbers are indicative only and do not take into account specific local conditions, which are extremely important for estimating the costs. The estimates account only for certain investments and do not include the cost of policy development and capacity building and developing an information infrastructure. These estimates also do not account for economies of scale, which may bring some costs down. Investment estimates are driven by population growth rates and take into account a conservative 2% annual inflation.

2.1.4 Institutions and Governance

G5 Sahel countries are facing several governance and institutional challenges that negatively impact their development trajectories and climate action. In particular, as outlined in previous sections, national responses to climate change are undermined by limited governance mechanisms and institutional capabilities. A better articulation of climate change and governance challenges is pivotal to promoting more inclusive and sustainable growth and development in G5 Sahel countries. To ensure more sustainable development, climate change dimensions need to be more systematically integrated into core government functions at both central and subnational levels.

Several areas of transformation could be identified, while keeping a selective and practical approach to gradually build climate change awareness and capabilities. G5 Sahel countries face a challenging context with multiple priorities (economic growth and social development, demographic growth, insecurity and political instability, lack of inclusion), limited resources and capacities, and structural gaps and limitations in existing core systems. As a result, any transformational approach could aim to be targeted, selective, and practical to promote a gradual and effective transformation. Areas of focus to enhance climate change action could include: (i) strategic planning and coordination, (ii) data collection, (iii) public financial management, (iv) public asset and public investment management, including land governance and management, (v) public procurement, (vi) taxation, and (vii) local governance and decentralization.

Strategic planning & coordination for climate change

G5 Sahel countries face numerous development challenges while being increasingly vulnerable to climate change. Often, G5 Sahel countries rely on multifaceted development plans to address some key national challenges such as economic growth, social inclusion, and sector-specific priorities. Yet, climate change adverse effects (variability of rainfall, desertification, etc.) compound already existing social and political tensions, as well as insecurity. Plans to address development challenges could therefore aim to mainstream climate change dimensions into existing strategies including national development strategies, public investment plans, and sector strategies rather than relying on silo-based and unidimensional approaches. Some trends, such as sustained demographic growth and rapid urbanization, also exacerbate existing environmental pressures and tradeoffs between adaptation and mitigation measures. To ensure sustainable development and growth, these demographic trends could be systematically integrated in climate adaptation and mitigation strategies.

Potential actions for enhancing climate change strategic planning and coordination could include:

- **Drafting and enacting a climate change framework legislation consistent with World Bank standards.** Such framework laws lay out governance arrangements for climate change action and policy implementation as well as long term strategies and medium-term indicators and targets for mitigation and adaptation. Currently, none of the **G5 Sahel countries** have approved such a comprehensive law. The World Bank Reference Guide to Climate Change Framework Legislation, December 2020, sets out certain criteria for these framework laws. It includes:
  - **Setting country targets for 2050 aligned with the country's commitments under the Paris Agreement.** Currently, only **Burkina Faso** can be said to have such a strategy.
  - **Ensuring consistency of long-term strategies with other development plans and national strategies.** Mitigation and adaptation initiatives and strategies could be mainstreamed in national development plans and aligned with NDCs and other long-term strategies, including public investment plans and sector strategies, and ultimately the budget. Consistency is best ensured if

strategies are extended to the subnational level to include local actors and to parastatals actors, notably major SOEs, especially in climate-sensitive sectors (e.g., energy, transport, water).

- **Defining intermediate and sectoral targets.** 2030 is often used as a milestone against which progress can be evaluated. Sectoral targets help engage sectoral ministries in climate change action. Those targets could either be defined in the framework law, or the framework law could require that each sectoral ministry develop its own mitigation and adaptation plans aligned with the overarching strategy. The second option offers more flexibility and may prove less contentious.
- **Defining coordination mechanisms and M&E procedures.** Complementing climate change objectives and targets with a clearly defined coordination and monitoring system will be critical to enhance the probability of effective implementation.

- **Ensuring systematic integration of demographic trends and other cross-cutting challenges such as urbanization and migrations in climate change adaptation and mitigation strategies.** Dynamic population growth in G5 Sahel countries compounds existing challenges in service delivery, access to infrastructure, employment, and exploitation of natural resources. Related growing needs for food, housing, energy, and transportation will likely result in increased GHG emissions and natural resources exploitation while increasing natural disasters' risks and consequence. Mitigation and adaptation strategies will need to rely on models and growth trajectories to plan for future needs in a climate-smart way and arbitrate tradeoffs between adaptation and mitigation objectives.

- **Building climate change technical capacity at all levels, including in key sectoral ministries (e.g., energy, transport, water, agriculture).** Each sectoral ministry could appoint climate focal points to help mainstream climate change in sectoral policies and liaise with other stakeholders such as ministries of finance and environment. In **Kenya**, the Climate Change Act 2016 requires the cabinet secretary to establish accredited training programs on climate change. Mandatory training of relevant staff and agencies is also included in **India** and **South Africa**.

- **Enhancing coordination between all actors of central government, in particular ministries of finance, planning, and environment, as well as sectoral ministries, to mainstream climate change dimension in all relevant public policies.** Clear mandates could be assigned to all actors based on their different roles. A dedicated coordination authority with strong political legitimacy and power to promote and coordinate climate change action at ministerial level could be set up. In **Kenya**, the Climate Change Act 2016 establishes a National Climate Change Council, chaired by the President, as an overarching national climate change coordination mechanism and the lead agency in charge of climate change plans and actions. The Act also outlines specific duties for all ministries, departments, and agencies. In **Bulgaria**, coordination is led by the Ministry of Environment. Currently, most **G5 Sahel countries** appear to rely on a coordination mechanism through dedicated directorates or units within the Ministry of Environment.

- **Planning for extreme weather and climate related disaster leveraging GovTech and digital tools.** Government and business continuity can be ensured through the development of e-government services. Digital tools and solutions can prove extremely useful in this context:
  - IT systems need to be screened for resilience to extreme weather and disasters events: diagnosis of whether they can continue operating throughout extreme weather events.
  - Creation of a government cloud to ensure business continuity (**P164824 Serbia**).
  - Creation of a Data Disaster Recovery Center (**P164824 Serbia**).
  - Adapted PFM and procurement mechanisms can also be mobilized to ensure efficient post-disaster response (cf. below in PFM and procurement).

- **Building a comprehensive civil registry.** Comprehensive civil registries can contribute to better planning of policies, reduction of GHG, and better disaster-response.
    - The existence of comprehensive and well-maintained civil registry with digital options for filing and declarations helps limit emissions through a reduction of physical movements to go to the registry. It also helps limit shocks and facilitates recovery by allowing for speedy identification of population affected and distribution of help, including social benefits when applicable (**P167588 Grenada**).
    - Over time, linking civil registries with smart IDs could also be considered to facilitate delivery and targeting of services and assistance, including climate-related actions.

- **Ensuring a clear distribution of competences and responsibilities among stakeholders, including with the subnational level and parastatal actors such as SOEs** (cf. below in Local Governance).

- **Strengthening land use planning and managemen**t (cf. below in Public Assets and Investments Management).

Systematic collection & publication of climate change data

Enhanced collection, treatment, and publication of climate change data is critical to ensuring better planning, coordination, and implementation of climate strategies. Data could cover current baselines on emissions, adaptation needs, and financial and human resources dedicated to adaptation and mitigation. Once collected, information could be made publicly available to inform all stakeholders and citizens. Currently, most **G5 Sahel countries** lack a comprehensive system of climate-related data collection. When climate-data is collected, it lacks granularity and is not systematically published, nor communicated to local authorities and more broadly to the public.

Potential actions for strengthening climate change data collection and publication could include:

- **Collecting more systematically comprehensive data on climate change trends and effects (disaster occurrence) at the national and subnational levels.** Emission inventories contribute to better informed decision-making and planning by identifying areas of improvement, including geographically. For instance, vulnerability and exposure to climate-related disasters can be identified through a Household Income and Expenditures Survey (**P164322 Maldives**). The data collected through these surveys can be used for damages and losses assessments, screening of public investments, land use, and planning.
- **Publishing relevant data to raise awareness of local public actors and of private actors (households and economic actors).** For instance, the publication of zoning plans helps remove asymmetry of information and rent-seeking behaviors and empowers private actors (citizens and enterprises) to make better-informed decisions on where to settle houses and companies, (**P171216 Ho Chi Minh DPO**).

Collecting data and sharing information at sub-national levels (to be linked with local governance below). In **Kenya,** the Climate Change Act 2016 decentralized climate information services planning to the county level. This helped gather more detailed and granular information and integrate tailored climate information products based on local specificities to help give local populations better forecasts.

Public financial management (PFM) for climate change

Climate responsive public financial management is critical to furthering the climate agenda and promoting sustainable growth and development. Consideration of climate risks and opportunities could be integrated at every stage of the policy process, from planning, to design, implementation, and evaluation. This requires a comprehensive approach that encompasses the PFM-cycle, including budget preparation, economic analysis, public investment, procurement, and expenditure management. Currently, none of the **G5 Sahel countries** have mainstreamed climate in the budgetary process or employed systematic budget tagging of climate-related expenditures.

Potential actions for integrating climate considerations into PFM could include:

- **Preparing climate informed fiscal risk assessments.** Climate induced disaster and risks can create fiscal risks and tensions that need to be anticipated and evaluated.
- **Mainstreaming climate change strategies in budgetary documents.**
  - **Drafting a climate fiscal framework** (**Bangladesh, 2014**). Such frameworks need to (i) identify existing expenditures and modalities for delivering climate-related finance; (ii) identify additional expenditure requirements drawing from national action plans and climate strategies and other sources; (iii) identify financing gaps and preferred modalities for delivering further sources of public investment (external and domestic); and (iv) create an enabling environment for private financial flows.
  - **Ensuring that climate-related projects and initiatives and expenditures are costed.** Activities could be costed in a consistent manner in the medium-term budget and sectoral medium-term strategic plans.
  - **Integrating climate change actions (mitigation and/or adaptation) into the budget circular.** This could include guidance on how to factor these actions into budget proposals and how to limit expenditures counter to climate, with a reference to the national climate change strategies (**P149160 Philippines**).
  - **Publishing a citizen's climate budget (Bangladesh, 2016).**
- **Tracking of climate-related expenditures.** Given the cross-cutting nature of actions and programs targeting climate change, related expenditures are complex to track and aggregate. Tagging supports awareness, better resource allocation and resource mobilization, as well as accountability. Tagging also generates financial climate data that can inform governments' strategic budget planning process and prioritizing climate appropriations by revealing unfunded or poorly funded policy priorities. Budget tagging has become a significant tool supporting this effort. Since 2012, several countries have implemented climate expenditures tagging in their budgets (e.g., **Philippines, Bangladesh, Indonesia, Nepal, Cambodia, Kenya, Pakistan, Ghana, Uganda**). (cf. **P167329 Uganda**; **P149160 Philippines**, at the central and local levels). Several methodologies can be applied to define climate relevance and to the tagging process itself (Rio Markers of OECD, MDB approach, etc.)
  - In **Bangladesh**, the government created a Climate Expenditure Tracking framework (CETF) module which is a database tool attached to the computerized budget database at the ministry of finance. It allows to tag CC-related expenditures (according to the national definition) while allowing to generate different types of budget and account reports and comparisons.
  - In **Uganda** (**P167329**), the government created a climate change budget tagging system, as well as guidelines to help with the tagging process.

- **Developing disaster-responsive PFM mechanisms.** Institutional and budgetary arrangements for post-disaster situations can be stated in legislation to facilitate management and avoid uncertainty.
  - **Laying out the procedures and identifying responsibilities of key finance actors in the context of disasters in budget laws.** That includes identifying specific budgetary processes that

can be mobilized after a disaster and the duration for which such mechanisms can be applied. Post-disaster financing could also be specified.

- **Conducting budget planning for disaster relief and recovery through appropriation of reserve funds, contingent spending arrangements, etc.** (**P162949 Sri Lanka**: contingency plans for budgetary response in the event of climate-related disaster).
- **Ensuring post-disaster expenditures control, traceability, and oversight.**

Climate-smart public asset management (PAM) and public investment management (PIM)

Public assets and public investments can both be affected by climate change and contribute to it. Public assets, such as lands, buildings, and infrastructures, as well as public investments into certain sectors can be adversely impacted by climate change and natural disasters. Designed to last for decades, these buildings and infrastructures have long lasting effects on urban planning and development and can contribute to increased GHG emissions. Climate-smart management of public assets and investments can therefore contribute to the mitigation of climate change. Land management could also be included in this assessment to ensure proper asset and investment management overtime.

Potential actions to strengthen climate-smart PAM and PIM could include:

- **Setting up a comprehensive and digital cadaster.** This can support more resilient land use and disaster-risks planning (**P170728 Colombia**). Land governance arrangements are central to disaster preparedness and response. Considering the role of local authorities in such matters, decentralization to and capacity building of local authorities to support a more comprehensive coverage of cadastral information can prove useful (**P170728 Colombia**).
- **Streamlining and digitizing land tenure formalization processes.** This can contribute to climate change mitigation and adaptation through the incorporation of environmental considerations into the process of public land adjudication, enabling better land management and lower degradation of land in the agriculture sector, and avoiding deforestation, or any other natural ecosystem transformation (**P170728 Colombia**).
- **Drafting an asset inventory and identifying critical and at-risk public assets.** Assets could include those not owned by the government but of critical importance such as schools, hospitals, fire and police stations, bridges, and power plants. This inventory can be through georeferencing and satellite mapping of public assets. Once assets are mapped, each can be assessed against a risk-scale with related guidance on how to strengthen protection against natural disasters and climate risks. For instance, **Vietnam** established an inventory of health care facilities and using flood hazard maps assessed that 34% of all health care facilities would be affected by flooding with a 100-year return period.[1]
- **Approving a strategy to manage critical assets and infrastructures.** This strategy can require the implementation of climate-related disaster resilience standards for critical public assets and infrastructures. The strategy can include standards for energy efficiency, sustainability, and climate resilience. Green building codes can be introduced (**P170728 Colombia**).
- **Conducting energy audits of public buildings, equipment, and transport systems.** Once realized, the upgrading and careful maintenance of critical building and infrastructures can be done to mitigate GHG emissions and climate adverse effects. Indicators could include the percentage of public assets that have improved emissions.
- **Publishing relevant information to raise awareness of relevant stakeholders.** Spatial and urban planning requires better information on existing and anticipated risks related to climate change as well as climate-smart requirements to limit GHG emissions and environmental destruction (see above on Data Collection).

- **Defining procedures and rules to adapt and mitigate identified climate risks in PIM.** That can include the enactment of guidelines for green screening, appraisal, and selection of projects, as well as the imposition of requirements for both adaptation and mitigation (to be connected with procurement) (**P166923 India:** guidelines for capital projects only; **P168180 Uzbekistan** for integration of climate change and disaster-risks mitigation in PIM). Mainstreaming climate change in PIM can be done through a pilot program in selected ministries (**P164322 Maldives**). Most countries of the **G5 Sahel** currently rely on PIM guidelines referring in general terms to climate and environmental risks.
- **Strengthening land use and coastal management plans.** Enforcing risk-informed land use and urban planning could analyze whether it is required and consistently enforced. The resulting plans could be published to inform private citizens and economic actors of risks associated with certain locations. This action could be linked with the land governance framework applicable to each country to ensure ownership and effectiveness. Land Governance Assessment Frameworks were conducted for **Burkina Faso** (2014), **Mali** (2016), and **Mauritania** (2014).

Green public procurement

Building climate responsive procurement contributes to more sustainable investments and development. Drafting a climate responsive procurement framework could ensure that public authorities buy goods, services, and works that cause minimal adverse impacts on climate change while assessing resilience and responsiveness of the procurement system to climate induced risks and disasters. Green procurement can also favor goods or services that are more durable to wider ranges of climate variability which may require introducing new costing methods integrating asset depreciation for instance.

Potential actions to promote green public procurement could include:

- **Introducing climate indicators in procurement processes.** Procurement tenders could be screened, appraised, and awarded based on climate indicators. This could cover:
  - Energy efficiency standards and life cycle costing.
  - Introduction of a law to mandate the use of climate informed procurement for certain product categories.
- **Introducing climate performance and resilience clauses in operations.** Climate performance clauses could be included in contracts to cover both adaptation and mitigation measures. Climate related disaster resilience standards for goods, services and works could be introduced.
- **Developing mechanisms for emergency procurement for climate-related disaster response.** The existence of emergency procurement procedures and strategies can assist post-disaster relief and response. Such procedures and strategies should be pre-existent to the occurrence of the disaster. That includes sourcing strategies, framework agreements, but also handbooks and other manuals as well as model documents to support efficient and speedy post-disaster procurement.
- **Updating PPP regulations.**

Climate change revenue policy & tax administration

Taxation has proven to be one of the most effective tools in fueling behavioral changes of private sector actors but is underused in G5 Sahel countries. While the current focus in G5 Sahel countries may be on climate change adaptation, taxation of GHG emissions and activities with adverse climate impacts is an effective instrument in favor of mitigation. Taxes can notably target energy (carbon tax, fuel taxes) but also pollutants, waste, durables (vehicles, appliances, and equipment), property, land use, etc. to reflect social costs. Such policies can be combined with tax incentives and social programs to incentivize the adoption of greener solutions while mitigating extreme impacts on the poor. Tax and customs administration reforms can also

support the efficiency of climate related taxes. Striking the right balance between, on the one hand, policies promoting the reduction of GHG and decarbonization of the economy and, on the other hand, policies promoting growth, climate resilience and protection of the poorest will likely emerge as an increasingly complex tradeoff.

Possible actions to consider in the areas of climate change revenue policy and tax administration could include:

- **Analyzing and measuring the climate change impact of existing revenue policies.** As a first step, the existing tax and customs policies could be reviewed in view of determining and quantifying their impact on climate change, distinguishing between mitigation and adaptation and taking a risk-based approach focusing on areas with the highest climate change impacts. Building on the analysis, which could be periodically repeated, a strategy could be developed for progressively greening the revenue policy regime.
- **Building capacity of tax administration, including on taxes aimed at reducing GHG and increasing climate resilience.** A file of emitters could be built, with assignment of risk levels based on the size of the emitter, the characteristics of the activity, etc.
- **Compiling a list of taxpayers and beneficiaries of social benefits.** This can help in disaster-related recovery (**P167588 Grenada**).
- **Enhancing e-services/e-filing for taxes and civil registry.** This can lower vulnerability to climate change disasters by facilitating access to help, benefits, services in general.

Climate change sub-national governance and parastatal actors & SOEs

Climate change action requires cooperation of all actors in government and the parastatal sector. Subnational stakeholders and levels of governments, including de-concentrated and decentralized actors, are often motivated to address climate change and incorporate some climate considerations in their operations. Their proximity can confer better knowledge of climate related challenges and implementation hurdles. SOEs also bear a responsibility in climate action, especially SOEs operating in climate-sensitive sectors such as energy, transportation, water, and agriculture. However, even where subnational governments intervene, national rules and standards can be applied. Climate responsive fiscal decentralization arrangements and broad application of national climate mechanisms in core government functions (PFM, procurement) contribute to more climate responsive actions at the national level.

Possible climate change actions to consider in the area of sub-national governance and parastatals and SOEs could include:

- **Defining a framework for local governance in climate action.** Local authorities could be empowered to act at the local level on climate related actions based on their unique understanding of the local context and challenges. However, national rules and standards may need to be applied to ensure effectiveness and more ambitious action. Lack of clarity in functional assignments, finance policy issues and fiscal decentralization undermine the effectiveness of climate action. A clear distribution of power and responsibilities between the central and decentralized/de-concentrated levels could be defined. This can be achieved through legislation that defines institutional mandates and obligations for climate change and disaster risk management and response as well as obligations for mitigation through GHG emission reduction targets for instance. Coordination mechanisms could also be specified. In **Mexico**, municipalities are required to develop local mitigation and adaptation programs. In **Colombia**, the framework law requires local authorities to incorporate climate change management into their development and land management plans.
- **Drafting climate responsive fiscal decentralization arrangements to encourage and facilitate local climate policies.** In particular, subnational authorities could be given proper means and resources

to conduct climate change related policies. Adequate fiscal transfers could be implemented. Transfers could also incorporate incentives for GHG emission reduction.

- **Extending climate-smart mechanisms for core government functions (PFM, procurement, etc.) to all relevant subnational and parastatal actors.** For instance, national tracking of green expenditures could also be applied at the subnational level and to parastatals. Climate-smart procurement and public investments management rules could also be made applicable to subnational actors.
- **Integrating a climate dimension into SOE reform.** Strengthening the ownership function, control, oversight over SOEs in key sectors (energy, transport, etc.) can have a positive effect on climate change through enhanced efficiency and screening of SOE investment projects (e.g., roads/infrastructure, railways, energy projects, etc.). More transparency and accountability help reduce corruption and enhance accountability. Projects could focus on transport ministries to start with (**P157125 Zimbabwe**).

2.1.5 Finance

2.1.5.1 Leveraging financial sector solutions and instruments for adaptation and resilience in G5 Sahel

FCI Inputs - CCDR

2.1.5.1.1 Risk profile and financial exposure in G5 Sahel

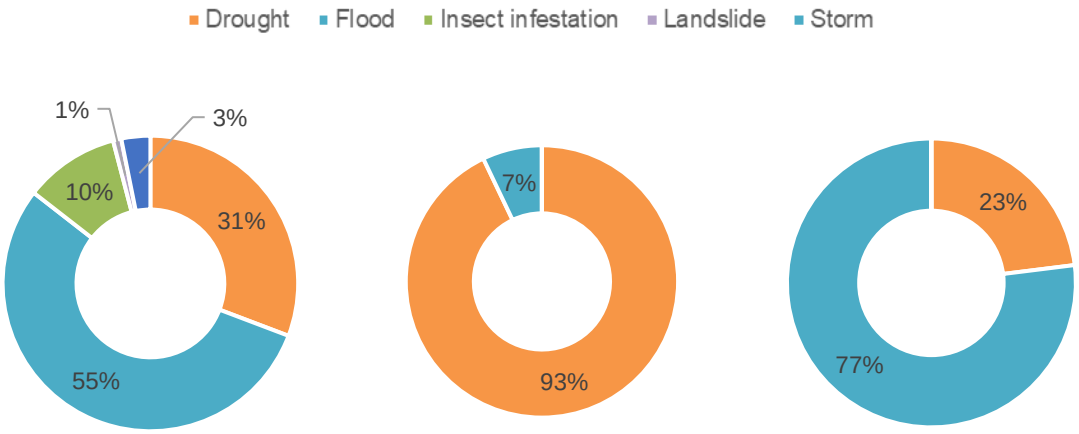
The G5 Sahel countries are among the countries most threatened by and vulnerable to climate change. They are very low emitters of greenhouse gases (in both absolute, per capita, and historical terms), however they ranked as very high to high risks (Table 2-10). The region is highly exposed to a wide range of adverse natural events, with hydrometeorological hazards (principally drought and flood) having the largest impact. According to the EM-DAT database, over the last century, the region was affected by around 220 climate events (of which 55% were floods, 30% were droughts and 15% locust infestations, storm and landslides). These disasters affected around 88 billion people. Droughts – slow onset, multi-year events – affect the highest number of people (90% of people affected by disasters) while flood have the highest financial impacts. Additionally, Sahelian countries are exposed to epidemics, locust infestations and storms, although with lower economic impacts (Figure 2-24).

Table 2-10: Climate risk and vulnerability indexes for Sahelian countries

Countries	INFORM Risk Index[81]	Climate Risk index[82]	ND-GAIN country index[83]
Burkina Faso	15 (High risk)	130 (Medium risk)	158 (High risk)
Chad	5 (Very high risk)	130 (Medium risk)	182 (Very High risk)
Mali	11 (Very high risk	90 (Medium risk)	170 (High risk)
Mauritania	41 (High risk)	58 (High risk)	140 (High risk)
Niger	8 (Very high risk)	9 (Very high risk)	176 (High risk)

Climate shocks in G5 Sahel countries are being exacerbated by structural vulnerability factors. Such factors include limited economic diversification, high rates of population growth, low human capital (health and education), a large informal sector, an underdeveloped private and financial sector, infrastructure gaps, weak institutions, and political instability. Furthermore, Sahelian economies are heavily reliant on the agricultural sector, which is particularly exposed to flood and drought risks. Climate related risks have major human and economic impacts. Indeed, droughts and floods particularly exacerbate food insecurity with damages to crops, livestock, infrastructures and resulting in short- and long-term economic losses, increased pressure on fiscal budgets. All these effects could cause major GDP growth losses without decisive adaptation and resilience actions.

Figure 2-24: Number of disasters (left), total population affected (middle) and total damages (right), across Sahelian countries, 1901 to 2021



Source : EM-DAT: The Emergency Events Database, Université catholique de Louvain (UCL)

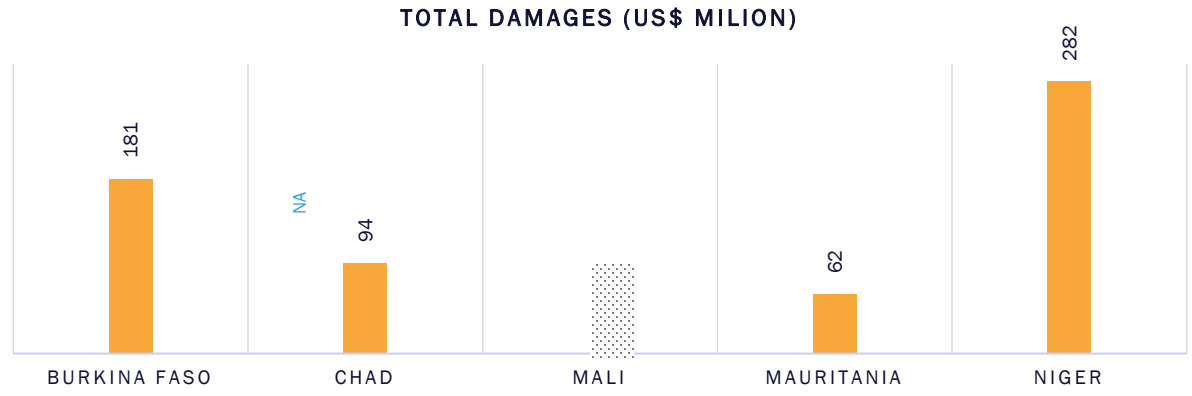
81 The INFORM Risk Index is a global risk assessment tool according to three dimensions: hazard & exposure, vulnerability and lack of coping capacity. Countries are ranked from 1 (higher risk) to 191 (lower risk).

82 The Climate Risk Index (CRI), published by GermanWatch, ranks countries based on the impacts of extreme weather events and its associated socio-economic data. Countries are ranked from 1 (higher risk) to 182 (lower risk).

83 The Notre Dame Global Adaptation Initiative (ND-GAIN) Country Index summarizes a country's vulnerability to climate change in combination with its readiness to improve resilience. Countries are ranked from 1 (lower risk) to 181 (higher risk).

The economic damages resulting from climate related shocks over the last century is around USD 620 million (80% from floods).[84] Across the 5 countries, Niger has been the most heavily affected in terms of economic impacts with around USD 280 million economic losses over the last century (Figure 2-25). Country-level disaster risk profile provides additional information on country-level risk profiles. For G5 Sahel countries, financing the economic costs of climate related shocks is more than ever critical to build their financial resilience. Indeed, the climate projections indicate that exposure to climate shock in the Sahel is expected to increase. Global warming is expected to increase the frequency of meteorological drought and double their duration from 2 to 4 months which will substantially increase water stress on populations. Water-related impacts of climate change in the Sahel are projected to reduce regional GDP by 11.7%, well above global projections (0.49% decrease).[85] More recently, in 2020, a nationwide flood hit Niger, affecting over half a million and destroying around 50,000 houses and huts. An assessment of the impact of the flood event estimated the total direct damages and indirect losses at US$ 261.7 million, equivalent to 2.1% of the 2019 GDP. The Agriculture and Livestock (around US$ 125 million) and the Housing (around US$ 66 million) sectors were hit the hardest with around US$ 191 million or 73% of the total losses and damages. The Post Disaster Needs Assessment for the 2009 floods in Burkina Faso concluded that damages amounted to around USD 102 million, and losses to USD 33 million, while needs for construction, reconstruction and restoration amounted to USD 266 million (around 1.5% of national GDP).

Figure 2-25 Total economic damages from drought and floods across the Sahel region, 1901 to 2021



Source : EM-DAT: The Emergency Events Database, Université catholique de Louvain (UCL)

A forward-looking statistical analysis conducted to estimate the frequency and severity of climate shocks (floods and drought) in G5 Sahel countries. Annex 2: Country-level financial exposures further describes economic losses from flood and droughts at the country level.

Aaccording to WRI's Aqueduct Floods, floods are expected to cause significant damage annually.[86] Aqueduct Floods global model provides estimates for urban damages and economic losses from riverine floods under both current baseline conditions and future projections in 2030, 2050, and 2080. By 2030,

84 Figures – and in particular economic losses – are underestimated due to lack of data reporting and difficulty in assessing indirect losses which occur after the emergency phase and have complexes cross-sectoral consequences.

85 Projections for 2050, under SSP3 and without adaptation.

86 https://www.wri.org/applications/aqueduct/floods/

Mali and Niger are the most exposed with annual average losses greater than USD 2 billion (5.5 to 7% of their total capital stock). Relative to the size of its economy, Chad is expected to have the greatest exposure, with average annual losses reaching up to 10% of its national GDP. AAL by 2030 for the entire Sahel region totals around than USD 6.7 billion (Table 2-11).

Table 2-11 Modeled Annual Averages Losses (AAL) due to riverine floods by 2030, G5 Sahel countries

Country	AAL (USD million)	AAL (% of capital stock)	AAL (% of GDP)
Burkina Faso	230	0.34%	0.73%
Chad	900	2.33%	3.31%
Mali	2,300	5.51%	2.85%
Mauritania	570	2.60%	10.4%
Niger	2,700	7.18%	2.37%

Source: UN Office for Disaster Risk Reduction, Global Assessment Report GAR, 2017

According to probabilistic model of food crop production losses developed by the WBG for West Africa, Burkina Faso, Chad, Mali and Niger show a high exposure to agricultural production shocks. The analysis shows that on average, the four countries lose more than US$600 million per year through production shortfalls of their five most important food crops. For particularly bad production shocks occurring once every five years, these production losses can exceed US$960 million.

Table 2-12: Aggregated crop risk assessment across Burkina Faso, Chad, Mali, and Niger

Return Period	Loss at Risk (USD million)	Loss at Risk (% of exposure)
AAL	602.61	6.52%
1-in-5 year	959	10.38%
1-in-10 year	1,236	13.37%
1-in-50 year	1,751	18.95%
1-in-200	2,114	22.88%

Source: WBG analysis

Niger and Mali are contributing the most to the overall loss of the regional portfolio. Proportional to its contribution to total crop area and to the overall economic output, Niger is the country contributing the most to the annual average loss (AAL). Mali, although this is not as highly reflected by its economic output value, shows high losses relative to its crop area, especially due to the high reliance on maize which is extremely impacted by production shocks. Across the portfolio, millet and cow peas are the largest contributors to aggregate annual average loss.

The financial sector in G5 Sahel countries is exposed to the effects of climate shocks. According to WAEMU FSAP Mali, Niger and Burkina Faso will have highest credit exposure at risk due to Extreme, consecutive, prolonged regional drought event over 3 years and they are also the most affected by extreme regional urban flood. With a return period of 1-in-20-year event by 2050, the share of regional credit portfolio

exposed to extreme, consecutive, and prolonged regional drought (credit exposure at risk) is estimated at 12% (up to 14 percent of domestic in Mali). Under the scenario Sustained Heatwave with a return period of 1-in-50-year, Burkina Faso will be the most affected. The credit exposure at risk in such scenario is estimated at 3% (up to 9% of domestic credit in Burkina Faso). Finally, considering an extreme regional urban Flood with a regional return period of 1-in-200-year, Mali, Burkina and Niger will be among the most affected. The credit exposure at risk in such scenario is estimated at 0.2% of regional credit (and up to 1% in Niger). This call for the banking sector to adapt their business and to have instruments allowing them to seize the new opportunities and to manage risks emerging and affecting them.

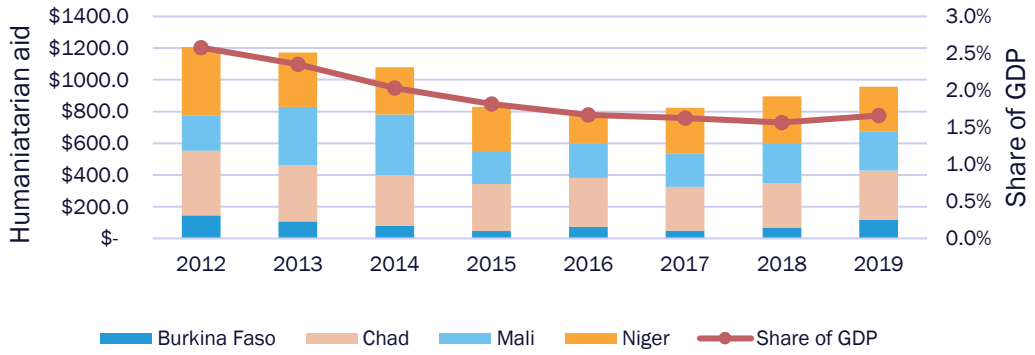
Such context calls for financing solutions for adaptation and resilience building that help managing climate risks and to seize new opportunities. Adaptation and resilience building initiatives have a cost, however that is certainly lower than the cost of inaction on climate change. Given the limited fiscal space of G5 Sahel countries, the mobilization of private sector financing will be key as adaptation and resilience requires significant long-term resources.

2.1.5.1.2 Financing for adaptation and resilience

Governments in G5 Sahel countries have a relatively low recourse to financial protection mechanisms to address climate and disaster risks which creates significant funding gaps in the aftermath of shocks. Several countries in the WAEMU region have strengthened their financial response to natural disasters (especially drought). Several financial protection mechanisms were established to mitigate the impact of natural disasters on households, farmers and businesses. Among those mechanisms, there are scalable safety nets, risk transfer instruments including insurance or national disaster funds (refer to Chapter 2 on Country climate commitments, policies, and capacities and Annex 3 of this document further present the risk finance instruments available). While several financing mechanisms exist (both government-led and donor-funded), they are not consistently funded.

Countries continue to rely on ex post international support to finance required humanitarian activities to respond to climate shocks. Data from the U.N. Office for the Coordination of Humanitarian Affairs (OCHA) shows that during the period 2012 – 2019, the four Sahel countries received on average almost US$1 billion per year or 1.9% of their GDP in international humanitarian assistance (Figure 2-26). The large amount of external support to the Sahel countries illustrates their overall low degree of financial resilience or preparedness to deal with humanitarian shocks. 46% of national humanitarian appeals remain unfunded, indicating larger need. International donors can be an important source of finance for humanitarian shocks, but funds tend to arrive with great delay, thus enabling slow-onset crises such as droughts to grow and become even more expensive, and it tends to be unreliable.

Figure 2-26 Humanitarian aid inflows in million US$ and as % of GDP (Burkina Faso, Chad, Mali, Niger)



Source: U.N. OCHA FTS

Regarding the financial sector, capital markets could be an important channel to attract private investments for adaptation and resilience building, unfortunately this market remains shallow in G5 Sahel countries and doesn't offer many solutions. The capital market is not yet structured in Mauritania. As for WAEMU countries (Mali, Burkina, Niger) and CEMAC (Chad), conducive conditions[87] for capital markets development are not fully met. For investors to invest in a market macroeconomic and political stability

87 World Bank Group. 2020. Capital markets development: Primer for policymakers. This report identified the following set of conditions as the foundation of capital market development: i) macroeconomics and policy stability; (ii) solid legal, regulatory, and institutional framework; and (iii) some level of financial sector development.

must be maintained over an extended period. Political stability remains a challenge for all these countries which, despite being landlocked and a difficult security environment, have maintained relative macroeconomic stability over the past decade with real GDP growth rates of around 5%, until the COVID-19 crisis. The sovereign bond market has steadily increased on the back of growing domestic financing needs across the region. The recourse to the capital market in the G5 Sahel countries is mainly to finance fiscal deficit. Government bond issuance constitutes 95% of total securities in the WAEMU market. This strong presence of Governments can crowd out the private sector by disincentivizing investors from considering other types of assets and could discourage private issuers. The market lacks the necessary critical mass, participation (issuers, investors, etc.) and product diversity. In 2020, the market capitalization and the amount resources raised in the WAEMU zone, stands at 10.419 billion FCFA and 2,018 billion FCFA respectively. The market is dominated by bond issuance 97% of which are bond issuance and 3% are equity issuance. The shares of private and regional organizations and foreign investors stand at 2.7% and 0.03% respectively. Finally, the stock market did not attract many quotes. As of January 2020, there are 46 listed firms, 2 rating agencies and 22 fund managers for OPCVM (*Organisme de placement collectif de valeurs mobilières*). Since the last FSAP only 8 new firms have listed shares in the stock exchange. A dedicated SME window was also created but no companies have listed yet.

Although capital markets reforms are being carried out, the legal and regulatory framework still needs to be strengthened. In 2021, Mauritania finalized the feasibility and design of a stock exchange study and started work on the legal framework that will regulate the future Mauritanian capital market. In WAEMU, with the support of the WB, the Circular No. 01/CREPMF/2020 on the establishment of a Guide for the issuance of green, social and sustainable bonds on the regional financial market was adopted in March 2020. This guide to green, social, and sustainable bond issues aims to: (i) broaden the base of potential investors; (ii) improve the conditions for financing ambitious projects, by targeting investors who are sensitive to the objectives and commitments announced; (iii) be part of the sustainable development objectives and to demonstrate the commitment of the Union Authorities to the achievement of these objectives. It is aligned with the standards of the ICMA (International Capital Markets Association) . In addition, OHADA accounting standards have been reformed to get them closer to IFRS standards. Nevertheless, the cornerstone for a successful capital market development is the respect for the rule of law, the protection of property rights and contract enforcement. In G5 Sahel countries this is still challenging. According to the Doing Business 2020 report, on average, it takes more than 1.8 years to enforce a simple contract.

The financial sector in the G5 Sahel countries is dominated by the banking sector, which is profitable but with a high level of concentration and persistent non-performing loans. The sector is profitable with positive trends in 2019 on Return on Equity (ROE) and Return on Assets (ROA) ratios with 14.6% and 1.3% respectively. However, the loan portfolio remains highly concentrated. Fifty percent of the loan portfolio is linked to the 50 largest borrowers in the WAEMU region. In Mauritania, profitability is low (ROA 0.2% in 2020) due to the narrowness of the market and the level of competition. Credit risk remains high. NPL levels have been going down over the years but remain high from 13% in 2017 to 10.9% in 2019 in WAEMU. The gross NPL ratio in 2020 was above the WAEMU average for Niger (12.2%), lowest in Burkina (7.8%) and 9.9% in Mali. In 2020 in Mauritania, gross NPL rose to 24.1%.

Climate shocks could generate sizeable impact on the banking sector, especially on NPLs and liquidity ratios calling for a need to protect them from climate risks or they could be a source of systemic risk that could be transmitted into real economy. Indeed, In WAEMU zone, credit to the economy amounts to 29% of GDP geared toward the following sectors: trade, manufacturing industries, transportation and communications, construction and public works and community services. Climate risks can affect at least

three of the traditional financial risk categories: (i) Credit risk- natural catastrophes, such as droughts and floods, can impact the banking sector directly through increased non-performing loans (NPLs) in key sectors (e.g., agriculture, hydropower, rural households). Indeed, it can reduce borrowers' ability to repay and service debt or banks' ability to fully recover the value of a loan in the event of default, including through direct damages to physical assets, and this could in turn impact on profitability and capital adequacy for highly exposed banks (e.g. those with risk concentrated in agricultural sector and rural areas, including MFIs); (ii) Market risk resulting from a reduction in values of real or financial assets, resulting in downward price shocks and an increase in market volatility in traded assets; and (iii) Liquidity risk linked to banks' capacity to access to stable sources of funding which could be reduced as climate risk drivers may cause banks' counterparties to draw down deposits and credit lines. Physical risks can also indirectly impact the banking sector through its impacts on GDP, government debt, inflation, risk-free interest rate and exchange rates, which can cause NPLs across several sectors and affect the value of banks' investment portfolio.

In such context improving financial inclusion and facilitate access to financial services (savings, payment, credit and insurance) is more than ever critical for firms and households' adaptation and resilience to climate change. In 2017, only 9 percent of adults in Chad and 10 percent of adults in Niger held an account at a financial institution while Burkina Faso (23%), Mali (18%) and Mauritania (19%) had higher levels. Niger has made the strongest progress, increasing financial inclusion nearly 6-fold and reducing the gender gap. Chad and Mauritania have stagnated in terms of financial inclusion and the gender gap is worsening in Chad, Mali and Mauritania. The gap in financial inclusion between the poorest 40% and the richest 60% has reduced in all countries besides Chad (see Figure 2-27). Limited financial literacy, costs, distance from an access point and lack of necessary documentation are among the most prevalent constraints preventing individuals and businesses from accessing an account (Figure 2-28).

Figure 2-27: Cross country comparison % of adults with accounts at a financial institution, a) by gender b) by income

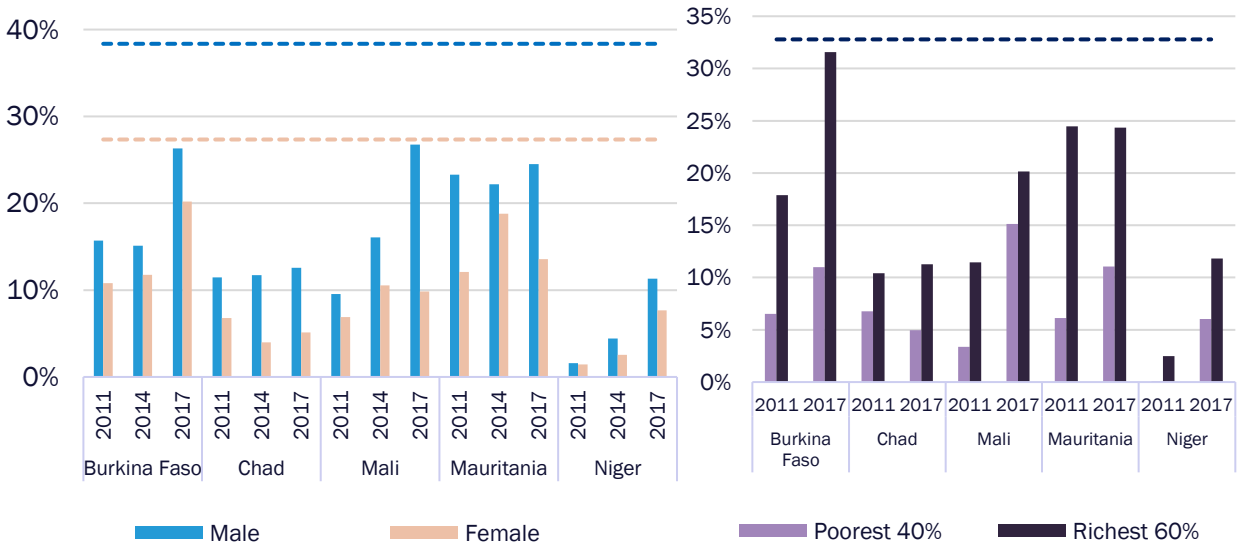
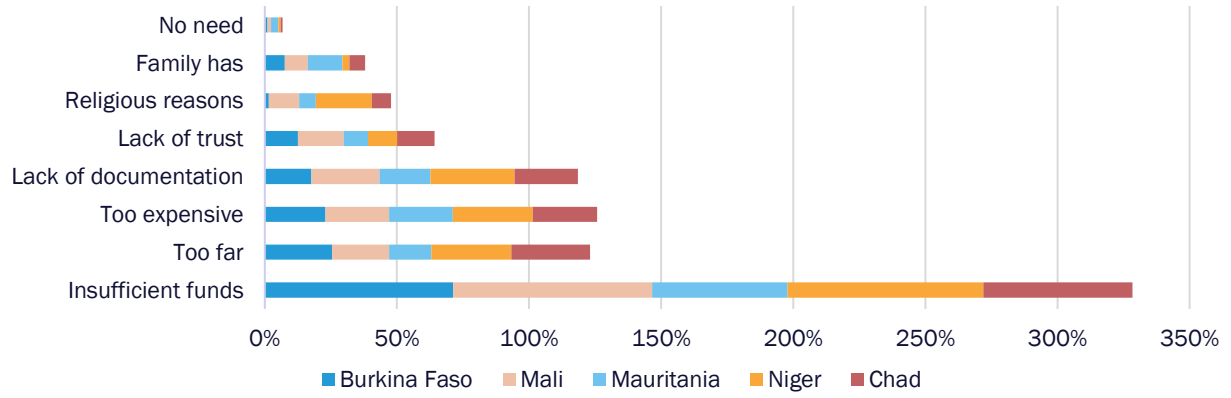


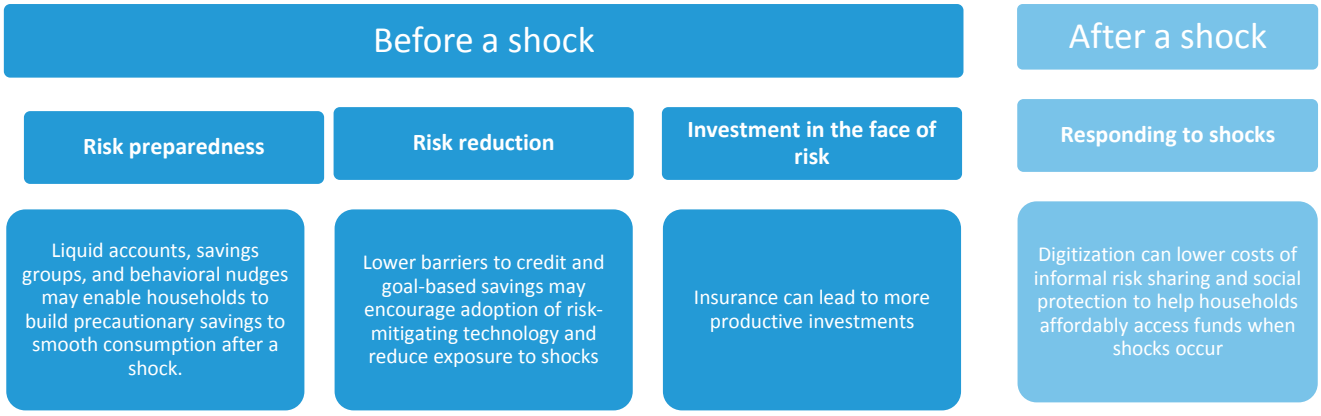
Figure 2-28: Barriers to access to a financial institution account (% adults without formal accounts)



Source: Findex 2017

Financial inclusion can enable households and business to be better able to manage risk before a shock and to recover after a shock occurs. Low-income households are particularly vulnerable to shocks, but the least prepared when a shock hits. The effects of climate change exacerbate vulnerability. Risk management solutions (formal and informal) contribute to build resilience and the ability to mitigate, cope, and recover from shocks and stresses without compromising future welfare. Evidence suggests well-designed financial products and services can play a role in increasing low-income families' resilience by helping them be prepared for risk, reduce risk, increase investment in the face of risk, and respond when a shock occurs (**Error! Reference source not found.**).

Figure 2-29: Emerging evidence on building resilience through financial inclusion



Source: CGAP

2.1.5.1.3 Policy recommendations

Efforts to support the G5 countries leveraging the financial sector solutions should focus on managing risks and seizing opportunities for the different stakeholders:

Governments

- *Supporting countries to strengthen their financial resilience to natural disasters with pre-arranged risk retention, risk sharing and risk transfer instruments that provide rapid, cost-efficient liquidity to governments in the aftermath of shocks*
    - **Increasing knowledge and understanding of climate risks through** building a single source of reliable risk information supporting a wide range of climate and disaster risk management applications, including on climate adaptation finance and insurance and ddeveloping national, comprehensive climate risk assessment to identify critical sources of financial vulnerability across sectors, geographies, businesses and populations and to build capacities to help inform strategic decision-making on climate-related financial risk management.
    - **Strengthening post-disaster expenditure tracking** by ensuring that the public financial management system accounts for post-disaster budget expenditures on an annual basis. In most countries, this effort is led by ministries of finance. Tracking such expenditures would allow the government to make informed decisions about how to manage these costs and to determine appropriate levels of risk retention and risk transfer to international markets.
    - **Diversifying sovereign climate risk finance instruments with consideration for contingent line of credit such as CAT DDO, public assets and infrastructures insurance, etc.** that can help preventing resort to adverse financial coping mechanisms such as high interest borrowing, and by accelerating recovery.
    - **Adopting risk finance strategy** to help ensuring coordination, coherence of disaster risk financing instruments to address different layers of disaster risks.
    - **Developing regional cooperation and approach for risk financing.** There are benefits from participating countries and the private sector for a regional approach such as sharing some risk infrastructures, lowering operating costs of risk finance instruments.
- **Supporting countries in establishing the fundamentals of capital markets development before even engaging this market in green finance**. A broader engagement with private sector stakeholders will be essential to achieve such result and should consider both supply and demand side and market infrastructure requirements.

Financial institutions

- *Supporting financial institutions to manage climate shocks and incentivize green growth and finance by*:
    - **Leveraging the data and analytics to build robust scenarios for stress testing and vulnerability assessment by Central Banks and Financial Regulators, as well as financial institutions** based on the understanding past and existing exposures and vulnerabilities of the real economy and financial institutions to physical climate shocks, the quantification of risk transmission channels on main macroeconomic variables and on financial risk metrics and analysis of largest losses
    - **Supporting the adoption of a Green Taxonomy** that helps banks and other financial institutions to assess the climate eligibility, measure development impact, including around adaptation, energy efficiency, green buildings, renewable energy, transport, water efficiency and more.
    - **Establishing green financing facility** that helps banks and other financial institutions to access long term resources via line of credit and climate related risk-sharing instruments that are shock-responsive in order to protect them against climate risks and to promote green economy and market development.

For firms and households

- **Improving access to finance for resilience.** Access to finance remains a major constraint for MSMEs development and adoption of climate smart solutions. Access to finance for resilience (including insurance solutions) will be critical for firms not to derail from their development and recovery path because of the occurrence of climate shocks. As such climate related risk sharing instruments could be considered.
- **Deepening financial inclusion by leveraging digital financial services** will be essential *as l*ow-income households are particularly vulnerable to climate shocks, but the least prepared when a shock hits. The effects of climate change exacerbate vulnerability. Financial inclusion can enable households to be better able to manage risk before a shock and to recover after a shock occurs. This build resilience - the ability to mitigate, cope, and recover from shocks and stresses without compromising future welfare. Evidence suggests well-designed financial products and services can play a role in increasing low-income families' adaptation and resilience by helping them be prepared for risk, reduce risk, increase investment in the face of risk, and respond when a shock occurs. Thus, the proposal to improve financial inclusion by leveraging digital solutions which address proximity and cost constraints and expanding access to financial services for risk management – including savings and insurance solutions (i) by removing both supply- and demand-side constraints (e.g. fast-track the roll out of national ID systems, implement tiered KYC regimes) to enable banks to better serve low-income households; (ii) creating a regulatory environment conducive to the delivery of savings, insurance and credit products through digital financial service platforms, (iii) expanding national financial awareness programs to financial risk management; (iv) facilitate access to climate insurance notably in agriculture sector through dedicated national programs or as transfer modality in social safety nets program; (v) adopting systematic electronic payments by government and other key stakeholders (G2P) and (P2G), including a range of agricultural payments (purchase of inputs and for the sale of crops); (vi) fostering interoperability between mobile money service providers and other financial sector institutions; (vii) increasing financial services providers awareness of gender gaps and support innovations for gender-sensitive products and delivery
- **Consider establishing a regional risk pooling solution for adaptive social safety nets.** Building on the World Bank Sahel Adaptive Social Protection Program (SASPP), shock-responsive safety nets are being developed and institutionalized by governments in the region as they are flexible financing arrangements providing rapid resources in case of a shock for horizontal or vertical expansion. Such financing could be pooled and pre-arranged at the regional level, e.g. through a regional fund or a common risk transfer mechanism.

2.1.5.1.4 Country-level disaster risk profile [88]

Burkina Faso

- Drought: With sporadic rains and poor water retention in soils, Burkina Faso has experienced 'quasi-drought' conditions since the early 1970s. These conditions are most pronounced between November and December when humidity averages 10%, and in the north where rain only comes during two months out of the year.
- Flooding: Burkina Faso's wet season is characterized by heavy and often relentless rain that can wreak havoc on the country's poorly constructed informal settlements and degraded landscape, disturb the entire water sector, and destroy or reduce infrastructure services. Over the past 30 years, severe flooding has occurred repeatedly especially in the north and center of the country, resulting from successive drought periods.
- Epidemics: Burkina Faso's hot and dry climate is favorable to meningitis outbreaks from October to May and to cholera epidemics. Deadly meningitis outbreaks occurred in 1996 (killing 4,000),

88 WBG Climate Knowledge Portal

2001 (killing over 1,500), 2006 (killing 600), 2007 (killing 1,330), and most recently in March 2010 with 193 fatalities. Measles epidemics are also a major issue.

- Windstorms and Insect Infestations: During the dry season, the harmattan winds spread across Burkina Faso, bringing hot, dry air and sandstorms across the central Mossi Plateau. When coinciding with locust outbreaks, the harmattan winds can accelerate their spread to communities at a rate up to 200 km per day.

Chad

- Repeated droughts have had substantial impacts on Chad's agricultural production and have affected up to 2.4 million people. Persistent drought has also aided in the acceleration of desertification in the northern part of the country, causing agro-pastoral areas to decline and livestock grazing areas to shift further south.
- Floods are a recurring natural hazard in Chad that may become worse with climate change.
- The country has a high prevalence of endemic diseases such as malaria, and suffers from epidemics of cholera, measles, and meningitis.
- Chad has experienced the drying of rivers and lakes in recent years, most notably of Lake Chad. Climatic forecasts by NASA have indicated that Lake Chad could disappear in 20 years at the current rate of water use and increased silting of upstream rivers.

Mauritania

- Mauritania's southern areas (Trarza, Brakna and Gorgol) are classified at high risk for river flooding due to heavy rainfall interspersed with increased aridity. Flash flooding is also considered likely.
- The country is at risk to water scarcity due to the projected increased variability of runoff and river flows, increased temperatures resulting in increased evaporation of surface waters and reduced runoff, increased competition over reduced water resources as well as limited infrastructure.
- Extreme heat is an existing challenge for the country and one that is projected to get increasingly worse. The entire country is ranked at high-risk for extreme heat.
- Mauritania is ranked as high risk for coastal flooding due sea level rise and increased vulnerability as the majority of its population residing along coastal areas.

Mali

- Agriculture contributes to 40% of the country's GDP and provides 70% of the employment.
- Droughts due to erratic rainfall are part and parcel of the natural variability in climate across Mali, and several traditional mechanisms are employed across the country to adapt to drought conditions.
- Nevertheless, more frequent and longer droughts have plagued Mali in recent decades, exacerbating natural adaptive capacities. Drought have contributed to severe food crisis including those in 1972-1974, 1983-1985, 2002-2003, 2011-2012 and 2015-2018, which was in part due to the 2015/2016 El Nino induced drought.
- Livestock are an important component of the agricultural economy of Mali, and livestock are adversely affected during droughts. Approximately 40% of livestock was lost during the 1972-1974 drought.
- Flooding is common in the rainy season along the banks of the River Niger which flows through the middle of the southern half of the country, passing through the country's largest cities of Bamako, Segou, Mopti and Gao. Mali's vulnerability to flooding has been shown several times in the past decade (e.g. 2012, 2013, 2016, 2017, 2018, 2019).

- Expanding agriculture, coupled with poor land management practices, particularly on the Niger River flood plain, has significantly increased erosion and sedimentation, and the propensity of some areas to experience severe flooding and subsequent crop loss.

Niger

- Multi-year droughts are a recurrent hazard in Niger which can affect crops and livestock. They have contributed to severe food crisis in 1980, 1988, 1990, 1997, 2001, 2005, 2009, 2011-2012, 2017, 2018 and 2020. Droughts have caused numerous adverse impacts on water resources, agriculture, human livelihoods, food security, GDP, and livestock.
- Agricultural production has been in a deficit since the late 1970s/1980s, with particularly poor crop production from 1989-1996.
- Drought risk is greatest in the regions of Maradi, Zinder and Tahoua.
- Droughts are projected to increase in frequency in the coming century, which will have negative consequences on public health - intensifying certain diseases, food security, agricultural and pastoral activities, nutrition, and natural resources
- Floods are a recurrent natural hazard in Niger during the rainy season, especially along the banks of the River Niger, which passes through the capital Niamey. Buildings in the city are set well back from the river to allow for normal overflows but damage still occurs. The risk is rarely insured. Floods also have negative impacts on agriculture, food security, GDP, endemic diseases (malaria), and contribute to rural poverty. Flood are projected to increase in frequency in the future, especially in the southern part of the country.
- Diseases such as malaria, meningitis, and measles are subject to change and cause adverse impacts on Niger's population in association with climate change. Increased temperatures, variability in rainfall patterns, floods, and more frequent droughts, are all factors that affect these main diseases and could increase their prevalence.
- Sandstorms are a frequent extreme event that hits Niger and adversely affects agriculture, livestock, water resources public health, and human life.

Chad

- Agriculture is a key sector in Chad employing around 80% of the population. The international livestock trade is the second most important sector to the economy and employs directly and indirectly about 40% of the population.
- Repeated droughts have had substantial impacts on Chad's agricultural production and have affected up to 2.4 million people. Persistent drought has also aided in the acceleration of desertification in the northern part of the country, causing agro-pastoral areas to decline and livestock grazing areas to shift further south.
- Floods are a recurring natural hazard in Chad that may become worse with climate change. Serious flooding affected large parts of the country in September 2019 and in the capital N'Djamena in September 2018 (resulting in the death of at least one person), and in June and September 2016. There was also serious flooding in 2010 and 2012.
- The country has a high prevalence of endemic diseases such as malaria, and suffers from epidemics of cholera, measles, and meningitis.
- Chad has experienced the drying of rivers and lakes in recent years, most notably of Lake Chad. Climatic forecasts by NASA have indicated that Lake Chad could disappear in 20 years at the current rate of water use and increased silting of upstream rivers.

2.1.5.1.5 Annex 2: Country-level financial exposures

Burkina Faso.

- Burkina Faso is the largest producer of cotton in Sub-Saharan Africa; the industry contributes 8 percent of the country's GDP and employs approximately 17 percent of the population. Erratic rainfall patterns have been reducing yields and resulted in important losses impacting all actors along the value chain.
- According to a 2016 WBG modelled simulation, average annual economic losses in Burkina Faso have been estimated around 73 million.
- The funding Gap Analysis showed that Burkina Faso was not able to support event with 20 % probability, as well as severe to extreme events. Overall, it was estimated that Burkina Faso would require an additional USD 325 million to face an extreme event occurring with 1% probability.

Table 2-13 Modelled aggregated economic losses in Burkina Faso[89]

Return Period	Economic losses (USD million)	Funding gap (USD million)
AAL	73	27
1-in-10 year	190	-89
1-in-50 year	352	-252
1-in-100 year	425	-325

Mali.

- Subsistence cereals dominate the production (rainfed millet and sorghum millet mainly), with commercial agriculture devoted to cotton and rice, the latter of which is irrigated. Cotton is the most exposed asset with recent losses due to drought, desert locusts and heavy rains. Erratic rainfall pattern makes it difficult to adapt seed.
- Drought: In Mali, annual agricultural income loss is estimated around USD 9.5 million. On average, once every 10 years a loss of at least USD 35 million in agricultural income will occur. Sikasso, Mopti and Segou are the regions that provide the greatest contribution to national crop losses.
- Flood: Damage of USD 600 million to crops and USD 1 billion to the building stock may occur in at least one flood in a person's lifetime. Bamako, Segou and Kayes regions contribute most to the national estimated building damage.

Table 2-14 Modelled economic losses in Mali[90]

Return Period	Agricultural income loss from Drought (USD million)	Agricultural losses / damage to crops from flood (USD million)	Damages to buildings from flood (USD million)
AAL	9.5	10	250
1-in-10 year	35	35	750
1-in-50 year	60	60	1,000
1-in-200 year	150	NA	NA

89 World Bank analysis 2016

90 GFDRR Disaster risk profile - Mali

Niger

- Niger is a major cereal producer that export to neighboring countries. Staple dryland crops include millet, sorghum and cowpea, while cotton and groundnut constitute major cash crops. Irrigated rice crops (uninsured) have been impacted by major floods over the last 3 years.
- Drought: On average, once every 10 years a loss of at least USD 60 million in agricultural income is expected to occur in Niger. For more extreme events, these losses will increase further: a loss of the order of USD 150 million would be expected approximately once in a lifetime.
- Flood: Annual Average Losses (AAL) from riverine floods are estimated between US$ 20 million and US$ 70 million in Niger. The 2017 Global Assessment Report (GAR) on Disaster Risk Reduction estimates the AAL to capital stock from riverine flood risk in Niger at US$ 21.4 million, or about 0.2 percent of the 2017 GDP. Because there is considerable uncertainty on risk estimates when limited data is available for calibration—as is the case of Niger—, it is a good practice to contrast the results of different studies. The 2019 GFDRR Niger Disaster Risk Profile for instance estimates AALs for riverine flood risk to be around USD 70m, significantly larger than GAR's estimates. According to GFDRR's estimates, over USD 500 million of damage to the building stock may occur in at least one flood in a person lifetime based on modeling.

Table 2-15 Modelled economic losses in Niger[91]

Return Period	Agricultural income loss from Drought (USD million)	Agricultural losses / damage to crops from flood (USD million)	Damages to buildings from flood (USD million)
AAL	15	1.5	70
1-in-10 year	60	7.5	300
1-in-50 year	150	15	500
1-in-200 year	300	NA	NA

2.1.5.1.6 Annex 3: Country-level DRM framework and DRF instruments

Some examples of key stakeholders and regulatory framework for DRF and DROM at the country-level include:

Burkina Faso. A variety of actors are involved in the management of responses to shocks and disasters, many of whom claim leadership and coordination. The management of risks, humanitarian crises and disasters is governed by Law n°012-2014/AN of April 22, 2014, and its decree n°2014-466/PRES of June 02, 2014. The Law and decree describe the framework for relief and emergency actions, humanitarian assistance and recovery to be implemented in the event of the occurrence of a disaster, as well as the institutional arrangement, the coordination arrangements between actors and the tools and instruments for the prevention and management of disaster risks. The country also has a Disaster Risk Management Strategy (*Plan national multirisque de préparation et de réponse aux catastrophes*) which clarifies the relationships and responsibilities between the various State technical services and humanitarian partners, in order to facilitate the coordination of prevention, preparedness and emergency response. Burkina Faso has also developed a National Climate Change Adaptation Plan (NCCAP), identifying many of the country's urgent needs for adaptation action. Institutional integration and strengthening of disaster risk reduction and climate change adaptation functions, functional weather information and early warning systems, and community-based adaptation actions are identified by the NCCAP as key cross-cutting priorities.

91 GFDRR Disaster risk profile - Niger

Mali. In 2007, Mali's NAPA laid the groundwork for a national plan of action on change and identified several poverty and economic growth criteria to be used in the evaluation and prioritization of proposed new projects. The plan focuses on the key vulnerable sectors identified in the NAPA and includes three focal areas:

- Expanding agricultural extension services–including the introduction of new cropping systems, strengthening early warning systems and helping farmers make use of agro-meteorological information, increasing the use of improved varieties that are adapted to local conditions, using new agricultural technologies (soil and water conservation), diversifying agricultural production, and improving access to credit for agricultural activities.
- Securing water for agriculture through the building and maintenance of wells, digging of canals to irrigate more land and cleaning of canals that have been filled with sand, and constructing new irrigation schemes based on water from the Niger and Boni Rivers. Domestic energy development through the use of improved stoves, replacing charcoal with gas for cooking, improving coal production efficiency, and regulating charcoal markets.

Mauritania. The Mauritanian Government has a legal and institutional structure for the organization of emergency relief (decree 2002-17). However, the level of planning for the financing of disaster risk remains relatively low and the country relies mainly on ad hoc financing strategies and the solicitation of Technical and Financial Partners (UN, NGOs, bilateral and multilateral partners). There is no legal or formal framework governing Disaster Risk Reduction or Disaster Risk Finance. The legal and institutional structures related to disaster risk management essentially focus on emergency management, particularly in food crisis situations. However, a Risk and Disaster Management Strategy has been approved in 2009. This plan notably provides for the establishment of an Inter-ministerial Disaster Risk Management Committee (CIGRC) and a National Disaster Risk Management Platform (PN). The work of setting up an institutional framework for disaster risk management is still in progress. Other DRR plans have been approved without leading to significant institutional changes in disaster risk management:

- 2004 National Action Plan for Adaptation to Climate Change (PANA)
- National Action Plan for the Environment 2012-2016 (PANE 2)
- National Action Plan for the Fight against Desertification (PAN-LCD 2005)

Niger. The country has developed over time a strong risk prevention and management framework for natural disasters, with a focus on food security**.** The framework for prevention and management of disasters and food crises (DNPGCCA), initially established in 1989 has been strengthened with donor support since the early 2000s. As a result, the framework's coverage has expanded, including early warning systems, prevention, social safety nets and humanitarian aid coordination. Thanks to the effective food security management framework, prices stabilized since 2000 and Niger appears to have performed somewhat better than other Sahelian countries on the inflation front. Similarly, with increased irrigation with the 3N Initiative, agriculture output has become less volatile over recent years, despite the more frequent droughts. These noticeable achievements on resilience result from increased irrigation and more effective social safety nets. Nevertheless, the increasing disasters have contributed to weakening further the structurally fragile fiscal and current account positions.

- **DRF instruments**

Risk retention instruments

Among the G5 Sahel countries, most governments have set up budgetary instruments (general contingency budgets or dedicated disaster reserve funds).

Burkina Faso has set up the moderately sized (annual budget of approx. US$750,000) "*Fonds National de Solidarité*" with a broad mandate to contribute to the care of individuals, disadvantaged groups and/or groups in difficulty, and victims of natural disasters and humanitarian crises. The fund is financed through the national budget. It operates in parallel with the newly set up "*Fonds de développement agricole*" which focuses more on investment support towards the agricultural sector at this stage. A dedicated disaster relief funds (*Fonds national de prévention et de gestion des risques, des crises humanitaires et des catastrophes)* was planned by Article 19 of the Law for the Prevention and Management of Risks, Humanitarian Crises and Disasters of 2014, but was not yet effective in 2021.

In Mali, only a small portion (approx. US$ 84,000) of the *National Agricultural Support Fund* is set aside for disaster response to responding to disasters. The fund is financed through the national budget. Besides, sectoral government structures are expected to rely on their own operating funds to prepare for emergencies.

In Mauritania, an annual contingent budget of USD 1.4 million (in 2017) is available for emergency interventions (i.e. distribution of food in affected areas). Additional, unallocated budgetary reserves of USD 36.68 million (in 2016) are available to cover unforeseen expenses, including those related to disaster response.[92] Mauritania also used to operate two funds: a *Natural Disaster Fund*, aimed at covering losses in the agricultural and pastoral sectors, and a *National Fund for Humanitarian Action,* covering emergency operations. Those funds appeared to be inactive in 2017.

Niger operates a very large central (varying annual budget of almost US$15 million) relief fund that is a key funding instrument for food security interventions. This "*Fonds Commun des Donateurs*" (FCD) is financed exclusively through donor contributions. The FCD receives financial contributions every year. It serves as the central instrument for donors to channel and coordinate their humanitarian food relief funding.

Regional-level financing mechanisms were put in place to support the agricultural sector (among other sectors) in the WAEMU region. At the regional level, there is the FAGACE fund (*Fonds Africain de garantie et de coopération économique,* including Burkina Faso, Mali Mauritanie and Niger) and the *African Guarantee Fund* (private initiative). Most of the funds cited as examples result from national and regional policies that support among other things the agricultural sector. The sustainability of these funds is mixed, as their funding from state budgets depends on current priorities.

Risk transfer instruments / Insurance

Agricultural insurance is endowed with huge potential for development in the Sahel region. It remains, nonetheless, a precarious and largely untapped sector because of the inadequacy or rather the inexistence of insurance products. In the G5 Sahel countries, agricultural insurance has not yet fully reached national

92 Title 99 "Common expenditure, debt charges and special Treasury accounts"

scale and the overwhelming majority of agricultural holdings are deprived of any kind of protection against climate hazards. Example of existing agricultural insurance programs include:

- In **Burkina Faso**, a pilot scheme has been launched in July 2020 with the *Assurance Récolte au Sahel* (ARS), in partnership with local insurer SONAR IARD and the agricultural mutual insurance company of Morocco (Mutuelle Agricole Marocaine d'Assurances - MAMDA). The initiative is covering three regions and the key crops sorghum, maize and rice. In 2021, around 800 producers had subscribed to the pilot. Previously, the microinsurance specialist broker PlaNet Guarantee, supported by Allianz Burkina Faso and Oxfam had operated two insurance pilots – a credit-linked area yield index insurance programme for cotton and an evapotranspiration index insurance programme for maize. However, both initiatives have been unable to reach scale, selling together less than 10,000 policies in their peak year 2014. From 2011-2013, also an inter-ministerial technical committee (CTI) was active to assess opportunities for agricultural insurance. In 2014, the CTI ultimately recommended that a public-private partnership be set up, which however has not been realized to date.

- In **Mali**, the World Bank has backed the Meteosat index system which allows crops to be covered by affordable drought and excessive precipitation policies. Several index insurance initiative have been launched: (i) PlaNet Guarantee, together with other development and insurance partners, is supporting an evapotranspiration index insurance programme providing cover to more than 40,000 maize and sesame farmers; (ii) Développement international Desjardins (DID) and the Agriculture and Rural Financing in Mali project (FARM) have launched another program providing cover to approximately 1,500 rice, maize, and onions farmers; (iii) World Food Programme and the Start Network have purchased insurance policies which use pre-defined triggers related to rainfall (or lack of rain), to help increase the protection for a number of West African countries including Mali, who have been subject to significant hardship due to drought impacting the local population, crops and livestock; (iv) African Risk Capacity Limited (ARC) has reportedly been working in partnership with insurtech Pula to develop agriculture index insurance cover. For flood, property policies are normally excluding damages but this may be bought back. However, few insureds take this option.

- In **Niger**, there have been few initiatives on agricultural insurance. They include the preliminary development of a weather index by the International Research Institute for Climate and Society at Columbia University as part of the 'Programme Africain d'Adaptation' of the U.N. Development Programme (UNDP) which, however, has not been translated into an insurance programme. Besides, a pasture-drought insurance product for the pastoral areas has been developed and tested by IBISA in 2019. For flood, Property policies normally exclude flood damage, but this may be bought back. However, few insureds take this option.

- In **Mauritania,** Law No. 2013-024 of July 5, 2013 provides for the establishment of a livestock insurance system. This has not been implemented since, but a 2017 report commissioned by the Prime Minister presents a financing strategy for the agricultural sector which provides in particular for the establishment of crop insurance and the creation of a compensation fund for disaster risks. For flood, cover is not normally provided.

- In **Chad,** only the sugar company, *Compagnie Sucriere du Tchad*, insures its crops, which occupy some 3,500 hectares. No other existing experience with agricultural insurance products could be identified. Flood is not often insured, although it may be included in some multi-risk policies.

All G5 Sahel countries have signed MoUs with the African Risk Capacity (ARC), a specialized agency of the African Union offering climate risks insurance products and reinsurance services to member states, to support emergency relief efforts. Burkina Faso, Mali, Mauritania and Niger have purchased sovereign drought index insurance coverage for the 2021/2022 agricultural season, demonstrating the strong interest in ARC across the region (Table 2-16). However, the size of the insurance cover is often relatively small, and the participation of countries has been inconsistent. For Burkina Faso and Mali, the World Food Programme (WFP) is purchasing ARC replica insurance to mirror its in-country finances for response lead by NGOs.

Table 2-16: ARC products purchased by Sahelian countries within Pool VIII, 2021/2022 agriculture season

Sovereign products purchased	Coverage	Payouts (USD)	Insured People
MALI	15 000 000	15 000 000	15 000 000
REPLICA_MALI	7 362 989	7 136 192	736 299
REPLICA_BURKINA FASO	3 018 474		301 847
MAURITANIA CROP	3 082 217		308 222
MAURITANIA RANGELAND	4 000 000		400 000
REPLICA MAURITANIA CROP	2 055 370		205 537
REPLICA MAURITANIA RANGELAND	2 667 133		266 713
NIGER	7 000 000		700 000

Source: ARC website

The World Bank and the International Livestock Research Institute (ILRI) are exploring the feasibility for drought risk finance solutions in Sahel countries, including three of the focus countries. The aim of the project is to conduct a broad assessment of the feasibility of implementing financial protection index-based solutions against drought in four Sahelian countries (Burkina Faso, Niger, Mali and Senegal). Focusing on pastoral populations, the project also aims to identify potential concrete application and implementation modalities, as part as wider drought risk management and pastoral development initiatives.

Scalable Social Safety Nets

Scalable social safety nets are emerging as an important approach to responding to disasters in the Sahel region. Scalable safety nets are part of the 'shock responsive or 'adaptive' social protection agenda that seeks to help households build resilience against shocks. Different programs are experimenting with scalable safety nets in all eight focus countries. Some of these programs have even been used to deliver payments to shock-affected households, most recently in response to COVID-19. The shock-related cash transfer payments have so far largely not been financed through established pre-arranged mechanisms but through ad hoc payments.

For instance, the World Bank's Sahel Adaptive Social Protection Programme (SASPP) is a major initiative aiming to build the resilience of people at national, community and household levels so they can better prepare for climate hazards and other shocks, protect their assets and livelihoods, and lessen humanitarian

crises.[93] The program aims to cover 1.8 million people across the region.[94] In Niger, the Government is working on a pilot programme using satellite imagery for a rules-based rapid trigger of shock-response scale-ups of the safety net. In Chad, a SSN programme was established in 2016 to benefits 15,000 vulnerable households. Discussions around the implementation of adaptive social safety nets are also being held in Burkina Faso.

93 The SASPP multi-donor trust fund was established in March 2014 with contributions from the UK Department for International Development (DFID), the French development agency (AFD), and the German Federal Ministry for Economic Cooperation and Development (BMZ).

94 World Bank, 2019

2.1.5.2 Treasury Perspective: Financing Options for Green and Resilient Infrastructure in the Sahel

This note is designed to outline the preliminary assessment of the potential financial solutions for green and resilient infrastructure investment in the Sahel region. Further research, analysis, and recommendations are required to develop this outline into a more in-depth, actionable report.

Identifying the Investment Gaps

The five countries of the Sahel are significant fossil fuel importers (and Chad is an exporter), which contributes to GHG emissions. At the same time, these countries are severely impacted by the consequences of climate change. The countries have enormous potential for renewable energy, such as solar power generation, which would help address the climate impacts of fossil fuels (which are limited for this grouping of countries), the fiscal volatility of fuel imports for power generation, and rising costs of power production. The investment needs are massive for green and resilient infrastructure. In the energy sector alone, electrification is only 20 percent. Also, all Sahel countries are signatories of the Paris Agreement and have set forth ambitious Nationally Determined Contributions (NDCs) to meet their commitments. Table 2-17 below provides a snapshot of the estimated NDC investment programs to 2030 for each country, all of which run into the billions. Although the NDC targets may not consist of actual project pipelines that are bankable, the NDCs do provide a guide for identifying the investment gaps and needs.

Table 2-17 Sahel NDC Investment Targets to 2030

Sahel Country	NDC Document	Estimated Mitigation Investment Needed ($ by 2030)	Estimated Adaptation Investment Needed ($ by 2030)	Total NDC Investment Estimate ($ by 2030)	NDC Investment as % of 2021 GDP
Burkina Faso	2021	1.34	2.79	4.12	2.2
Chad	2021	6.70	5.00	11.70	12.2
Mali	2021	4.34	8.00	12.34	7.4
Mauritania	2021	34.26	10.63	44.88	54.2
Niger	2021	3.17	6.74	9.91	7.7

Challenging Access to Financial Markets

The five countries of the Sahel do not issue international sovereign debt or raise significant external market-based financing, and only Burkina Faso, Mali, and Niger have international credit ratings, which are all non-investment grade. Table 2-18 below provides a snapshot of the financial access of the five countries of the Sahel and the associated debt dynamics. Most government external debt is from concessional sources or semi-concessional development lenders. However, some commercial financing has come through for various purposes, such as mining. The Sahel country governments also raise funds domestically and in the respective regional financial markets (WAEMU and CEMAC), and there are development banks specific to each sub-regional economic bloc. That said, the domestic and regional debt is typically short-term in tenor. This is in part due to the underdeveloped financial sectors in the Sahel countries, with limited institutional investors present and active in the region, including small banking sectors. In addition, Chad and Mauritania have a high risk of external debt distress, and Chad, Mauritania, and Niger have zero limits for non-concessional external borrowing under World Bank and IMF programs. In fact, all countries are classified as IDA and benefit from the Debt Service Suspension Initiative (DSSI). Burkina Faso, Chad, Mali, and Niger have currency pegs to the Euro but in two different monetary regimes.[95] This already challenging

95 Burkina Faso, Mail, and Niger are part of the West African Economic and Monetary Union (WAEMU) and Chad is part of the Economic and Monetary Community of Central Africa (CEMAC).

financing landscape faces increasing headwinds, including political instability in Mali and Burkina Faso and debt restructuring in Chad under the Common Framework.

Table 2-18 Financial Access and Debt Dynamics of the Sahel

Sahel Country	WAEMU Member	CEMAC Member	Pegged to EUR	Risk of External Debt Distress	External Debt Stock to GNI (% in 2020)	International Credit Rating	Debt Service Suspension Initiative (DSSI)	WB Financing	WB Financing Type (IDA)	Non-Concessional Borrowing (NCB) Ceiling	Value of NCB (2022 exchange rate)
Burkina Faso	X		Yes	Moderate	27	No	Yes	IDA Only	50:50 Grants: Credits	410 Billion CFA (FY21)	623 Million EUR
Chad		X	Yes	High	37	No	Yes	IDA Only	Grant	0	0
Mali	X		Yes	Moderate	36	No	Yes	IDA Only	50:50 Grants: Credits	526 Billion CFA (FY21)	800 Million EUR
Mauritania			No	High	73	No	Yes	Gap	Credit	0	0
Niger	X		Yes	Moderate	35	No	Yes	IDA Only	50:50 Grants: Credits	0	0

Finding Potential Financial Solutions

The potential financing solutions will necessarily have to consider the challenges facing these Sahel countries and the restrictions on non-concessional external financing. There are several positive factors to build on within the Sahel to finance the region's substantial climate investment needs. First, unlike much of the region, the Sahel countries benefit from a low inflation environment. in the region, the stable currency (pegged to the Euro) and direct trade flows with a major economy (Europe), the existence of regional financial markets that enables a broader investor base beyond a country's financial system, and the track record of domestic and regional level debt issuances by the Sahel governments.

Although Burkina Faso and Mali had envelopes of non-concessional external borrowing, given the coup governments in both countries, it is not clear how possible such kinds of non-concessional debt would be raised in reality at what cost. Therefore, it is assumed that the financing possibilities for both countries would be led by concessional financiers and through domestic (and sub-regional) funding raised from banks and other institutional investors. The other three countries have zero limits for non-concessional external borrowing, so concessional lending partners and domestic and regional sources will be the most likely sources of funding for the NDC commitments and investment plans. With these constraints in mind, there are a number of potential financial solutions for the Sahel countries to explore to raise new funding for mitigation and adaptation investments across the region. The options to be explored in greater depth include the following:

Blended Financing Facilities

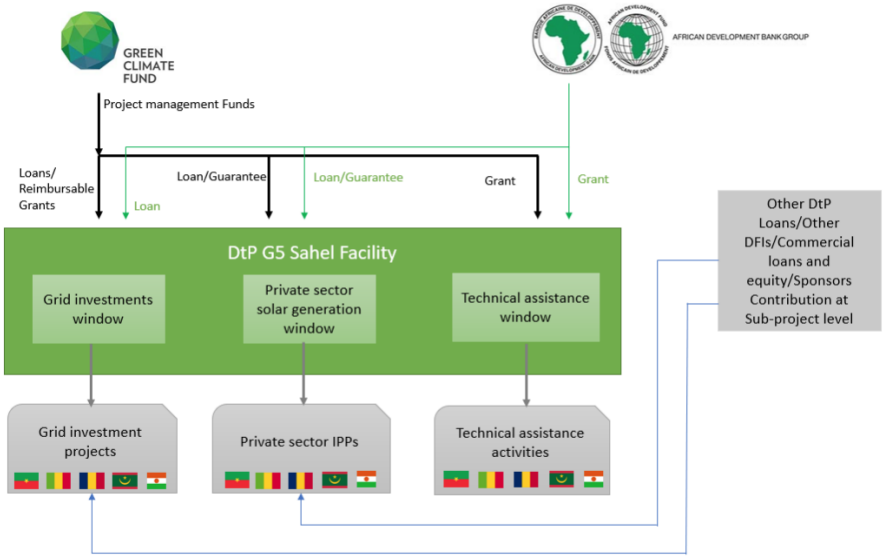
Given the complex economic situation, concessional lending from donors or multilateral development Banks represents the most significant potential source of financing for Sahel countries. Nevertheless, one institution alone would not suffice to finance the investment gap needed. This is why several initiatives blending donors and multilateral development banks (MDBs) have been implemented across the region. The Great Green Wall (GGW) and Desert to Power are two of the most emblematic ones.

Launched in 2007 by the African Union, the African-led Great Green Wall initiative aims to restore the continent's degraded landscapes and transform millions of lives in the Sahel. This ambitious project is being implemented across 22 African countries and will revitalize thousands of communities across the continent. It brings together African countries and international partners under the leadership of the African

Union Commission and the Pan-African Agency of the Great Green Wall. In terms of funding, the Great Green Wall initiative has received pledges of US$19 billion by 2025, which could be a major source of concessional financing for green and resilient investment projects, particularly for public goods (e.g., nature conservation, biodiversity preservation, adaptation projects) with limited financial returns.[96]

Similarly, the African Development Bank (AfDB) launched a $150 million investment in its Desert to Power G5 Financing Facility from the Green Climate Fund (GCF) in November 2021.[97] Desert-to-Power is a flagship renewable energy and economic development initiative led by the African Development Bank. Its objective is to light up and power the Sahel region through photovoltaic solar systems via public, private, grid, and off-grid projects by 2030. The objective of the umbrella Desert to Power G5 Financing Facility is to assist the G5 Sahel countries in adopting a low emission power generation path by making use of the region's abundant solar potential. It will mobilize $966 million over a seven-year implementation period, including US$379.6 million from the AfDB[98] and about US$400 million of the total package from private sector loans and equity. Figure 2-30 below provides an overview of the flow of funds for this initiative. Also, Annex 1 provides additional views on efforts to build on what is being developed in such initiatives as the Desert to Power G5 Financing Facility.

Figure 2-30 The flow of funds of the DtP Sahel5 Financing Facility



In addition to the already existing initiatives, several new financial institutions are expanding the scope of their activities to Africa, creating the potential for new blend financing. Two examples are the recent lunch of the European Investment Bank (EIB) global to increase impact investing outside the European Union and the first Asian Infrastructure Investment Bank loan in Africa to Rwanda to support MSMEs. Such blended finance facilities can be developed for new investment focus areas in the Sahel, including nature and biodiversity conservation and climate-resilient infrastructure and agriculture. The funding for such a facility can blend IDA grants and credits and funding and guarantees from other MDBs, development institutions, and public sector funds. New tools to measure and model risk components of the downstream projects can

96 See: https://www.greatgreenwall.org/great-green-wall-accelerator#:~:text=About%20the%20Great%20Green%20Wall%20Accelerator&text=From%20an%20initial%2014.3%20billion,for%20the%20Great%20Green%20Wall.

97 See: https://www.greenclimate.fund/sites/default/files/document/funding-proposal-fp178.pdf.

98 See: https://www.afdb.org/en/news-and-events/press-releases/african-development-bank-group-approves-3796-million-desert-power-financing-facility-g5-sahel-countries-49325.

be deployed to identify the critical risks that require public sector financing to enable private sector investment. This would allow for more pinpointed financing and efficient use of scarce public sector financing.

Green and Sustainable Bonds

Green, sustainable, and sustainability-linked (GSS) bonds are debt obligations of sovereigns that require the use of proceeds to be allocated to eligible projects (e.g., renewable energy, conservation, etc.) that are transparent, verified, and reported on. In the case of sustainability-linked bonds, the use of proceeds is not earmarked for specific projects or expenditures, but the issuer must commit to key performance indicators (KPIs) for sustainability policies and actions that are verifiable and ambitious. In most linked structures, if the KPIs are not met, the borrower will have to pay a coupon step-up to investors, so in a way, it is a tradeoff feature for not tracking the use of proceeds. Annex 2 has more details on these GSS instruments and their applications.

GSS bonds are based on principles set forth by the International Capital Markets Association.[99] To move forward with GSS bonds, the country will need to establish a GSS debt framework and applicable regulations, identify green assets/expenditures (green taxonomy, climate budget tagging), align GSS bonds to the overall debt management strategy, apply technology to verification and impact reporting, and political commitment to GSS agenda (such as a sustainable finance strategy). The World Bank can support all of these aspects and bring in donor support for governments. In the case of WAEMU, there is an added advantage in that the Regional Council for Public Savings and Financial Markets (CREPMF), the financial market supervisor in WAEMU, issued the guidelines on Green, Social and Sustainable Bonds issues. Therefore, investors are familiar with GSS bonds and beginning to get interested in GSS bonds as a new asset class. In addition, the same type of guidelines will soon be issued for the CEMAC region. Both sets of guidelines were developed with World Bank support and technical assistance.

International market demand for GSS bonds is growing exponentially, and with relatively little supply of sovereign issuances, GSS bonds are now coming in with favorable terms in terms of price and tenor. In the case of the Sahel, it may be possible for certain countries to issue privately placed GSS bonds with interested and/or specialized international investors if the bonds embed significant donor support (e.g., guarantees, coupon subsidies) to bring the terms in alignment with the non-concessional borrowing limits. However, a prerequisite to issuing GSS bonds will be to secure a credit rating. Donors can also support the associated transaction costs, including legal, banking, and compliance-related costs, of the GSS bonds. Such GSS bonds could also be considered for issuance in the domestic or sub-regional markets. Again, donors could support such bond issuances.

The region is not new to GSS bonds, with the West African Development Bank (BOAD) issuing 'Africa's first sustainability bond in January 2021 for EUR 750M in Luxembourg. The bond came in with a 12-year maturity and was oversubscribed by 6 times with a coupon of 2.75%.[100] Therefore, it is possible that regional funding for investments in the Sahel could be structured through new GSS bond issues by BOAD (Burkina Faso, Mali, and Niger are shareholders) or the Development Bank of Central African States (BDEAC), where Chad is a shareholder. Donor support could also be brought into such transactions to guarantee certain risks or cover some portion of the interest and pay for the transaction costs. The advantage to this approach would be that the banks would manage the use of proceeds with their governance and credit risk systems, and the banks could crowd in other lenders to syndicate loans.

Finding a Way Forward

99 See: https://www.icmagroup.org/sustainable-finance/the-principles-guidelines-and-handbooks/.

100 See: https://gsh.cib.natixis.com/our-center-of-expertise/articles/boad-issued-the-first-ever-sustainability-bond-in-africa and https://www.boad.org/en/sustainability-bond-of-the-year-supranational-sub-sovereign-and-agency-ssa-boad/#:~:text=In%20its%20new%20Strategic%20Plan,including%2040%25%20from%20the%20UK.

The Sahel 5 countries have significant potential to mobilize donor-driven funding that can be leveraged to crowd-in private investment into some key sectors, such as solar and renewable energy development. The financial constraints in the region are serious, and scarce public financing, be it directly from governments or development finance institutions and donors, must be targeted carefully. This is especially so for projects with net positive cashflows and can attract private investment. At the most basic level, blended financial structures can help the Sahel countries use limited public financing to attract private capital into sectors with strong commercial potential, such as solar and wind power. Public financing can be raised through various means, including through GSS bonds. There are specialist international investors keen on making such investments in the region, both in terms of the financial assets (e.g., bonds) and directly in the projects. Still, public financing is needed to overcome hesitancy due to the range of risks at a country, sector, and project level, as described in Annex 1. Successful demonstration projects will be critical to bringing external private capital to the region to finance climate-related investments, particularly in the mitigation area (e.g., renewables).

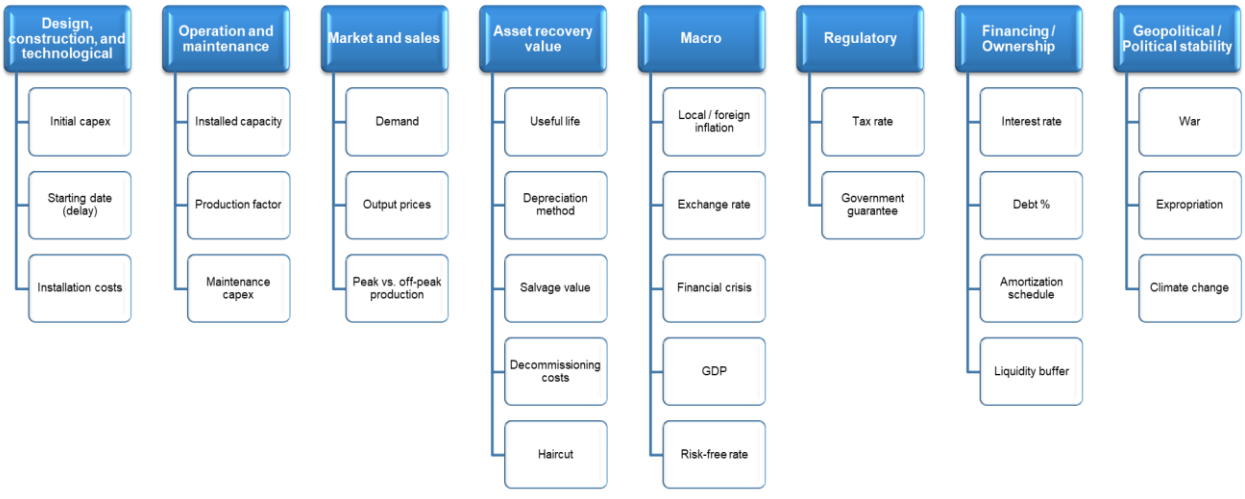
Also, it must be recognized that at this moment, public goods types of investments in adaptation and resilience projects will require public funds as the valuation of natural capital is not yet sufficient to draw in private capital at scale. However, the Sahel countries should begin exploring the potential for carbon credits in the region, particularly as the Great Green Wall initiative takes root and shows results as some estimates show enormous potential for carbon sequestration. Another financing consideration may be pursuing debt for nature types of transactions that might generate some debt relief in return for nature-based outcomes and conservation. This has limited potential for the region, given most external debt is not commercial, but all options should be explored.

As a practical next step and way forward, deeper analysis is needed to understand the full financing possibilities. This analysis will include consultations with investors, financiers, lawyers, developers, governments, and donors to explore the perceived and actual barriers to financing the climate agenda in the Sahel. Such consultations must be technical and focused on practical solutions that will work for the region and will be grounded in international experiences with what has succeeded in similar institutional environments. This would cover specific countries, sectors, and projects and focus on developing transactions. A donor-funded technical assistance and capacity facility could be established immediately to support this analysis, work with governments to change policies as needed, and prepare the pipeline of bankable projects.

Realizing the Potential of Solar Energy in the Sahel

The G5 Sahel has a vast renewable energy potential (mainly wind and solar). The area receives some of the highest solar irradiation in the world. Solar photovoltaic and wind are rapidly increasing but still represent less than 5% of the electricity generated in most countries, except Mauritania (where they represent 15%). The continuous decline in solar and battery storage prices represents a unique opportunity to develop these resources at the least cost. To realize this massive energy potential, which can also help the countries to wean off fossil fuel dependence and its associated risks in terms of price volatility, the countries in the Sahel will have to explore a variety of blended financing structures. The public resources deployed toward solar projects can be layered and targeted around the various risks of the projects. Figure 2-31 provides a basic overview of the potential risks a renewable energy project faces.

Figure 2-31 Risks for renewable energy projects



Source: Cambridge Judge Business School, Modelling Debt Risk on Infrastructure Projects, April 25, 2018.

Various financial solutions can be deployed to manage the various risks across a renewable energy project, such as a solar farm. Such tools include insurance for various liabilities, derivatives for weather events and financial risks (e.g., interest rates, currencies, etc.), and guarantees for a range of factors, including sovereign and political risk, minimum revenue, breach of contract, non-honoring of obligations, and others. However, often what is required to get such projects off the ground is simpler, such as concessional debt financing from the public sector to bring in other types of investors to projects, from other development institutions to commercial financiers. All options should be explored, and there are certainly a wide variety of potential solutions for financing solar in the Sahel.

In the case of the Sahel 5 countries, the starting point would likely be with the basic structure of blending financing from a development financier with IDA-type financing to get new investment into critical renewable projects flowing. In particular, two basic blended financial solutions may be possible to support investments in solar power generation and transmission projects:

Interest Rate Reduction: In terms of the interest rate reduction option, the scale of the incentives will be derived from the size of the funding sources available to subsidize the possible loans. Several scenarios have been developed to assess the amount of money necessary depending on the targeted interest rate reduction. The more concessionality provided, the more grant funding is required to fund the financial incentive for the client. The following scenarios have been prepared across four different interest rate reduction options:

1. 1% interest rate reduction
2. 2% interest rate reduction
3. Reduction of the interest rate to an IDA credit equivalent
4. Grant element greater than 35% (concessional financing)

Table 2-19 Interest rate reduction options

Scenarios	Principal	Concessionality Spread	Concessinality Amount	The total amount of interest to be paid	Final interest rate[101]	Grant element (based on IMF's pricer)[102]
Initial loan	100,000,000	N/A	N/A	40,704,005	3.29%	17.31%
Reduction of 1%	100,000,000	1.00%	12,372,038	28,331,967	2.29%	26.42%
Floored at IDA rate	100,000,000	1.84%	22,764,550	17,939,455	1.45%	32.64%
Reduction of 2%	100,000,000	2.00%	24,744,076	15,959,929	1.29%	33.71%
Grant Element greater 35% (concessional loan)	100,000,000	2.22%	27,500,000	13,204,005	1.07%	35.15%

The scenarios constructed are necessarily standardized and simplified to quantify a theoretical example and are dependent on the availability of IBRD-like financing for the beneficiary countries. In addition, the assumptions behind the interest rate incentive options are as follows:

- $100M IBRD or IDA Scale-Up Window (SUW) Loan with one disbursement upfront, level repayment, 25-year maturity, 5-year grace period. The selected financial terms will have an impact on the amount of concessionality needed and the grant element. Other development finance institutions provide similar terms, so IDA grants could be deployed to leverage such loans.
- Interest rate is fixed at the time of the disbursement, and the spread is assumed to be constant. Data based on Bloomberg as of February 28, 2022, subject to change based on market conditions.
- The interest rate benefit starts at the outset of the loan.

Concessional Loan: The second blended financing option that can be provided is a concessional loan from donors or IDA to a more commercial financing provider. Again, this option is predicated on the availability of IBRD-like financing to be blended with IDA-type resources. This concessional lending option would primarily be to increase the overall funding amount for the eligible projects and lower the overall cost by blending the financing with IBRD / IDA SUW financing (or similar term financing). The concessional loans are assumed to be provided on IDA Credit Regular terms (e.g., 38-year final maturity, 6-year grace, and 1.45% interest in USD).[103]

Table 2-20 Concessional Loan Options

IBRD or IDA SUW			Concessional loan (IDA credit terms)			Overall		
Amount	Rate	Grant element	Amount	Rate	Grant element	Amount	Rate	Grant element

101 Rates as of Feb. 28, 2022.

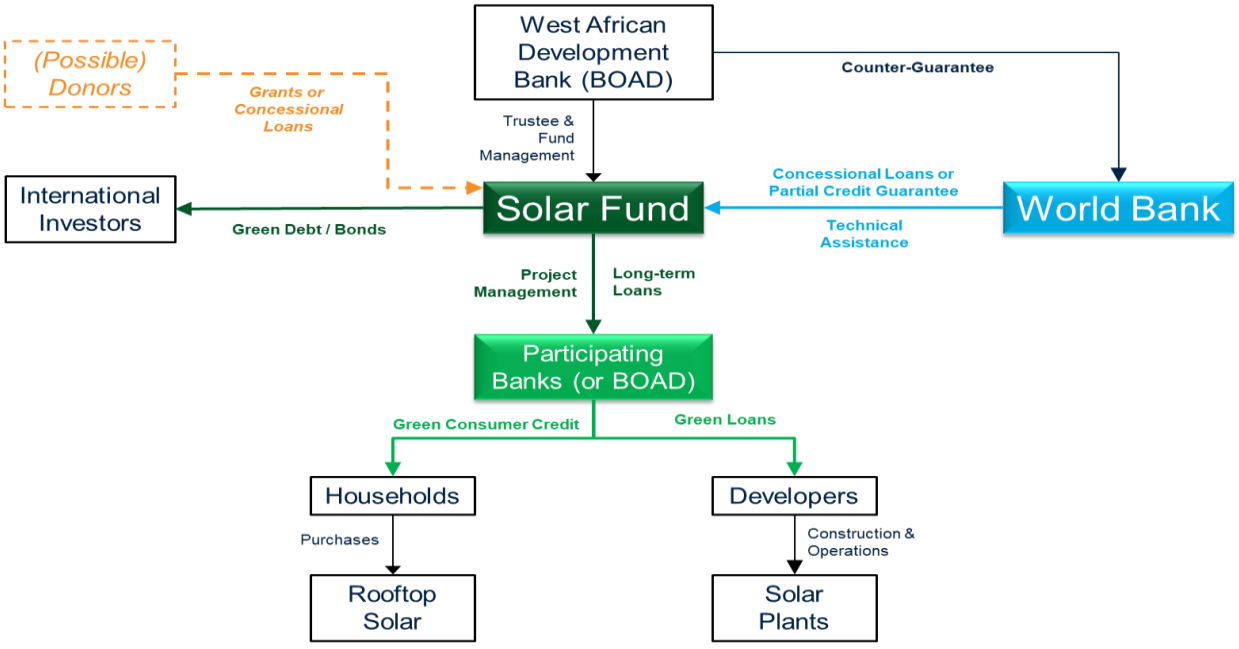
102 International Monetary Fund, Calculation of Grant Element, https://www.imf.org/external/np/pdr/conc/calculator/.

103 See IDA Terms, https://thedocs.worldbank.org/en/doc/7d6a0de7eb1be32d6952ba5a593543da-0410012021/original/IDA-terms-effective-jan-1-2022.pdf.

100,000,000	3.29%	17.31%	15,000,000	1.45%	44.49%	115,000,000	3.05%	20.86%
100,000,000	3.29%	17.31%	25,000,000	1.45%	44.49%	125,000,000	2.92%	22.75%
100,000,000	3.29%	17.31%	50,000,000	1.45%	44.49%	150,000,000	2.68%	26.37%
100,000,000	3.29%	17.31%	100,000,000	1.45%	44.49%	200,000,000	2.37%	30.90%

Beyond such initial blended financing options, a next phase (or in parallel) could design downstream uses of concessional finance to support innovative structures to generate regional and domestic investment in the solar sector. Given the track record of the regional development bank, BOAD, which the World Bank lends to and has issued a sustainable bond, consideration could be given to developing a solar fund run by BOAD. Such a fund could crowd in concessional financing from IDA and donors and intermediate it alongside commercial financing from BOAD and investors of BOAD / Solar Fund green bonds. This Solar Fund could then on-lend directly from BOAD or through banks in the region to households to invest in rooftop solar and developers to build and operate large-scale solar farms. Given the backing from the World Bank and donors, the Solar Fund could provide longer-term, lower interest loans to the beneficiaries than would otherwise be possible. This would help incentivize solar investment across the region and in a financially positive way. Technical assistance could be provided through the whole financing chain, from BOAD to participating banks to developers on all facets of the financing and development of solar.

Figure 2-32 Wholesale financing of solar in the Sahel



Examples of Climate-Related Market Financing Instruments and Potential Use Cases

Uses	Examples of Instruments	Key Features	Benefits and Limitations and Examples					
			Affect public debt sustainability?	Useful for countries with weak credit quality?	Useful for projects without or weak revenues?	Scalable?	Improve market access and/or financing costs?	Case Study Examples
Linking Use of Proceeds to Projects	Sustainable, Green, and Social bonds	Transparency on how 'investors' money is used and wide investor acceptance	Increase public debts if issued by governments	No; limited pipeline of eligible projects, ESG investments more prevalent for high-grade assets	Yes, as long as the issuer is bearing full risks – these are use of proceeds bonds	Yes	Very little; perhaps only at margin	Egypt: Issued its first sovereign green bond in Sept. 2020. Bond was USD 750 million and 5x oversubscribed). Bond was a 5 year note with a yield of 5.25% (50 bps less than guidance). Egypt's sovereign green financing framework benefitted from WB support and was included in a recently approved DPO as a PA.
Linking Repayments to KPIs	Sustainability-linked bonds	Result-orientation, announcement on the 'issuer's commitment to achieve defined results	Increase public debts if issued by governments	No; potential financial penalty for failure to achieve KPI may increase debts	No, as the funding is general revenue (not use of proceeds for specific projects)	No; calibration of appropriate KPIs and penalties is highly customized	Yes with a step-down performance linked coupon	Italy: Enel, the state-owned energy utility, issued a multi-tranche Sustainability-Linked bond for institutional investors in the Eurobond market totaling 3.25 billion euros in June 2021. bond, which is guaranteed by Enel, was oversubscribed 3.5 times and sold at a discount (lower rate than the market rate) with a 25-bps step-up coupon if Enel does not meet performance targets.
Linking Repayments to Future Revenue Flows	Green project bonds Green Asset Backed Securities (ABS)	Transparency on how 'investors' money is used and clear linkage between project revenues and debt repayments	Does not affect public debt sustainability, unless host-government provide guarantees	Yes; project revenues can be used for credit enhancement, pooling of credits can diversify risk, can be supported by state owned entity or government guarantee	No	Possibly	Yes, for well-structured deals in low-credit countries	United States[104]: Government owned Fannie Mae issued US$85 billion of green bonds through 4,000 individual bonds since 2012 that has financed over 4,100 multi-family housing units meeting green building standards. Allows for lower rates, greater loan amounts, and associated services for eligible loans.

104 The US has other incentives for issuers in the form of offsetting the costs of coupon repayment; some jurisdictions also offer tax incentives to investors who hold green bonds. Brazil has similar incentives in place.

Uses	Examples of Instruments	Key Features	Benefits and Limitations and Examples					
			Affect public debt sustainability?	Useful for countries with weak credit quality?	Useful for projects without or weak revenues?	Scalable?	Improve market access and/or financing costs?	Case Study Examples
Linking Provision of Guarantees and/or grants to Projects or Policy Actions (Blended finance)	Guaranteed Sustainable Bonds and Loans	Improved financial terms Better investor acceptance	Increase public debts if issued by governments	Yes	Yes	No	Yes	Seychelles: Blue bond issued by government; WB customized a US$15M, 10-year private placement bond aligned project funding needs and 'Seychelles' liability profile and integrated a WB partial credit guarantee of US$5M to lower borrowing cost by 2.0% per year and a US$5M in concessional financing from the GEF, which further lowered the net borrowing cost by over 3% per year.
Linking interest rates to policy actions	Interest buy-down facility	Facility to buy-down the interest of loans for sustainable development purposes	Yes	Yes	Yes	Possibly	No	Colombia: Global Concessional Financing Facility (GCFF) supported an IBRD loan of US$100 million by buying down the fixed interest rate to make it at IDA credit terms by providing $21.7 million of grant funding. The GCFF allocations are based on development impact criteria.
Linking repayments to natural disasters	Catastrophe Bonds	High-yield bond designed to fund governments only if specific disasters occur (insurance securitization)	No	No	No, funding is general revenue resource	Possibly	Yes	Jamaica: WB priced a catastrophe bond to provide the Government of Jamaica with financial protection of up to US $185 million against losses from named storms for three Atlantic tropical cyclone seasons ending in December 2023. GRiF trust fund paid $16.4 million in premium and transaction costs for the cat bond.

2.1.6 IFC's Engagements in the Sahel

IFC's approach for the G5 Sahel region is driven by private sector-led Jobs & Economic Transformation powered by: (i) Energy & Connectivity; (ii) Value-Chain Development & Local Transformation; and (iii) Technology-enabled Financial Inclusion. This approach is well aligned with both the WBG's Sahel Initiative[105] which is structured along three focus areas two special objectives, IFC's strategy for Africa, which is based on three overarching pillars and four cross-cutting themes[106]

Over the past 10 years, IFC has committed $1.5 billion (see bullet 1 below) in the G5 countries in the following sectors: financial services, infrastructure, manufacturing, agribusiness and services. Over the past two years alone, IFC has committed $228 million across the G5 countries with an $11 million advisory portfolio.

1) IFC's FY11-FY20 LTF Commitments in the Sahel

Table 2-21 IFC's FY11-FY20 LTF commitments in the Sahel

Country	FIG	INR	MAS	PPP	Total
Burkina Faso	210.6	63.2	193.9		467.7
Chad	10.0	126.3	1.4		137.7
Mali	34.6	5.0	12.5		52.1
Mauritania	256.3	300.0	261.0		817.3
Niger	15.6			74.1	89.7
Grand Total	**527.0**	**494.6**	**468.8**	**71.4**	**1,564.5**

2) IFC's Portfolio as of February 28th 2022 (Latest available)

Table 2-22 IFC's investment portfolio by country

Country	Investment Committed Portfolio
Burkina Faso	85.4
Chad	11.1
Mali	45.8
Mauritania	81.3
Niger	4.9
Grand Total	**228.5**

105 WBG Sahel Initiative - three focus areas - (A) Agriculture and Water Management; (B) Human Development; and (C) Connectivity and two special objectives – (i) Female Empowerment and (ii) Electricity Access.

106 IFC AFR Strategy - (A) bridging the infrastructure gap; (B) building productive real sectors, and (C) leading inclusive business approaches, and the themes being a) climate change, b) investment climate, c) gender and d) partnerships.

Table 2-23 IFC's investment portfolio by industry group

Industry	Committed Portfolio (in US$mn)
CDF	0.0
FIG	93.6
INFRA	65.6
MAS	69.4
Grand Total	228.5

2.1.7 Critical Business Reforms

Critical business reforms are still needed, despite the progress made for an enabling environment for private sector participation:

- **Collateral registries reforms** to facilitate access to finance: modernize collateral registries by computerized them, expand the scope to include moveable collaterals will contribute to improve accuracy, and accessibility of collateral information. Online registries tend to reduce the costs and speedier processes than older paper-based procedures. Moveable collaterals open new markets for borrowers unable or unwilling to pledge immovable property.
- **Land reforms:** to strengthen the registration and valuation of movable and immovable property, while ensuring that registration is affordable. Additionally, there is a need to digitalize the land registration process and automate procedures to reduce processing delays. Country like Niger made significant progress to reduce the time needed to transfer and register property (13 days and 4 procedures to register a property, down from 35 days and four procedures.)
- **Contract enforcement:** to decrease the time and cost for resolving a commercial dispute. In Burkina, enforcing contracts takes an average of 446 days. The judiciary system capacity is among the key factors constricting enterprise development and growth. Measures to reduce the time and cost to resolve commercial dispute will be essential. In Niger, the creation and operationalization of the Commercial Court had a positive on enforcing contracts.
- **Tax administration and tax rates**: in Burkina, 270 hours and 45 payments are required to comply with tax regimes, therefore decreasing the time, automating the procedures, and making tax policies more favorable to businesses.

In Burkina Faso, and according to According to the recent CPSD validated in 2020, the overall business enabling environment is weak in Burkina. Strong efforts in terms of reforms are needed to enhance the general Investment climate in the country. The diagnostic revealed that since 2004 more than 200 private sector-oriented reforms have been undertaken, regulatory impediments—red-tape, tax regimes, customs and trade regulations—constitute a critical obstacle to private sector operations. Burkina Faso ranks 151 out of 190 countries in the 2019 World Bank's Doing Business, down from 143 in 2016, as the reform momentum has faded.

The diagnostic also revealed that the costs of doing business are high and pervasive in Burkina Faso. For example, the costs of starting a business amount to 42.5 percent of per capita income in Burkina Faso, compared with 8.1 percent in Niger. Similarly, enforcing contracts takes an average of 446 days, while 270 hours and 45 payments are required to comply with tax regimes. The delays (169 days) and costs (9,000

percent of per capita income) to obtain an electricity power connection are daunting in the country. This makes Burkina Faso one of the worst performers on this indicator.

On the positive side, Burkina Faso has recently implemented several key reforms that make doing business easier. For instance, in 2018 it adopted a law that regulates all aspects of mediation as an alternative dispute resolution mechanism, it adopted the Law on Public- Private Partnerships, and adopted a new investment code and a law for the promotion of SMEs. The country has also made progress with reforms regarding business licenses and launched a new credit information bureau. However, critical additional business reforms are required in the areas of taxation, access to land, and the enforcement of contracts.

Niger has recently made some progress in improving its investment climate. Improvement includes an increase of 44 places in the Doing Business from 2014 (176th) to 2020 (132nd out 190 economies. For example, Niger has reduced the time (from 17 days in 2014 to 3 days in 2020) to create a business, and cost of registry and the capital requirements to start a business, which is expected to facilitate the formalization of businesses. As a result, more than 38,800 businesses were created between 2013 and 2021 versus 1913 in 2013. In addition, in 2018, Niger made registering property faster by decreasing the time needed to transfer and register property. It now takes 13 days and 4 procedures to register a property (down from 35 days and four procedures). Areas of doing business that were improved include: trading across borders, enforcing contracts with the creation and operationalization of the Commercial Court, resolving insolvency, protecting minority investors, getting credit, getting electricity, dealing with construction permits.

Despite the recent efforts, primary constraints facing businesses in Niger as they were identified in the World Bank Enterprise Survey as being the most problematic and having the greatest impact to business, and coupling this information with latest Doing Business report findings on Niger were in order of priority: (i) the high rates of informality (and resulting unfair competition from the informal sector), (ii) poor access to finance, (ii) lack of reliable electric power, (iii) political instability and corruption, (iv) excessively restrictive labor regulations, (v) tax administration and high tax rates, and (vi) lack of entrepreneurial skills. The country's weak judiciary system is also perceived by the private sector as constricting for Nigerien enterprise development and growth.

According to the Country Economic Memorandum (CEM), consistent misapplication of official policy and legal frameworks has colored the business environment with the perception of corruption. Various foreign firms operate in the nascent gold and oil sectors, but several businesses have been turned off by the outdated and opaque bureaucratic investment framework. The framework for market competition is very weak and driven by informal rules. The failure to develop a level playing field over the years had a negative effect on the private sector.

The lack of effective Public Private Dialog (PPD) mechanism, as recognized by both private and public sector representatives, despite the existing of the plethora of PPD entities in the country, does not favor the proper identification and carrying out productive development policies to better address market failures business are facing. Besides, the COVID-19 pandemic has worsened the existing challenges. During the first three months of the pandemic, according to the CEM, monthly sales by firms in Niger declined by 56 percent with small and medium firms and those operating in services being the most affected. Around 95 percent of firms experienced a decrease in hours worked relative to the same period in the previous year, while 85 percent saw their cash flow availability reduced.

2.1.8 Integrating Clean Cooking in the G5 Sahel

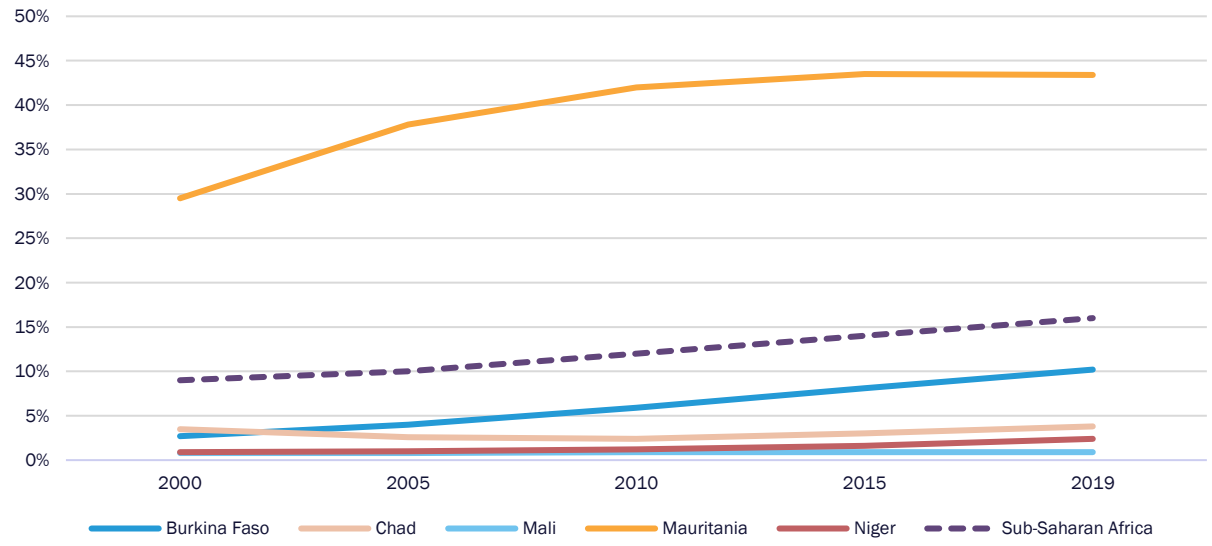
Burkina Faso, Chad, Mali, Mauritania, and Niger

Background Note

CLEAN COOKING IS VITAL TO COMBATING CLIMATE CHANGE AND ENSURING EQUITABLE DEVELOPMENT

Access to clean cooking is a development issue, contributing to energy poverty while impacting the multiple sectors such as health, climate change, gender, environment. Today, more than 78 million people in the G5 Sahel countries live without access to clean cooking fuels and technologies. According to the 2021 Sustainable Development Goal (SDG) 7 Tracking Report[107], Mali, Niger, and Chad are among the top 20 countries with the lowest population shares having access to clean fuels and technologies (2015-19 average) with access rates at only 1 percent, 2 percent, and 4 percent respectively in 2019. Mauritania, the only country tracking above the Sub-Saharan average rate for clean cooking access, has the highest access rate across the G5 Sahel region at 43 percent in 2019. Burkina Faso's recent change has occurred at a pace comparable to Sub-Saharan Africa's average and has reached 10 percent access rate in 2019 (Figure 2-33).

Figure 2-33 Access to Clean Cooking Rate Evolution and Progress, 2000-2019



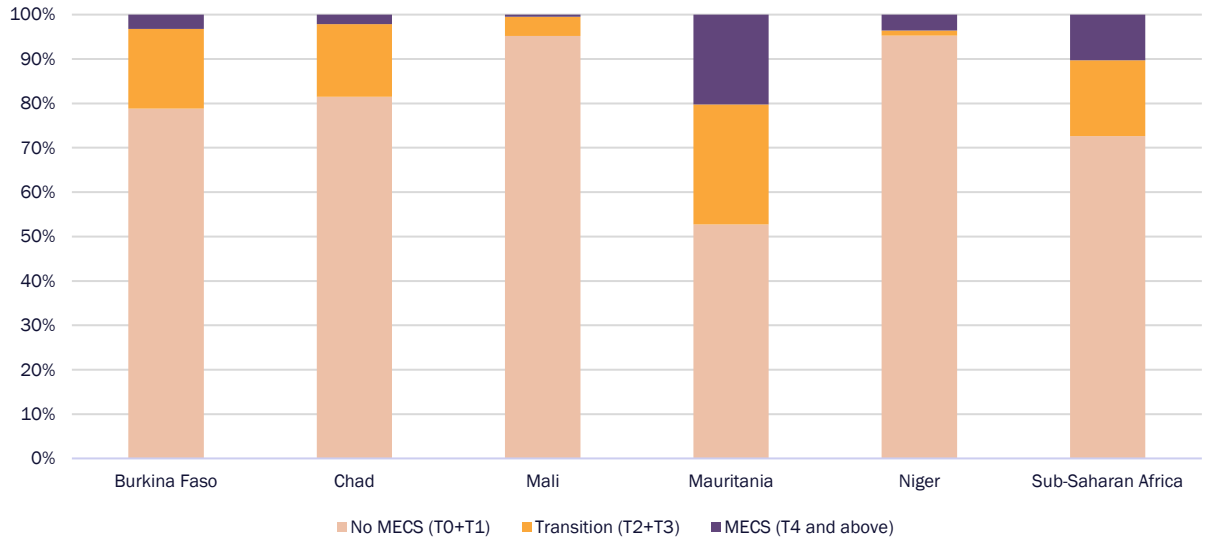
Source: Household Energy Database, WHO, January 2021.

The progress of the G5 Sahel countries in meeting the UN Sustainable Development Goals (SDGs) is constrained by the high dependence on biomass for cooking, leading to forest degradation and deforestation. Despite improvement in the share of population with access, population growth in the G5 countries still outpaces the progress achieved over the last decade. Based on the World Bank's Multi-Tier

107 IEA, IRENA, UNSD, World Bank, WHO. 2021. Tracking SDG 7: The Energy Progress Report. World Bank, Washington DC.

Framework (MTF)[108], it is estimated that among 74.79 million people without access to modern energy cooking services (MTF Tier 4 or above which is considered as clean, efficient, convenient, safe, reliable, and affordable) in the G5 Sahel countries, 7.59 million people (9.2 percent) are considered in transition with access to improved cooking services (MTF Tier 2 or 3) and the rest still use the most polluting and primitive cooking practice (Figure 2-34). Within this context, the demand for charcoal and firewood is driving deforestation and forest degradation in the G5 countries, and is undermining agricultural productivity and food security, water security, and hydroelectric generating capacity – leaving the G5 countries more vulnerable to climate shocks.

Figure 2-34 Multi-Tier Framework (MTF) Tier Distribution, by Countries



Source: World Bank MTF country datasets. Demographic and Health Surveys (DHSs), Multi-Indictor Cluster Surveys (MICSs), and Task Team analysis.

The consumption of fuelwood is worsened by the widespread use of inefficient cooking methods, and unsustainable fuel collection and production. Cooking with three-stone fires or low efficiency traditional charcoal/wood stoves remains the primary solutions across the G5 Sahel countries. Over the last few decades, introducing new fuel-saving technologies has proven difficult in the region, with households' ability to adopt and willingness to pay (WTP) being constrained by poverty. The sustainability of the cooking sector remains wedged between the need to alleviate the pressure of a rapidly increasing demand for fuel, led by demographics, and the constrained wood supply in Sahelian countries where wooded biomass is characterized by slow growth and low yields.[109] As a result, the net annual wood fuel balance has been increasingly negative (natural regeneration minus annual fuel use) and is now heavily affecting the wood stock of the G5 countries.

Clean cooking is a key climate mitigation measure of the G5 Sahel countries' National Determined Contributions (NDCs), aligned with achieving the UN SDG 7 along with SDG 1, 3, and 13. Cooking with

108 Energy Sector Management Assistance Program (ESMAP). 2020. The State of Access to Modern Energy Cooking Services. Washington, DC: World Bank.

109 Niger Accelerating Electricity Access Project (HASKE), Project Appraisal Document, World Bank 2021.

traditional stoves and fuels in the G5 has adverse impacts on health, gender, climate, the environment, employment, and society. The negative impacts can be given a dollar value to quantify and estimate the costs associated without action in addressing access to clean cooking. The total cost of inaction on the clean cooking agenda in the G5 is estimated to be US$51.46 billion per year stemming from the negative externalities for health, gender, and climate. The health impact is estimated at US$32.37 billion per year linked to deaths and disability-adjusted life years (DALYs) from household air pollution (HAP). The gender impact associated with the time spent performing cooking-related tasks, such as fuel collection, cooking, and stove cleaning, and lost productivity is estimated at US$15.18 billion per year. The annual cost of inaction on climate and environment is estimated to be US$3.91 billion per year (See Annex II for detailed methodologies).

Transition to clean cooking solutions is a key climate adaptation action for the G5 Sahel countries. Climate variability and change cause greater incidence of dry spells and intense rainfall events. These changes lead to an increase in the frequency of floods, droughts, and pest and disease outbreaks, with severe economic and social consequences. High levels of deforestation from use of solid fuels for cooking are rapidly depleting the G5 countries' forests, intensifying climate change. Climate change itself further poses an increasing threat to forests, and to poor and vulnerable populations that are dependent on it for cooking fuel. To ensure food security through sustained availability of fuel for cooking, a climate-adapted approach is needed in the G5 Sahel countries so that the population has access to diversified fuel and technologies for cooking, can lower reliance on technologies that are more vulnerable to climate change effects and increase the capacity for people to withstand shocks to fuel supply.

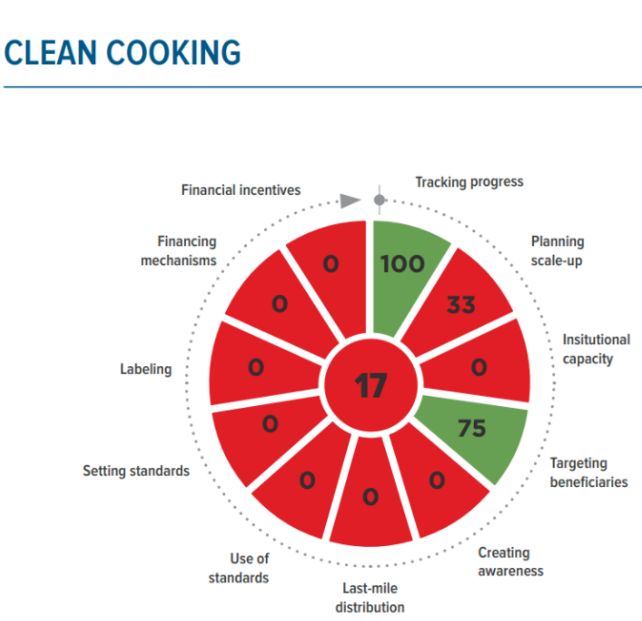
A climate adaptive approach should be reflected in policies, data, institutions, behaviors, and finance. This would include actions like identifying the populations that are most vulnerable to losing access to fuels for cooking due to climate events like droughts, flooding, etc., internalizing externalities of polluting cooking technologies through carbon prices, reflecting adaptation principles in tax policies, and improving cross-ministerial coordination. An important climate-adaptive step is to identify population that are most vulnerable to losing their source of fuel for cooking, help them transition to a cleaner, more efficient, safer, and available fuel source, and include clean stove/fuel stacking as part of a climate adaptive strategy. Identifying such populations and ensuring adoption of solutions will require data, an understanding of fuel preferences and finance.

CLIMATE COMMITMENTS, POLICIES, INSTITUTIONS, AND CAPACITTIES

According to the World Bank's 2020 Regulatory Indicators for Sustainable Energy (RISE)[110], Chad and Burkina Faso scored the lowest among the G5 Sahel countries on their clean cooking policy frameworks against global best practices, at 15 and 17 (out of 100) respectively, indicating that policy adoption remains at an early stage for both countries. Meanwhile, Niger, Mali, and Mauritania scored 63, 56, and 44 respectively, indicating that those countries have begun to make serious efforts to develop policy frameworks but still have some room for improvement.

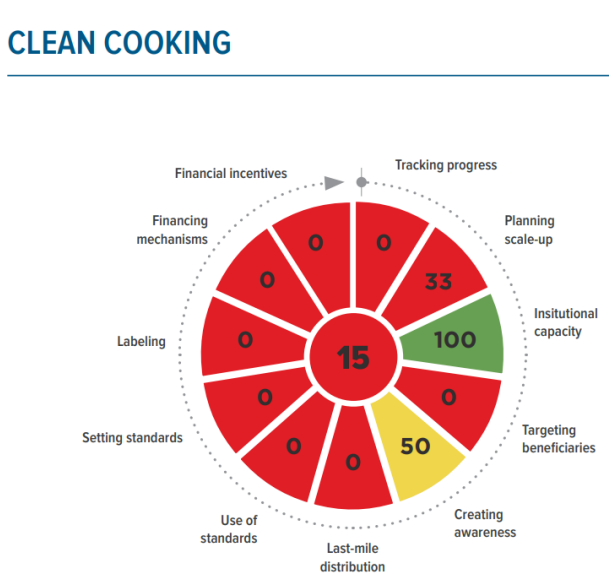
110 Energy Sector Management Assistance Program (ESMAP). 2020. Regulatory Indicators for Sustainable Energy (RISE) Sustaining the Momentum. Washington, DC: World Bank.

Burkina Faso



The Burkina Faso government's 2010 Plan d'Action National des Energies Renouvelables (PANER) set the goal of achieving 100 percent access to modern cookstoves for the country's urban population and 65 percent access for the country's rural population by 2030. Currently, access to clean cooking in Burkina Faso is only slightly above 10 percent of the total population. The clean cooking section of the PANER does distinguish between geographic areas and their specific needs, but there is no last mile distribution program to accommodate the specific geographic needs. The PANER prioritizes butane gas, LPG, biogas, and solar-powered electric cookstoves. However, no standards or labeling schemes are in place to mandate improved cookstoves or cooking fuels. A subsidy program for improved cookstoves is being discussed but has not been drafted yet. In 2019 it was also proposed to implement a price ceiling for butane gas distributors, but no subsidies to support suppliers have been finalized yet.

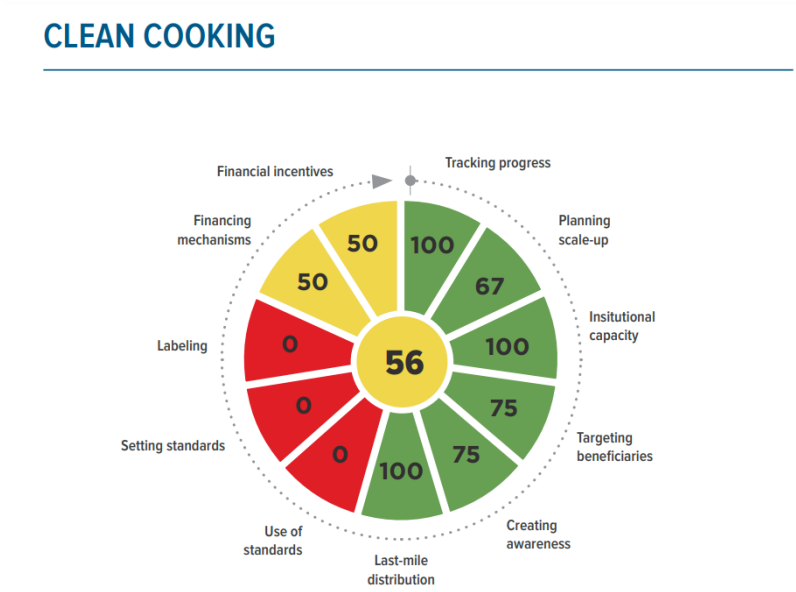
Chad



The Agency for Domestic Energy and the Environment or Clean Cooking (AEDE) has been an active government entity in Chad for nearly 20 years, but little progress has been achieved on clean cooking policies and regulations since its founding within the Ministry of Environment, Water and Fishing in 2002. The first regulatory step the agency took was to adopt and enforce a ban the use of wood as a cooking fuel in households and the use of wood in industrial settings and factories all together. In 2008, the AEDE published a national clean cooking action plan outlining these reforms. However, standards for cooking fuels or types of stoves have yet to be adopted or implemented. The plan only describes regulatory measures intended to ban fuels in household cooking but

is lacking any incentives or market-oriented approaches to improve the standards of cooking (e.g.: cleaner fuels, improved stoves) for households.

Mali

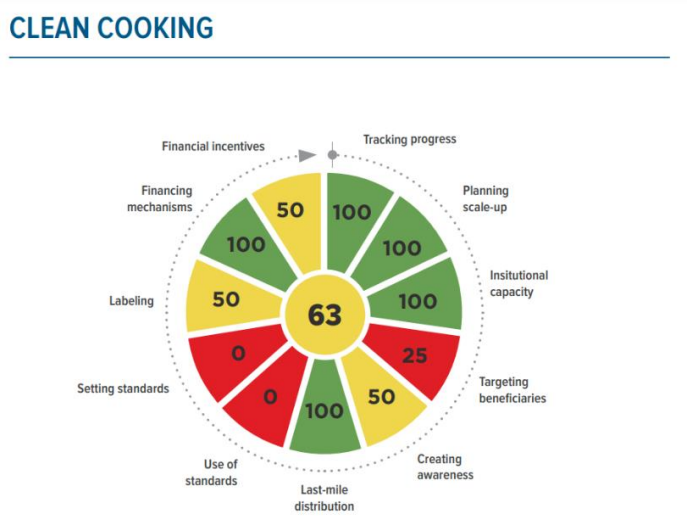


Mali has a moderately developed policy framework for clean cooking that is focused on building capacity and lacking in mechanisms to increase uptake and enforce standards. The government introduced the Plan d'Action National d'Energies Renouvelables (PANER) du Mali, under which the government set the objective to bring improved cookstoves to 100 percent of the population by 2030, of which 62.5 percent of the population would be provided with access to modern fuels like butane. The plan targets Tier 3+ cooking solutions, provides action items to include women throughout the clean cooking supply chain, recognizes the importance of creating awareness, with particular emphasis on women and vulnerable consumers. The plan also sets out last mile distribution strategies for clean cooking fuels and technologies.

There is defined institutional capacity to carry out the clean cooking agenda, but policies to implement the agenda are missing. Agence Malienne pour le Développement de l'Energie Domestique et de l'Electrification Rurale is responsible for setting the clean cooking strategy, Agence des Energies Renouvelables du Mali is in charge of tracking access and adoption, and Agence Malienne de Normalisation et de Promotion de la Qualité (AMANORM) is charged with setting, monitoring and enforcing standards for clean cooking solutions. Despite the institutional capacity conspicuously absent from Mali's clean cooking policy and regulatory framework are standards and labeling for clean cooking solutions, and financing mechanisms to improve their supply and consumption. In terms of financial incentives, there are value-added tax (VAT) exemptions available for biogas, but it's not a fuel that's in use for cooking. All in all, the policies that are currently in place have failed to jumpstart the transition to modern energy for cooking in Mali.

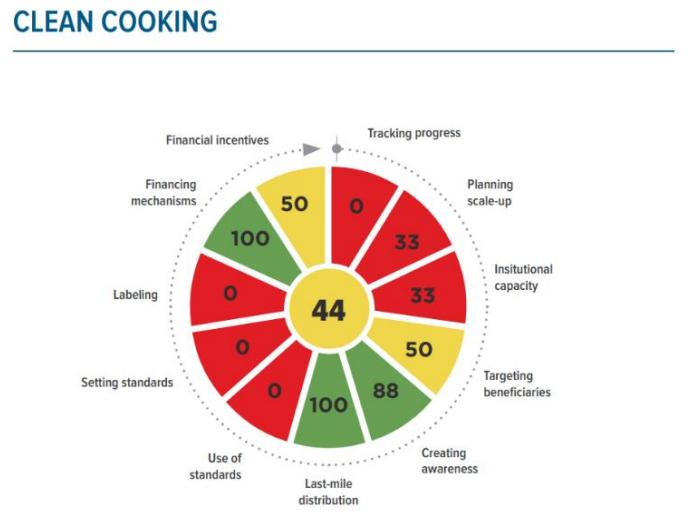
Niger

Niger has achieved a significant progress in enhancing its clean cooking policy framework since 2010 when the country first started developing its institutional capacity for planning and tracking clean cooking access nationally. As of 2010, Niger scored only 18/100 on the RISE clean cooking pillar. There was no regulatory consideration given to clean cooking at the time, other than a limited progress in institutional capacity development. In 2017, a considerable advancement in clean cooking initiatives was recorded - periodic



updates in tracking access to clean cooking rates started to be published, scale-up deployments were included in policy planning, institutional capacity was enhanced, and strengthening last mile distribution networks was included in clean cooking strategy. In addition, initiatives such as creating awareness, labeling of products and financial incentives for suppliers also were introduced. With these achievements, the overall score of Niger in 2017 was 63/100. However, the progress towards targeting beneficiaries from vulnerable groups and promoting higher tier technologies was very slow-paced. No progress recorded towards development of national standards and quality assurance regime to ensure its implementation. In 2019, Niger could not increase its score further and overall score was maintained at 63/100. However, Niger's current score of 63/100 is significantly higher than the global average[111] of 37/100 and the Sub-Saharan Africa regional average of 35/100.

Mauritania

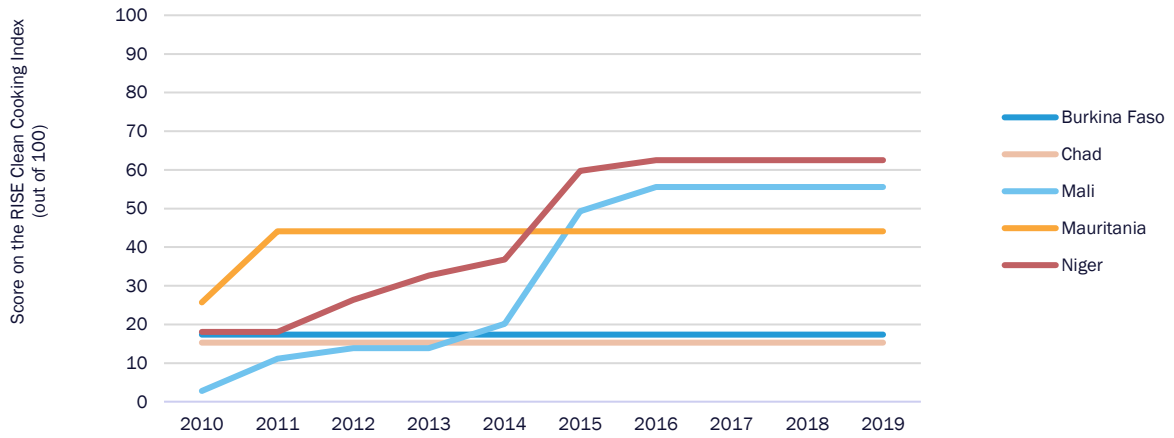


Mauritania's progress towards developing regulatory framework for advancing clean cooking agenda in the country could have been much better in the past decade. In 2017, Mauritania scored 26/100 on the RISE clean cooking pillars on account of institutional capacity in developing clean cooking action plan, awareness program to enhance demand, financial mechanisms to support end-users with adoption and financial incentives for suppliers. In 2017, the overall score got increased to 44/100 as the country also started focusing on the other crucial aspects such as developing national plan to provide universal access to clean cooking, spelling out quality criteria focusing on higher tier technologies, intensifying awareness campaigns with focus on health aspects and strategizing last mile delivery of clean cooking solutions through stronger supply chain. However, there was no progress recorded towards developing standards, introducing quality assurance measures, and labeling of clean cooking solutions. In 2019, the overall score was found to be unchanged i.e., 44/100. Although lower compared to many other countries in the Sub-Sahara Africa region, Mauritania's current score of

111 The RISE clean cooking pillar is only scored for 55 access-deficit countries (as identified in IEA, IRENA, UNSD, World Bank, and WHO, 2020) and is averaged into the overall score for those countries only.

44/100 is still higher than the regional average score of 35/100. It is also higher than the global average score of 37/100.

Figure 2-35 Evolution of the G5 Sahel Countries' Performance on the RISE Clean Cooking Index (2010-2019)



Enabling Environment

The G5 Sahel countries' efforts to improve access to clean cooking can be seen through the following policy commitments:

Table 2-24 Clean Cooking Targets for G5 Sahel Countries[112]

Country	Clean cooking targets
Burkina Faso	Universal access in urban areas and 65% in rural areas, by 2030. LPG urban penetration of 68% by 2030.[113]
Chad	N/A
Mali	Universal access by 2030.[114]
Mauritania	100% access to LPG in urban areas and 50% access to LPG in rural areas by 2030.
Niger	100% urban penetration of improved cookstoves (ICS) and 30% rural by 2030. Support to biogas and biofuels.[115]

Source: IEA 2021.

The following cooking related targets were also included in the Nationally Determined Contributions (NDCs) submitted by the G5 Sahel countries.

112 Clean Energy Transition in the Sahel, IEA, September 2021

113 The Global LPG Partnership (2017).

https://static1.squarespace.com/static/5633c4c2e4b05a5c7831fbb5/t/5acbc7d6562fa79982af9a6a/1523304406277/National+and+Regional+Targets+for+Clean+Cooking+Energy+Access+in+Africa+by+2030.pdf.

114 SEforALL Africa Hub (2021), Mali Country Overview, https://www.se4all-africa.org/seforall-in-africa/country-data/mali

115 SEforALL Network (2015), Niger Country Overview, http://www.se4all.ecreee.org/content/niger

Table 2-25 NDCs of G5 Sahel Countries

Country	NDC clean cooking targets	Estimated investment cost
Burkina Faso (2015-2030)	540,000 improved cookstoves are produced and distributed, at least 50% in urban and semi-urban areas over 15 years.	US$12,096,000
	80% of dolo beer brewers use an improved cookstove, 95% of which are in rural areas and 100% in urban and semi-urban areas.	US$75,600,000
Chad (2021-2030)	Distribute 3,000,000 improved wood-burning stoves and 1,500,000 charcoal-burning stoves	N/A
Mali (2021-2030)	N/A	US$1.16 billion for energy
Mauritania (2021-2030)	Distribution of 150,000 improved stoves by 2030	US$3 million
	Distribution of 170,000 LPG stoves by 2030	US$5.1 million
	Promotion of 10,000 efficient electric stoves by 2030	US$0.5 million
Niger (2015-2030)	Cooking energy: reduction in the demand for wood energy per inhabitant by the mass spread of improved cookstoves, with a rate of penetration of 100% in urban areas and 30% in rural areas; promotion as domestic gas of biogas and biofuels at both the industrial and family level.	US$8.667 billion in total

Summary of On-going and Recent Programs

Below is a summary of the recent World Bank projects to be implemented in the G5 Sahel region:

Niger Accelerating Electricity Access Project (Haské) (P174034). The Haské project was approved in December 2021. Haské will co-finance its Subcomponent 3.3 '*Increasing access to Clean and Efficient Cooking (CEC) solutions'* with the Clean Cooking Fund (CCF) under the ESMAP MDTF to accelerate access to clean cooking in Niger. The CCF provided a US$7.5 million RETF grant to support technical assistance and market development through a results-based financing facility targeting rural households, refugees, and host communities. Haské will also allocate US$7.5 million in IDA funding, matched by US$7.5 million in CCF grant funding to contribute to both Niger's and the global clean cooking agenda. As a result of this financing, approximately 550,000 families will be able to use environmentally friendly cooking facilities.[116]

Chad Energy Access Scale Up Project (P174495). Component 3 will support clean cooking for refugees and nearby communities. The component aims to (a) reduce demand of fuelwood; (b) promote sustainable supply by optimizing fuelwood consumption and diversifying fuel substitution options, including via solar and liquefied petroleum gas (LPG) cookstoves; and (c) restore degraded forests/areas affected by fuelwood collection and strengthen the national and local institutions or stakeholders involved in the sustainable management of natural resources in areas affected by refugee inflows. The subcomponent will be implemented in two phases: the first phase (Subcomponent 3.1) is expected to last up to 1.5 years and should lead to an integrated national strategy with specific actions identified for funding and implementation in some of the nine provinces, housing refugees and host communities, under the second phase (Subcomponent 3.2 and Subcomponent 3.3). In total, 70,000 families from refugee camps and host communities will benefit from clean cooking solutions and related economic and health benefits.[117]

116 Niger: The World Bank is supporting the strengthening of economic governance and human capital and increased access to energy. World Bank press release, December 10, 2021.

117 Chad Energy Access Scale Up Project, Project Appraisal Document, World Bank 2021

LESSONS LEARNED FROM THE WORLD BANK'S OPERATIONAL EXPERIENCE IN THE EFFICIENT AND CLEAN COOKING AND HEATING SECTOR

Building on the World Bank's lending experience in the cooking sector, the Energy Sector Management Assistance Program (ESMAP) conducted a portfolio review of World Bank efficient, clean cooking and heating (ECCH) operations over the last 10 years to review the operations models used and synthesize the lesson learned. The operations models basically involved streams of support for technical assistance and investment. Specifically, the interventions included (i) technical assistance provided to governments and key stakeholders to improve the enabling environment and implementation capacity, (ii) Results-Based Financing (RBF) and its variance under country conditions to incentivize private-sector enterprises to deliver defined results on improved cooking and heating technologies, (iii) Community Driven Development (CDD) approaches involving public-sector procurement to support end users to obtain improved cooking technologies, (iv) training of NGOs and local partners to increase their capacity to deliver cooking technologies, (v) access to finance support to stove/fuel enterprises and/or end users mainly through credit-line operations, and (vi) business incubation support to small- and medium-sized enterprises (SMEs), including those focused on stoves and fuels.

Key lessons learned from the sector portfolio review are summarized as follows:

- ***Access to clean cooking services is a development issue.*** Access to modern-energy cooking services is closely related to the level of economic development and urbanization rate. The most effective way to reduce household air pollution (HAP) is by switching to modern clean fuels (e.g., electricity, natural gas, LPG, ethanol, and biogas). Fuel switching should be encouraged, and more efforts are needed to invest in the delivery infrastructure. At the same time, it should be recognized that large-scale fuel switching is unlikely to occur in rural areas until rural economies become substantially more developed or ongoing public funding is provided for fuel switching. To lower HAP in rural households where the use of biomass is likely to persist over the near term, it is important to modernize the biomass fuel sector and promote integrated and cost-effective approaches (e.g., improved/advanced biomass stoves, together with improved ventilation and behavior change).

- ***A systems approach is needed to promote access to clean cooking.*** In order to make the cooking process clean, the whole system of interactions of cooking technologies (the combination of stove and fuel) with human behavior (e.g., what to cook, how to cook, and how often and long to cook) and housing conditions (e.g., kitchen location, arrangement of rooms and size, construction materials, and quality of ventilation) needs to be considered. It is important to encourage innovation in each element of the system.

- ***Local innovation and localized solutions are critical for long-term sustainability.*** Cooking is a contextualized system with no one-size-fits-all solution. Although projects share common barriers, the best solutions will vary by location owing to differences in cooking behavior, culture, resources, institutions, and market conditions. Therefore, empowering the development of localized solutions, based on lessons from international experience, including the latest technology innovations, will be key because localized solutions are more likely sustainable. And only when solutions are sustainable can they be truly transformative.

- ***A national program with high-level support is essential to scale up access to clean cooking.*** While such programs need to involve stakeholders from a wide variety of positions and roles (public sector, civil society, and private sector) at all levels (i.e., local, provincial, national and international), there is no substitute for high-level political, technical, and financial support from national leaders and agencies.

- ***Incentives or subsidies will be needed to achieve universal access to clean cooking.*** Like universal access to electricity—which no country has achieved without some form of subsidy—subsidies will be needed to achieve universal access to modern-energy cooking solutions. Market forces and mechanisms are powerful tools for ensuring a sustainable supply of modern cooking technologies and should be harnessed in a way that helps the private sector to develop, market, and deliver modern cooking solutions. However, if left to market forces alone, access will be limited by affordability and other constraints that affect mainly poor households, particularly in less developed and more remote areas. Thus, government policies are needed to (i) establish and maintain adequate levels of subsidies and (ii) design and implement effective subsidy allocation mechanisms to mobilize and sustain private-sector participation and target households who have an affordability gap.

- ***Results-Based Financing has been demonstrated to be an effective approach to using public resources to incentivize the market and can be designed to fit the country context and market conditions.*** The World Bank has implemented the RBF framework to support ECCH solutions in 10 client countries with variations based on country conditions (e.g., in Bangladesh, China, Indonesia, Kenya, Lao PDR, Mongolia, and Uganda). The results demonstrate that RBF is an effective instrument to incentivize private-sector investment and deliver clean and efficient cooking and heating solutions with pre-defined result levels and triggers for payment. The RBF framework can be used to unify key elements and interventions needed to achieve results. In addition, its flexibility allows for designing and adjusting the pre-defined results and associated incentives based on the country context, market conditions, and feedback from program implementation.

RECOMMENDATIONS AND NEXT STEPS

Investment needs:

Based on the World Bank's Multi-Tier Framework (MTF), it is estimated that among 74.79 million people without access to modern energy cooking services (MTF Tier 4 or above) in the G5 Sahel countries, 7.59 million people (9.2 percent) are considered in transition with access to improved cooking services (MTF Tier 2 or 3) and the rest still use the most polluting and primitive cooking practice.[118] Major drivers of households' lack of access include the lack of alternative solutions, low awareness, and unaffordability; but awareness raising, behavior-change campaigns, and financing support for high-performing technologies that reduce fuel use can overcome these obstacles.

118 Energy Sector Management Assistance Program (ESMAP). 2020. The State of Access to Modern Energy Cooking Services. Washington, DC: World Bank.

Table 2-26 Population Access to Modern Energy Cooking Services (MECS), by Countries (Millions of people and Tier %)

	Burkina Faso (2014)	Chad (2015)	Mali (2015)	Mauritania (2015)	Niger (2020)
No MECS	13.87 (78.8%)	11.42 (81.5%)	16.64 (95.2%)	2.20 (52.7%)	23.07 (95.3%)
Transition (Tier 2 and 3)	3.15 (17.9%)	2.29 (16.3%)	0.75 (4.3%)	1.13 (27.1%)	0.27 (1.1%)
MECS (Tier 4 and Above)	5.67 (3.2%)	0.30 (2.2%)	0.09 (0.5%)	0.85 (20.2%)	0.87 (3.6%)

Source: World Bank MTF country datasets. Demographic and Health Surveys (DHSs), Multi-Indictor Cluster Surveys (MICSs), and Task Team analysis.

To achieve the clean cooking targets set out by the G5 Sahel countries, a total investment of around US$486 million is needed each year, including US$232.2 million for Burkina Faso, US$39.8 million for Chad, US$68.5 million for Mali, US$111.7 million for Mauritania, and US$33.9 million for Niger (Table 2-27). Specifically, it is estimated that approximately US$142.3 million is needed from the public sector to fund awareness raising and technical assistance as well as subsidies to ensure that improved or modern cooking solutions can be afforded by the poorest, US$20.3 million from the private sector to install downstream infrastructure for the functioning of modern energy cooking markets, and the rest from households' direct contributions (See Annex III and IV for detailed methodologies).[119]

Table 2-27 Estimated investment needs by public sector, private sector, and household's contributions to reach clean cooking targets in G5 Sahel countries by 2030

Country	Clean cooking targets	Annual investment (USD/million)			
		Total	Public	Private	Household
Burkina Faso	Universal access in urban areas and 65% in rural areas, by 2030. LPG urban penetration of 68% by 2030.[120]	232.2	93.3	12.5	126.4
Chad	Distribute 3,000,000 improved wood-burning stoves and 1,500,000 charcoal-burning stoves	39.8	9.5	N/A	30.3
Mali	Universal access by 2030.[121]	68.5	16.3	N/A	52.2
Mauritania	100% access to LPG in urban areas and 50% access to LPG in rural areas by 2030.	111.7	15.1	7.8	88.8
Niger	100% urban penetration of improved cookstoves (ICS) and 30% rural by 2030. Support to biogas and biofuels.[122]	33.9	8.1	N/A	25.8
Total		486.1	142.3	20.3	323.5

119 World Bank Clean Cooking Planning Tool, 2022

120 The Global LPG Partnership (2017).

https://static1.squarespace.com/static/5633c4c2e4b05a5c7831fbb5/t/5acbc7d6562fa79982af9a6a/1523304406277/National+and+Regional+Targets+for+Clean+Cooking+Energy+Access+in+Africa+by+2030.pdf.

121 SEforALL Africa Hub (2021), Mali Country Overview, https://www.se4all-africa.org/seforall-in-africa/country-data/mali

122 SEforALL Network (2015), Niger Country Overview, http://www.se4all.ecreee.org/content/niger

By achieving the clean cooking targets in accordance with each G5 country's commitments, the overall benefit of transition totals US$10.68 billion each year, which is around 22 times of the estimated total investment (US$486 million each year) and 75 times of the public financing (US$142.3 million each year). The health co-benefit is estimated at US$5.8 billion per year linked to avoided deaths and avoided disability-adjusted life years (ADALYs) from reductions in exposure to HAP. The gender co-benefit is estimated at US$3.2 billion per year, associated with time savings in performing cooking-related tasks such as collecting fuel and cooking. Finally, the climate co-benefit is estimated at US$1.7 billion per year, due to reductions in greenhouse gas (GHG) and black carbon (BC) emissions by switching the targeted population to cleaner cooking solutions (Table 2-28). Achieving the clean cooking targets above will contribute to the G5's climate adaptation through reducing reliance only on charcoal and fuelwood, providing vulnerable populations with alternative clean cooking solutions, and aligning policies, data, institutions, behaviors, and finance for more green, resilient, and inclusive development.

Table 2-28 Benefits of transition by health, climate, and gender co-benefits by achieving clean cooking targets in G5 Sahel countries by 2030

Country	Health co-benefits			Climate co-benefits			Gender co-benefits		
	Benefits of transition (USD/billion)	Avoided DALYs in 2030	Avoid Deaths in 2030	Benefits of transition (USD/billion)	Emission savings (tCO2eq/yr) Rural	Emission savings (tCO2eq/yr) Urban	Benefits of transition (USD/billion)	Time saved Rural (hrs)	Time saved Urban (hrs)
Burkina Faso	2.5	178,890	3,713	0.4	4,924,647	4,223,122	0.7	541,504,674	796,186,178
Chad	0.8	77,374	1,601	0.4	6,276,239	1,610,499	0.5	678,226,603	199,117,713
Mali	1.1	67,549	1,711	0.6	8,049,786	5,976,775	1.2	1,572,197,773	731,099,692
Mauritania	0.9	23,472	603	0.1	1,326,784	1,321,511	0.2	186,620,559	111,233,016
Niger	0.5	54,567	1,316	0.2	3,218,339	1,697,561	0.6	704,773,861	471,530,947
Total	5.8	401,852	8,944	1.7	23,795,795	14,829,468	3.2	3,683,323,470	2,309,167,546

Source: World Bank Clean Cooking Planning Tool (CCPT), 2022

Policy recommendations:

Moving forward, as the clean cooking market is still nascent in most of the G5 countries (except for Mauritania), it is important to take an integrated approach by working across sectors and tackle on supply, demand, and enabling environment to support clean cooking market development in the region. With a substantial disease burden associated with HAP and rapid deforestation, the G5 countries need a timely cooking sector intervention:

At Sahel regional level:

- **Prioritize scaling up access to clean cooking, a low-carbon, pro-poor, and climate adaptive solution, in the Sahel region's climate agenda.** This includes making clean cooking access a political and climate prerogative through developing regional roadmaps, ensuring high-level

political involvement, and building coalitions and partnerships. It also includes embedding commitments in the broader regional and national 2030 SDG agenda and building technical capabilities and awareness of decision-makers.

- **Introduce regional coordinated efforts to scale up access to clean cooking with emphasis on knowledge exchange among Sahel countries.** Regional integration is critical for achieving universal access by leveraging each country's national comparative advantages on energy resources and advancing the sector from a regional standpoint.
- **Scale up public and private financing for clean cooking.** A dramatic scale-up in both public and private investments, along with dedicated policies, is needed to implement clean-cooking strategies and action plans to achieve on-the-ground results. By projecting Sahel region as a single market, private sector participation can significantly increase as a result of risk diversification and increased market size.
- **Leverage existing business models and harness clean energy businesses that are already active in the Sahel region.** Bundling cooking with other modern-energy products and services already present in the region can help cooking enterprises in the G5 to capitalize on existing distribution networks, potentially increase revenues, and spread risk.

<u>At country level:</u>

- **Formalize cooking energy demand in national energy planning and development of strategies for achieving universal access.** The effort needs to be led by a designated institutional champion responsible for coordination with key stakeholders and accountability for achieving results. The transition pathways of national roadmaps to universal access should be guided by a least-cost, best-fit strategy that reflects diverse users' needs, local market conditions, and national comparative advantages on energy resources.
- **Develop and enforce regulations and standards that promote market development for clean cooking solutions.** Governments should play a role in localizing international standards through close coordination with international standards-setters, strong domestic monitoring and enforcement, and engaging critical players to strengthen capabilities.
- **Expand data collection efforts and monitor progress.** To undertake more evidence-based decision-making, it is critical to expand implementation of national household-level surveys (e.g., MTF survey), combined with the sharing of lessons and insights through open-data platforms and consultations with stakeholders.

Annex I. Existing Cooking Players and Initiatives in the G5 Sahel Countries[123]

Table 2-29 Players with Headquarters in the G5

Type	Player Name	Operations	Features				
			Design	Manufacture	Assembly	Distribute	Retail
Enterprise	Actualite Energie	Burkina Faso (HQ); Zimbabwe	Yes	Yes	Yes	No	No
Investor	SOS Energie Burkina	Burkina Faso	No	No	No	No	No
NGO	Institut de Recherche en Sciences Appliquées et Technologies (IRSAT/CNRST)	Burkina Faso	No	No	No	No	No
NGO	SOS SAHEL International	Burkina Faso, Mali, Niger, Djibouti, Kenya	No	No	No	No	No
Government Entity	AGENCE POUR L'ENERGIE DOMESTIQUE ET L'ENVIRONNEMENT	Chad	No	No	No	No	No
Multilateral Organization	ENVODEV	Chad, Central Africa Republic	No	No	No	No	No
NGO	Association Lead Tchad	Chad	No	No	No	No	No
Government Entity	Mali-Foklecenter Nyetaa (MFC)	Mali	No	No	No	No	No
NGO	Africa diamond business	Mali	No	No	Yes	No	No
NGO	Association des femmes ingénieurs du Mali	Mali	No	No	No	No	No
NGO	Association GreenCom	Rwanda, Sao Tome and Principe, Senegal, Seychelles, Sierra Leone, South Africa, South Sudan, Sudan, Togo, Zambia, Zimbabwe	No	No	Yes	No	No
NGO	Global Institute for Women's Empowerment Group (GIWE GROUP)	Mali	No	No	No	No	No

Table 2-30 Initiatives

Initiative Name	Feature	Launch - End	ICS Only?	Goal/Target	Value/Funding Commitment	Reach	Funders
Africa Clean Cooking Energy Solutions (ACCES) Distribution Challenge Fund (DCF) Competition	Technical Assistance, Capacity Building, Special Finance, Funding, Policy, RBF	2015	No	Promote enterprise-based, large-scale dissemination and adoption of clean cooking solutions in Sub-Saharan Africa to alleviate the	Example: $2.2 million for Uganda: DCF	N/A	World Bank

123 Access to Modern Energy Cooking Services Players and Initiatives Database, World Bank, November 2019. https://energydata.info/cooking/initiativesandplayersdatabase

Initiative Name	Feature	Launch - End	ICS Only?	Goal/Target	Value/Funding Commitment	Reach	Funders
				adverse health, environment, and socio-economic impacts of traditional cooking practices in SSA			
Safe Cooking Energy Programme	Capacity Building	2013-2016	Yes	Extend the benefits of safe cooking energy to half a million households and small businesses	N/A	N/A	USAID

Methodological Note: Calculating the Cost of Inaction[124]

The cost-of-inaction estimates presented in this note rely on three separate calculations, all seeking to unitize the annual dollar value of sustaining the status quo (i.e., continuing to cook with the latest available global fuel mix). These estimates cover health (the costs of morbidity and mortality), gender (the costs of fuel collection, cooking, and stove cleaning), and climate (the social cost of carbon).

Health

The health calculation understands the cost of morbidity as the cost of one year of life lost to disability, including work absenteeism and medical treatment, resulting from household air pollution (HAP) and the cost of mortality as the cost of a life lost due to HAP. The calculation for health costs follows a top-down methodology. It takes estimates for deaths and disability-adjusted life years (DALYs) due to HAP.[125] It then multiplies each country-specific value by a country-specific gross domestic product (GDP) per capita expressed in PPP terms. Finally, this value is multiplied by a cost multiple specific to DALYs or deaths: DALYs are estimated at 5 times GDP per capita, while the cost of mortality or the cost of one death due to HAP is estimated at 70 times GDP per capita.[126]

Gender

The gender calculation, as well as the climate calculation below, follows a bottom-up approach. A factor multiple for time spent on fuel collection, cooking, and stove cleaning is applied to each country's primary-fuel proportion, using fuel-mix data; each factor multiple varies by primary fuel and all add up to a number of hours per year. This value is then multiplied by the cost of a woman's time, which is set at a conservative estimate of US$0.54 per hour.[127]

124 Energy Sector Management Assistance Program (ESMAP). 2020. The State of Access to Modern Energy Cooking Services. Washington, DC: World Bank.

125 The top-down calculation uses the estimates of the Health Effects Institute (HEI 2019), with data from the Institute for Health Metrics and Evaluation (IHME)-coordinated Global Burden of Disease (GBD) study 2017 (HEI Household Air Pollution Working Group 2018).

126 The cost multiples are aligned with those described in the World Bank's methodology for DALYs and deaths (Enriquez, Larsen, and Sánchez-Triana 2018).

127 The World Bank/Dalberg Results-Based Financing (RBF) Model is used for time multiples and the Dalberg Impact Model for cost multiples.

Climate

The climate calculation relies on the application of a fixed carbon cost to a global estimate of the carbon footprint of the current global cooking-fuel mix. The social cost of carbon, also described as the "present value of all future damages to the global society of one additional metric ton of carbon dioxide (CO_2)–equivalent greenhouse gasses emitted today", is set at US$45.92 (Howard and Sylvan).[128] This cost value is sourced from the United States Government Interagency Working Group and the New York University (NYU) School of Law. This cost value is then multiplied by a volume value—an estimate of the carbon footprint of the current global cooking-fuel mix (tons of CO_2 per year)—which is calculated using a bottom-up analysis: Each country's proportion of cooking fuel is multiplied by a factor-specific multiple to understand the tons of CO_2 per year resulting from yearly fuel usage (in kilograms), the total Kyoto emissions rate with fraction of non-renewable biomass (fNRB), total CO_2 emissions for production, and total black carbon (BC) emissions. When added together, these values produce a total estimate of emitted CO_2.[129]

Methodological Note: Calculating the Transition Costs[130]

The transition cost is a combination of costs associated with transitioning the population/households to Modern Energy Cooking Services (MECS) and Improved Cooking Services (ICS). Under the MECS Scenario, the global population accesses the Tier 4 (or higher) level of the Multi-Tier Framework (MTF) for cooking, while under the alternative Improved Cooking Scenario, it transitions from below Tier 2 access to at least universal Tier 2 access.

Data Sources

A wide range of data sources were used for this modeling exercise. They included in-depth data on modern energy use from the World Bank's Multi-Tier Framework (MTF) household surveys in six "archetype" countries (Cambodia, Myanmar, Nepal, Nigeria, Rwanda, and Zambia). Global fuel-mix data was compiled from Demographic and Health Surveys (DHSs), Multi-Indicator Cluster Surveys (MICSs), and national energy censuses. The report used the World Bank's country-level historical data for gross national income (GNI) per capita (1960–2018) and electricity access (1960–2017). Additional World Bank data sources included its List of Economies, covering country-level information on income group and country lending category (IDA/IBRD/Blend); Energy Consumption, covering per-country household-level information on annual energy-use expenditure; and Population, covering historical and projected country-level information (1960–2030) by total, urban, and rural populations. For household size and composition data, the report used United Nations historical and current country-level data.

MECS Transition Scenario

Modeling the cost of the MECS transition for each of the 71 countries involves three broad steps:

- Step 1. Sizing the number of households to transition to MECS by 2030. The population is first converted into households using the average household size for the selected country. Sizing takes

128 US$37 (2007 value) adjusted for inflation to 2019 value; sourced from Howard and Sylvan (2015).

129 Factor multiples are sourced from the World Bank/Dalberg RBF Model.

130 World Bank Clean Cooking Planning Tool (CCPT), 2022.

into account the user input (in percentage), which cannot be smaller than the 2030 Business-As-Usual (BAU) case. Depending on the user input in the MECS (percentage) slider, current ICS and traditional households transition to MECS. This step applies to both urban and rural households.

- Step 2. Assigning a fuel-mix transition pathway through which the selected country aims to achieve MECS access by 2030.

- Step 3. Applying a set of costs to transition. Following the selected fuel-mix pathway (Step 2), the transition cost figure is determined by multiplying the number of households (Step 1) by the weighted cost to transition.

  A bottom-up cost of transition per household is determined for each fuel (LPG/LNG, electricity, ethanol, pellet gas, and biogas). The cost estimates vary by household tier in 2020, locality (urban or rural), and income group (low, lower middle, and upper middle). The transition costs consist of those for a double-burner cooking setup (either two single-burner stoves or one double-burner stove), fuel, downstream infrastructure, and behavior change. The values for fuel consumed vary by urban and rural contexts and reflect unitized caloric values per person, validated through expert interviews. Fuel prices reflect market values as of January 2020, and stove prices reflect retail (unsubsidized) prices. Both fuel and stove prices for each transition include benchmarks, from which an average is taken.

ICS Transition Scenario

Modeling the ICS transition cost follows the logic of the MECS scenario but is applied to fewer population segments since the eligible proportion for transitioning to ICS is affected by the 2030 BAU case and the MECS (percentage) input. Only populations that currently have traditional access can transition to ICS. Once the households transitioning to ICS are sized, that number is multiplied by the corresponding set of cost to transition to obtain the total cost of the ICS transition. Adding the ICS transition cost to the MECS transition cost yields the total transition cost.

The ICS transition assumes displacement of traditional cooking by providing households a double-burner cooking setup. It assumes no fuel switch (i.e., households would continue to cook with such fuels as wood and other biomass) and no downstream infrastructure costs.

Disaggregated Costs

The MECS transition costs are disaggregated into public-sector, private-sector, and household costs for the urban and rural split. Public-sector cost means that government and development-partner contributions cover the affordability gap to help ensure households' adoption and continued use of MECS. Private-sector cost refers to private-sector contributions from investment in downstream infrastructure. It is expected that private-sector investment in stoves and fuels is fully reflected in the unit prices paid by consumers and thus is not included in the private-sector cost. Household cost refers to households' contribution to paying for the cost of stoves and fuels.

The ICS transition costs are disaggregated into public-sector and household costs for the corresponding urban and rural split. Since the ICS transition assumes no fuel switch and no downstream infrastructure costs, the ICS transition has no private-sector cost.

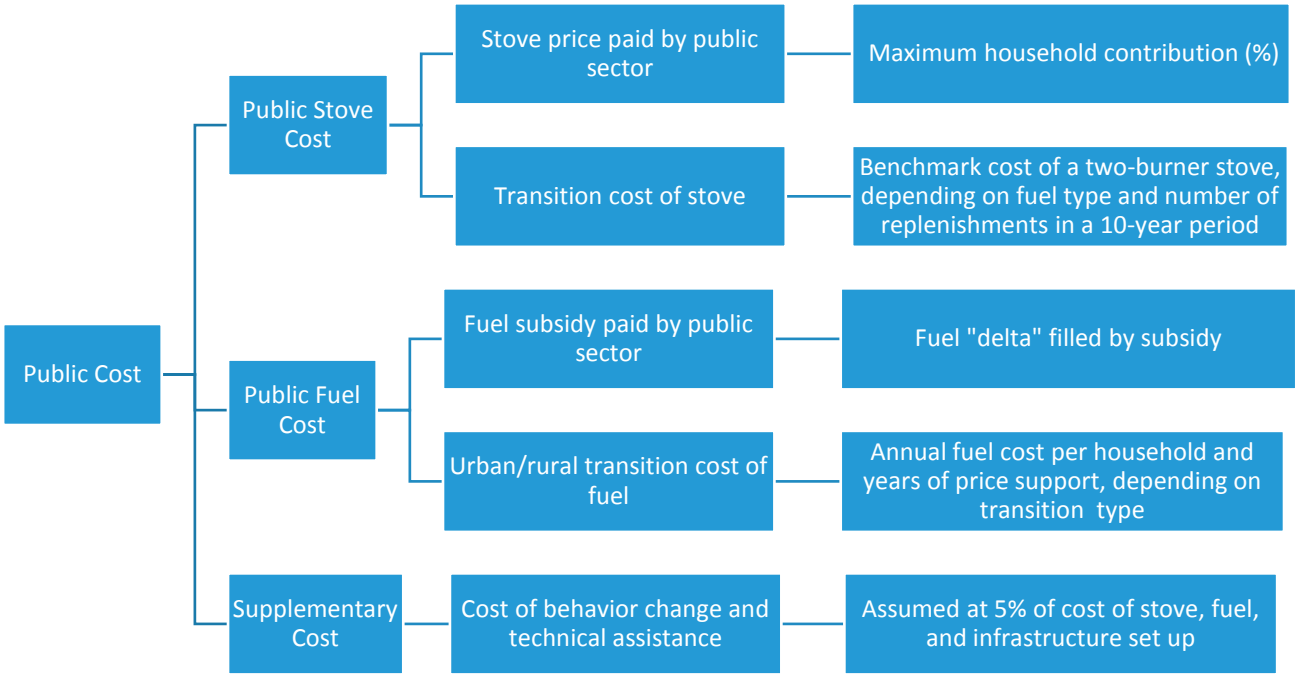
Thus, the CCPT displays the disaggregated costs as follows: public urban MECS, public rural MECS, private urban MECS, private rural MECS, households urban MECS, households rural MECS, public urban ICS, public rural ICS, households urban ICS, and households rural ICS.

Public Sector

A three-step process is used to calculate the public-sector cost. Estimating the number of urban and rural households to transition (Step 1) and assigning a transition pathway (Step 2) follow the same logic as described above for the cost of transition. Calculating the public cost (Step 3) combines three broad cost categories: the stove, fuel, and supplementary cost (Figure 2-36). These costs vary, depending on the urban and rural split.

A two-burner stove is considered as the benchmark in this analysis. The cost borne by the public sector on a per household basis is estimated using the product of (i) the price of the stove paid by the public sector to fill the affordability gap and incentivize adoption and (ii) the number of stove replacements (determined by the transition tier). The fuel "delta" is the difference between the annual fuel cost per household and the maximum household fuel contribution (capped at 5 percent of the household's monthly income). The product of the fuel "delta" filled by the public subsidy and the transition cost of the fuel yields the fuel cost. Finally, the supplementary cost is the share of overall program costs allocated to behavior change and technical assistance, which is assumed at 5 percent (Figure 2-37).

Figure 2-36 Public Sector Cost Categories



Private Sector

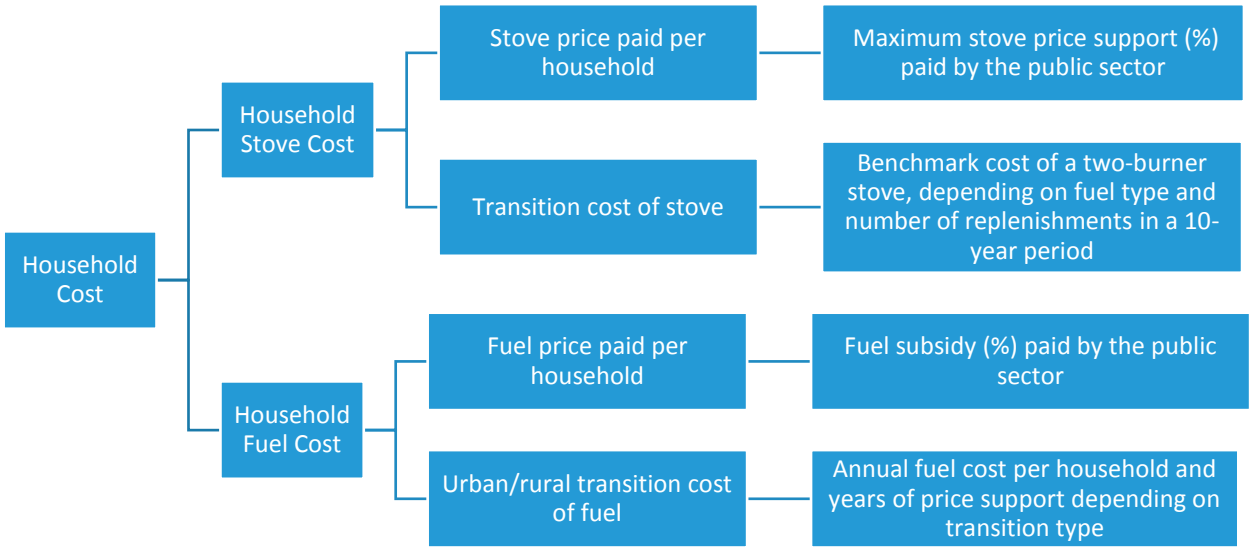
The private-sector cost is estimated using the cost of marginal distribution of infrastructure per household, which includes the cost of setting up the downstream distribution infrastructure, storage, and transport. In the case of such fuels as LPG, ethanol, biomass pellets, and biogas, this value is calculated from the

benchmark capital expenditure for plant setup on a per household basis. In the case of electricity, it is the cost of a one-time circuit and meter installation.[131]

Households

A three-step process is used to calculate the household cost of transition. Sizing the number of urban and rural households to transition (Step 1) and assigning a transition pathway (Step 2) are the same as those described above for the cost of transition. Calculating the household cost (Step 3) requires adding the stove and fuel costs borne by the household (Figure 2-37). The share of the household contribution is determined by the transition stove technology and fuel combination, the income group for the country, and the tier level of the household in 2020. These costs vary depending on the urban and rural split.

Figure 2-37 Household Cost Categories



The public-sector, private-sector, and household costs are added together to obtain the total transition cost.

Methodological Note: Calculating the Benefits of Transition[132]

The co-benefits estimates rely on three separate calculations. These estimates cover health, gender and climate benefits depending on the number of households that transition to MECS and ICS.

Health

The health benefits of transition calculation rely on a top-down methodology. It takes estimates for averted deaths (aDeaths) and averted disability adjusted life years (aDALY's) due to Household air pollution (HAP)

131 ESMAP (Energy Sector Management Assistance Program). 2020. The State of Access to Modern Energy Cooking Services. Washington, DC: World Bank.

132 World Bank Clean Cooking Planning Tool (CCPT), 2022

using the HAPIT tool.[133] It then multiplies this value by each country's GDP/capita expressed in PPP terms. Finally, this value is multiplied by a cost multiple specific to aDeaths and aDALY's. aDeaths are estimated at 70 times the GDP per capita and aDALY's at 5 times the GDP per capita. The HAPIT tool is used to calculate the aDeaths and aDALY's and provide a good enough evidence (not research quality evidence) based on best available health effects information linked to household air pollution.

Gender

The gender benefits of transition calculation uses a bottom-up process. Depending on the type of transition such as Traditional to MECS, ICS to MECS and Traditional to ICS, the amount of time saved in fuel collection, cooking time and cleaning time is calculated on an annual basis.[134] This is then multiplied by each country's corresponding households that transition to MECS and ICS which is further multiplied by the cost of a woman's time which is set at a conservative estimate of US$0.54 as described in the cost of inaction section.

Climate

Climate co-benefits are calculated using a bottom-up approach similar to the gender benefits of transition calculation. The social cost of carbon is multiplied by a volume value - an estimate of the carbon emissions reduction obtained in transitioning from traditional to ICS and MECS technology, which is further multiplied by the corresponding number of households that transition. This volume value of carbon emissions reduction in tons of CO_2 are obtained using each fuel type yearly fuel usage in kg, the total Kyoto emissions rate with fraction of non-renewable biomass (fNRB), the total CO_2 emissions for production, and total black carbon (BC) emissions.

2.1.9 Land restoration and clean cooking analysis[135]

Fuelwood harvest causes deforestation and land degradation, and its use for indoor cooking causes respiratory illness, which in turn leads to reductions in labor productivity and increases in health care expenditures. In the G5 Sahel, there is very limited access to clean cooking, at 10% of the population in Burkina Faso, and less than 5% of the population in Chad, Mali, and Niger. Mauritania has higher access at 43% of the population, but still has considerable room for improvement.[136] In this analysis, we consider two scenarios of future forest harvest and clean cooking access in the G5 Sahel countries between 2021 and 2050:[137]

- **BAU**: the percentage of the population accessing non-clean fuels for cooking remains almost constant over the time horizon, such that the absolute number of people without clean cooking

133 Pillarisetti, A; Mehta, S; Smith, KR. HAPIT, the Household Air Pollution Intervention Tool, to evaluate the health benefits and cost-effectiveness of clean cooking interventions. Ch 10 in Thomas, E., Ed, Broken Pumps and Promises: Incentivizing Impact in Environmental Health, Springer International Press, 2016, pp. 147-169

134 Factor multiples are sourced from the World Bank/Dalberg RBF Model.

135 This note is based on preliminary data.

136 Data from database: World Development Indicators

137 Population estimates and projections for the period 2021-2050 are from the World Bank.

access increases with population growth.[138] Land degradation is assumed to continue at the historically observed rate.

- **Aspirational Growth:** Follows the NDCs and National 2030 targets for land use change and shifts to improved stoves. These target universal urban access to clean fuels for all five Sahelian countries, with Mali aiming to achieve universal access for both urban and rural populations. Rural access targets for Mali, Burkina Faso, Chad, Mauritania, and Niger are 100%, 65%, 77%, 50%, and 30%, respectively.[139] We assume these targets are reached in 2030, and remain constant through 2050.[140] Under this scenario, we also assume that deforestation will stop by 2030, and that 2030 land rehabilitation targets will be achieved through a combination of newly planted forests, rehabilitation of existing degraded areas, and woodland/shrubland restoration. The transition is assumed to begin in 2021, the year that most of the national programs were drafted, and that investment support is completed by 2030 and maintained through 2050.

Methods

We consider the economic implications of fuelwood use and the associated land use changes separately. For fuelwood use in cooking, our analysis characterizes two categories of economic effects:

1. **Labor implications**. This has two components. First, women, who generally do the cooking and wood collection, spend considerable time collecting fuelwood that could otherwise be spent in the labor force.[141] Second, disability-adjusted life years (DALYs) and death caused by fuelwood cooking indoors also reduces available labor activity.[142] These effects are both monetized based on the Dalberg Impact Model and ILO statistics.[143]
2. **Health care expenditures**. Illnesses also have a health care expenditure impact that can be monetized.[144]

Taking the difference between total economic impacts under BAU and Aspirational growth provides the benefits of investment in improved stoves that require less or no fuelwood use. The annual investment costs in improved stoves to meet clean cooking targets are spread evenly over the 2021 to 2030 period, and then continue to be incurred through 2050 to accommodate population growth.[145]

138 World Bank Clean Cooking Planning Tool (CCPT, 2022)

139 Target clean cooking access is based on: Clean Energy Transition in the Sahel, IEA, September 2021; The Global LPG Partnership (2017); Chad Nationally Determined Contributions (2021-2030); SEforALL Africa Hub (2021), Mali Country Overview; SEforALL Network (2015), Niger Country Overview.

140 The "clean" fuel-mix is based on the national declaration (mainly focused on LPG utilization) or in alternative an equal share between LPG, Pellets, Biogas, Electricity, and Ethanol.

141 The amount of time saved in fuel collection, cooking time and cleaning time is calculated using factor multiples sourced from the World Bank/Dalberg RBF Model based on different types of stoves.

142 Deaths and DALYs due to Household Air Pollution (HAP) from the State of Global Air Report 2020, using GBD data from 2019, are used to estimate the incidence on population accessing fuelwood for cooking, values from: Health Effects Institute. 2020. State of Global Air 2020. Labour employment estimates from the International Labour Organization (ILO) are used to compute yearly hours of labour loss due to health impacts.

143 Lost time for women is set at a conservative estimate of US$0.54 per hour based on the Dalberg Impact Model, lost labour due to health effects is set at US$0.8 per hour based on ILO statistics.

144 Health expenditures are estimated at US$998 per DALY for all the Countries except for Mauritania (for medium HDI categories the value is set at US$6522), taken from: Daroudi, R., Akbari Sari, A., Nahvijou, A. et al. Cost per DALY averted in low, middle- and high-income countries: evidence from the global burden of disease study to estimate the cost-effectiveness thresholds. Cost Eff Resour Alloc 19, 7 (2021). https://doi.org/10.1186/s12962-021-00260-0

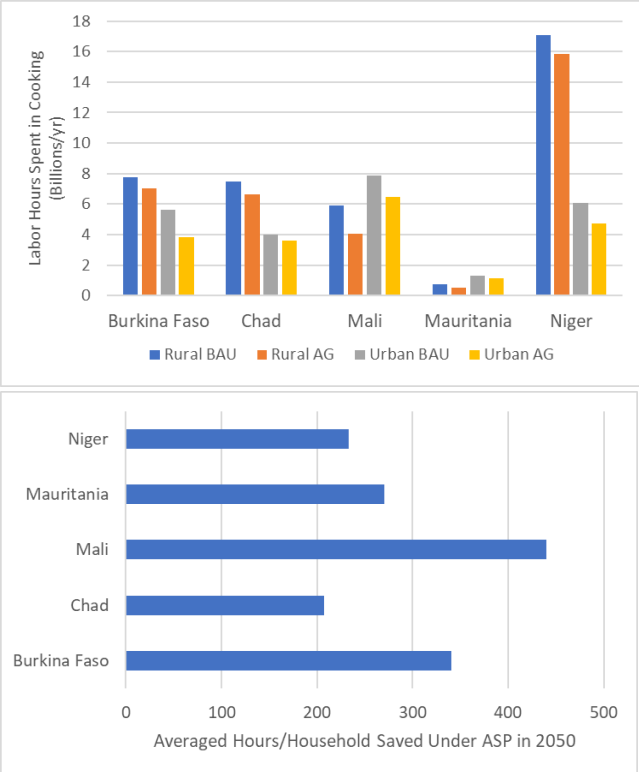
145 Estimates on the transition cost drawn from the World Bank Clean Cooking Planning Tool (CCPT, 2022) methods: Energy Sector Management Assistance Program. (2020). The state of access to modern energy cooking services. World Bank.

For land use changes, the benefits of land regeneration are based on the value of ecosystem services resulting from restoration of forests and woodland/shrubland areas.[146,147] Regeneration costs gradually increase until reaching the 2030 target and then maintenance costs remain constant until 2050.

Results

Under the BAU scenario, population growth drives an increase in the number of people accessing fuelwood, which causes higher health incidents related to household indoor air pollution, and economic loss due to reduced labor supply. These impacts have a disproportionate effect on women. The Aspirational Growth scenario, on the other hand, leads to avoided health expenditures and labor losses, and higher gender equity relative to BAU. In 2050, saved labor hours due to avoided illness range from 42 million for Mauritania to 630 million for Burkina Faso (0.5% and 1% of the total national labor force respectively), and the time saved every year by women with respect to the BAU clean cooking access ranges from 230 to 440 hours (Figure 2-38).

Figure 2-38 Hours spent in 2050 on cooking (left) and hours saved per household under the aspirational growth scenario (right)

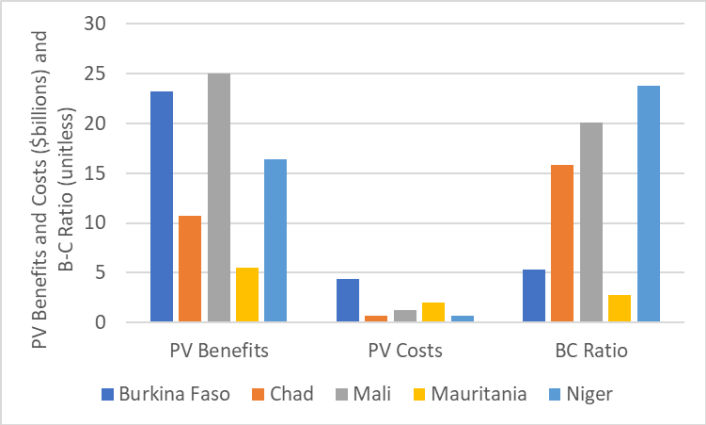


146 Niger values: the National Strategic Framework for SLM 2015-2029 and NDC 2030; Chad values: NDC 2030 and AFR100; Burkina Faso: NDC 2030; Mauritania: USGS, NDC 2030 and only assumed 1% increase in shrublands/woodlands. Mali: NDC 2030, LDN 2020 and only assumed 1% increase in shrublands/woodlands.

147 Both land regeneration benefits and costs are based on: Mirzabaev, A., Sacande, M., Motlagh, F., Shyrokaya, A., & Martucci, A. (2022). Economic efficiency and targeting of the African Great Green Wall. Nature Sustainability, 5(1), 17-25. For instance forest ecosystem service benefits range from $400 to $1800 per hectare per year depending on the age of the restored forest. The categories of ecosystem services include provisioning, regulating, habitat, and cultural.

Present value investment costs and program benefits over the 2023 to 2050 period (discounted at 3%) are reported for each country in Figure , along with the resulting Benefit-Cost (B-C) ratio. Benefits include monetized labor gains and health care expenditures saved. All B-C ratios are above one, ranging from 3 in Mauritania to 24 in Niger.

Figure 2-39 Present value benefits and costs of clean cooking investment program and b-c ratio, 2023-2050 (discount rate of 3%)



Under the BAU scenario, deforestation and land degradation continue increasing, such that by 2050, a total of 4 million hectares of forest and shrubland are lost. On the other hand, regeneration under the Aspirational Growth scenario leads to an increase of 2 million hectares of forests and shrublands by 2050, with and consequent enhanced ecological services. Figure 2-40 shows the comparison in share of total land cover that is forests in 2021 and under the two scenarios in 2050, while Figure 2-41 highlights the present value benefits and costs of the forest and shrubland regeneration program over the 2023 to 2050 period.

Figure 2-40 Forest cover as a percentage of total land area in 2021 and 2050 under the two scenarios

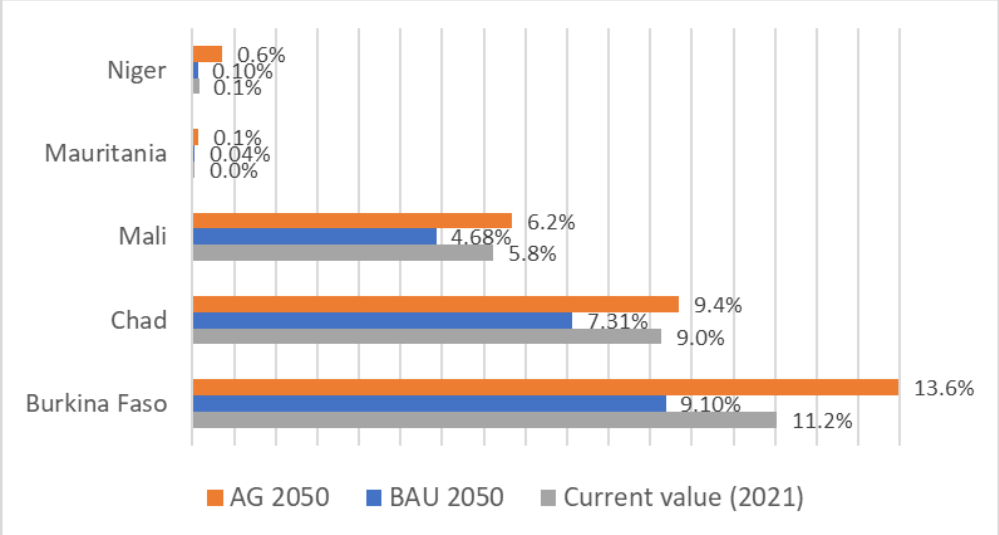
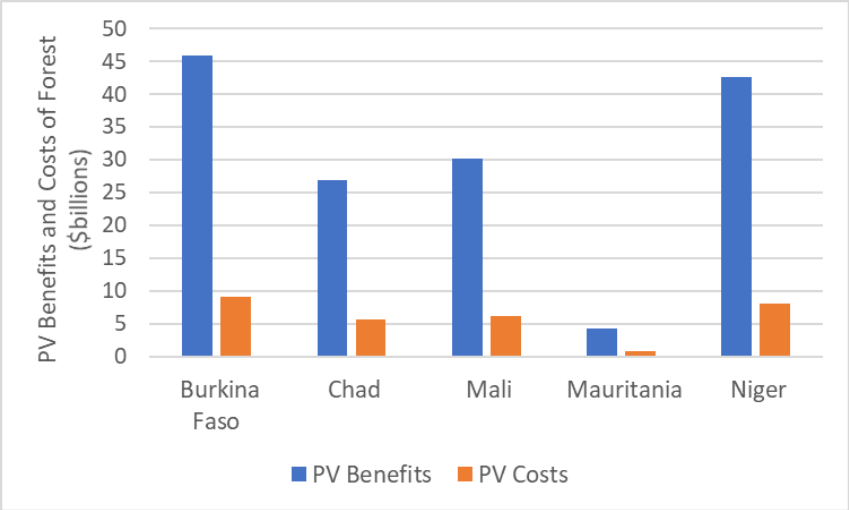


Figure 2-41 Present value benefits and costs of the land restoration program, 2023-2050 (discount rate of 3%)



2.1.10 Climate Smart Mining

While endowed with an abundant range of natural resources, including substantial mineral deposits, the Sahel is one of the poorest and most environmentally degraded regions in the world. To give but one example, Niger, despite its abundant extractive resources, is ranked 187/188 on the Human Development Index. The mining sector has been further complicated by conflicts with jihadist groups who are keen to take possession of precious metals, particularly gold, to help finance and support their campaigns. The competing needs for water and biodiversity to support livelihoods vs extractive industries and agricultural practices (particularly livestock) is also a recurring theme that compromises the area's overall sustainability.[148]

Not only is there little with regards to the promotion of sustainable mining practices, the region suffers from a lack of core good governance frameworks, making the prospects for developing an enduring sustainable, climate smart, approach to mining a significant challenge. That said, there may be some opportunities for the mining industry to take advantage of resource opportunities in the region that would work to supply the low carbon energy transition globally. These minerals and metals required to supply green technologies are referred to as climate action minerals.

None of these countries have included mining in their Nationally Determined Contributions (NDCs) and outside of gold (and uranium for Niger) little focus or effort has been devoted to exploring other minerals and metals potential in the export market, particularly for climate action minerals and metals. The exceptions are Mauritania with its history in developing iron ore and copper deposits and zinc for Burkina Faso.

With respect to governance, with the exception of Niger, all countries are members of EITI (Extractives Industry Transparency Initiative) and have to varying degrees local legislation which codifies mining

148 Cooper (2018). Natural Resources Management Strategies in the Sahel. Helpdesk Report. University of Birmingham. Available at: https://assets.publishing.service.gov.uk/media/5c6acc2340f0b61a196aa83a/453_Sahel_Natural_Resources_Management.pdf.

practices and revenues. What is lacking is a coherent approach that champions environmentally sustainable, equitable outcomes.

Climate Smart Mining (CSM) supports the sustainable **extraction, processing** and **recycling of minerals and metals** for low-carbon technologies and other critical sectors by creating shared value, **delivering social, economic and environmental benefits** throughout their value chain in developing and emerging economies.

The adoption of climate smart mining practices helps ensure that country's mineral resources are developed under higher sustainability standards and help them benefit from the growing demand for minerals and metals for the energy transition.

The adoption of a CSM approach can leverage some important opportunities from the mining sector namely, but not limited to:

- **Taxes and royalties**, critical to budgets of host country governments which, when well-managed, should deliver social and economic value.
- **Foreign exchange and international reserves**, which support macroeconomic stability and reduce risks resulting from exchange rate volatility or inflation.
- **Direct employment** and more significant **indirect job and growth multipliers**, driven by economic linkages, trade and FDI.
- **New local business opportunities** and **skills development**, through local content and training programs. Enhanced by "green jobs' for the energy transition.
- **Shared resilient infrastructure** (*e.g.*, power, rail, water, ports, roads) catalyzed through RE power-to-mine investments, and more resilient and "green" shared infrastructure.
- **Community Development and Climate Resilience**: climate risk mapping and mitigation for local communities; support to livelihoods through innovative waste management solutions, enhanced transparency on revenue sharing with local communities, etc.

2.1.10.1 Climate Action Minerals in the Sahel

A clear, but challenging, opportunity exists in the growth in demand for a range of minerals and metals in the region needed to supply low carbon technologies – climate action minerals. This would include deposits of bauxite, iron, copper, manganese, tin, tungsten, vanadium zinc, lead, silver and lithium.

While all G5 Sahel countries have at least some of the climate action minerals mentioned above, the best positioned would appear (we say appear since a geological update for the region is a key need) to be Mali (bauxite, iron, copper, manganese, tin, zinc, lead, and lithium) and Mauritania (iron, copper and silver). Mauritania also has in place a fairly mature mining industry in operation since the '60s. It also has a developed steel sector where there is some discussion about the possibility of transforming it into a niche "green steel producer". Niger is blessed with one of the largest deposits of uranium in the world (not included as a climate action mineral but technically a carbon free option in supplying the nuclear industry). Chad is mostly focused on oil and along with Burkina Faso, traces of climate action minerals have been discovered but the precise amounts and quality of these deposits has not been ascertained.

These operations will need to be developed with growing expectations on the part of governments, investors, consumers, and civil society that they be extracted and processed with ESG and climate considerations in mind. A climate smart, net zero, national strategy for the mining and processing

industries is a critical element in the G5's economic transition. Accomplishing this in circumstances of deep poverty, severe environmental degradation and weak governance systems makes for a significant challenge. The entire rationale of the Climate Smart Mining (CSM) approach is to help developing countries apply ESG and climate related policies and practices in their operations, so that they do not get marginalized in the global competition for building clean energy technologies and infrastructure.

Enablers for development of climate action minerals in G5 Sahel:
The first step in developing a viable economic activity in this promising area lies in working with G5 Sahel governments in developing and implementing policies and measures that help them build a long-term sustainable opportunity in this burgeoning field. The new demand for these set of minerals creates an opportunity for mineral-rich countries to develop new mining value chains that are from the start designed to be climate resilient and contribute to climate mitigation, making them more sustainable and internationally competitive. In practical terms, this can mean using renewable energy and enhancing energy efficiency, and/or explore opportunities to sequester carbon, whether through natural based solutions or technology capture options. Resilience activities would cover ways in which operations could best adapt to address from climate related impacts in a manner that complements the needs of local communities, for example, developing water access practices which also work to the benefit of local communities. Areas of focus to enable these opportunities include:

- Legal frameworks will need to be updated for mining laws and codes to account for developing the 'building blocks' of climate smart mining, covering mitigating GHG emissions, building resilience to climate, contributing to a circular economy approach and taking advantage of market opportunities.

- Capacity building in improving geological information on climate action minerals in the region and converting known deposits into workable reserves will be a key initial priority. The challenge is that the vast share of these resources are only found as deposits (vs formal reserves) and there are also many areas that are in need of geological updates. Considerable effort will be required to update geological information and developing these resource sites into formal reserves where mining companies can begin to operationalize their mining activities.

- Enhancing access to finance and markets by attracting significant additional private equity. Investors will have to be persuaded those investments will be secured in an environment of good governance, growing local capacities and a commitment to net zero impacts on climate and biodiversity in its operations. In that respect, these countries could also potentially be anchors for new emerging sectors such as hydrogen (H2), by providing a reliable demand for H2 (transport (trucks/trains) and/or heat) in their activities. As noted above, there is also already talk/analysis of Mauritania becoming a "green steel" producer. Long term financing is always an issue for this sector – plans must be made for investments that last 50 plus years. In the case of the G5 Sahel, some 'blue sky' thinking on the availability and accessibility to financing these sorts of ventures through innovative mechanisms such as green bonds and the carbon market would be incumbent for such a transition to occur in the Sahel region.

- Building Infrastructure and jobs in developing these projects will require significant support to build up infrastructure, such as roads, railways, ports, that meet the sector demands while being consistent with climate, environmental and social goals. Support to local communities is also critical. Where it has been successfully developed, mining has been known to provide a 'multiplier' effect greatly enhancing overall employment for relevant regions. It is incumbent for this to be done with the close consultation and participation of local communities. There are also growing opportunities for women in this sector – to give but one example, there is a preference amongst many companies

for women to operate heavy machinery as they are typically more safety conscious and cause less damage to expensive equipment.

2.1.10.2 Artisanal Gold Mining in the Sahel

Gold has been mined for centuries by artisanal methods in the Sahel, representing a source of income and livelihood for millions of people in the region, especially for young people. Revenues from artisanal and small-scale mining (ASM) have created employment and economic opportunities, often as a complement to agricultural income that is increasingly dependent on climatic and environmental hazards.

ASM gold production in Burkina Faso, Mali and Niger is estimated to be in excess of 50 tons/year. At today's gold price (US$ 2,000 ounce), this represents around US$ 3.5 billion per year, most of it exported illegally to Dubai. Although there are no accurate statistics on the number of ASM miners in the Sahel countries, the sector is the second largest provider of jobs after agriculture. According to recent estimates, more than 2 million persons are directly involved in artisanal gold mining in Burkina Faso, Mali, and Niger, with about 6 million people more indirectly dependent on the activity.

However, ASM also has a significant negative impact on the environment derived from factors such as: (i) uncontrolled pollution and contamination of surface and groundwater by chemicals (mercury and cyanide); (ii) degradation of soil, crops and farmland; (iii) deforestation caused by unsustainable demand for wood used in ASM pits and infrastructure; (iv) regression of nature and wildlife; and (v) the lack of site rehabilitation. In the Sahel, these impacts are aggravated by threats posed by prolonged conflicts, migration, human trafficking, food insecurity, the high frequency of climate shocks, such as extreme weather events, heat stress, drought, and overall vulnerability to climate change. Increasing resilience requires regionally coordinated multi-sectoral approaches based on improved understanding of environmental, social, health, cultural, gender, and economic issues.

Enablers of gold ASM resilience to climate change:

- Legal frameworks that provide security of tenure, bolstering artisanal miners' precarious legal status. Regulations for the allocation of land for use in mining activities reducing the level of intra-community conflicts and tensions between ASM and largescale mining.
- Capacity building for all levels of government, artisanal miners and affected communities for the organization of ASM, enforcement of legal requirements, enhancement of environmental protection rules and HSE standards and practices.
- Access to finance and markets through transparent trade channels to reduce artisanal miners' financial and commercial dependence on intermediaries. Fraud and tax evasion in the production, transport and trade of gold are rampant, as it serves as a legal parallel currency that can be used outside the country.
- Adequate and harmonized taxation. High taxes to generate revenue from ASM are counterproductive, especially in conflict-affected areas. Harmonization of fiscal regimes among countries in the Sahel is crucial as large differences in taxation among different countries are a key factor encouraging smuggling and tax evasion.

Following is a country breakdown of relevant climate action mineral capacity in the countries of the Sahel.

Mali

Gold is Mali's leading extractive industry, representing 95% of its mineral production. However, it is also blessed with a range of climate action minerals and metals, including bauxite, iron, copper, manganese, tin, zinc, lead, and lithium. The precise amounts and reserves of these commodities is not known with little extraction or development having taken place up.[149]

Niger

Niger is the world's fourth largest producer of uranium and exported over EUR 348 million in 2010, equivalent to twice the total development assistance it received in the same year Other climate action minerals and metals in its territory (but largely unexploited) includes iron ore, lead, zinc and tin.[150]

Chad

Chad's predominant export resource is oil. It is also blessed with a range of climate action minerals and metals, nearly all of which have yet to be developed in any way. Relevant climate action minerals and metals in its territory includes silver, bauxite, tin, tungsten and uranium but precise numbers on the potential are seriously lacking.[151]

Burkina Faso

The main mineral resource being exploited in BF is gold, but it also contains a range of climate action minerals and metals that includes zinc, copper, and manganese, Traces of bauxite, nickel and vanadium have also been recorded in various geological formations. Zinc is being developed and is a growing export for the country while the others mentioned above are for the most underreported and not undeveloped.[152]

Mauritania

Mauritania has vast mineral wealth including iron, copper and silver which it has been exploiting since the 1960s (Antil, 2014, p. 16) and is an integral part of the Mauritanian economy. Compared to the other members of the Sahel, it probably is the most developed economy with respect to mining capacity.[153]

149 https://www.arcgis.com/home/item.html?id=1b9f3eab1fcf43f8b73bf2ec62eea025

150 (https://www.legit.ng/1161400-list-natural-resources-nigeria-locations.html)

151 https://www.trade.gov/country-commercial-guides/chad-mining-and-precious-metals

152 https://eiti.org/burkina-faso

153 https://eiti.org/mauritania

2.1.11 Climate-related Risks and Urbanization Trends in G5 Sahel Countries

Droughts constitute a major driver of climate-related risk and hampers developments prospects in G5 Sahel countries. Due to the combined effect of high exposure154 to rainfall variability and structural weakness155, drought exacerbates food insecurity in rural areas and could cause GDP growth losses. EM-DAT figures report on average 2% of the 2020 G5 Sahel countries population affected each year by a drought event. Beyond humanitarian impacts, food insecurity variations in rural areas are largely driven by the quality of the rainy season: in Mauritania this impact has been quantified and reveals that when the rainy season is one SD below mean weather conditions, food consumption scores are reduced by 3.5 points on average. The aggregated growth rate of GDP/cap is also adversely affected by drought: fixed-effect econometric analysis evidenced how the mean drought event over 1981-2018 lowered GDP per capita growth rate by -1.5 to -1.8 percentage points (p.p.). Interestingly, even if rain deficits have been reduced during the last 20 years, the increase in mean temperature that the Sahel is already experiencing seems to be driving drought intensity higher through an exacerbated evapotranspiration effect.

This drought impact is more acute in rural areas, potentially multiplying existing threats to G5 Sahel countries. In rural areas, agriculture dependence coincides with high poverty and deficiency of public services and infrastructure, creating a situation where drought-related shocks can generate a complex set of interactions with situations of political instability, ethnic violence or transnational conflicts. When synchronized, these multiple shocks can feed-off each other to create a vicious circle, further worsening their development impacts. In these settings, rural migrations might appear as one of the only options left to improve living standards of the poorest population.

The G5 is mainly a rural region, although under fast population growth, G5 urban population has soared from 11.7M in 1990 to 28.9M in 2015 (+145%). Urban population is still less than 35% of total population in 3 out of the G5 Sahel countries**.** So far, urbanization in G5 has not been accompanied by the increase in productivity levels observed in other regions and a wide range of factors have been identified in existing WB reports (see *2019 Country Economic Memorandum for* Mauritania, *From rural towns to cities for* South MRT, *The missing link* for other 4 countries or the upcoming Territorial Development Tool analysis). Further in-depth assessments are beyond the scope of the proposed analysis -and probably redundant-, which rather focuses on highlighting distinctive urbanization patterns in G5 that can help understating why urbanization do not allow to fully leverage agglomeration economies.

Urbanization in G5 Sahel is still incipient and characterized by a rapid concentration of people in a few large cities, lacking enabling conditions to spur agglomeration economies. Population growth has been faster in larger cities than intermediate ones, resulting in a situation where the 8 largest cities concentrate almost 40% of the urban population in 2015. More than half of the cities still display population levels below 100,000 inhabitants and are not sufficiently large to create market potential or generate economies of scale. In addition, in most G5 cities, built-up areas have been increasing at a slower speed than population, suggesting that new dwellers are settling in poor-quality settlements and concrete urban infrastructure expansion has been limited. Likewise, population has been growing faster than density in

154 Mainly understood as the heavy reliance on the agricultural sector both in terms of output and employment (on average 31% and 58% respectively in 2019)

155 As reflected per the G5 performance across the RISE indicators but also factors such as the lowest percentage of agricultural area equipped for irrigation in the world.

almost all cities[156], fostering urban spatial expansion of cities and prompting an almost duplication of the built-up area since 1985.

Access to basic urban infrastructure is improving, though urban population growth and country-specific challenges remain. Urban access to electricity has increased over the last two decades for every G5 Sahel country except Niger, where it declined to 49% in 2019 from 63% in 2010. Mali and Mauritania have the highest levels of access, at 91% and 86% respectively in 2019, above the Sub-Saharan African rate of 75%, while Chad lags far behind with only 37% of urban residents with access to electricity as of 2019.[157] Growth in access to improved drinking water and sanitation mirrors that of the Sub-Saharan African region. Urban residents with at least basic access to an improved source of drinking water rose from 79% to 86% between 2000 and 2020. This closely mirrors Sub-Saharan Africa as a whole, which rose from 76% to 87%. Urban residents with limited access to improved drinking water increased from 7% to 10% between 2000 and 2020, unlike sub-Saharan Africa as a whole, where those with only limited access declined from 9% to 7%. The percentage of urban residents with access to improved sanitation increased from 33% in 2000 to 51% in 2020, lagging Sub-Saharan Africa, where access to improved sanitation increased from 67% to 78%. However, due to population growth, urban residents without access to improved sanitation also increased, from 2.76 million to 2.89 million.[158]

Urbanization trends are already exacerbating urban flood risk in the region. The spatial expansion of cities has not been guided by sound urban planning or risk-informed land-use planning. The growth rate of new built-up land in high flood risk areas has remained constant in recent years, resulting in a steady increase in the total built-up land exposed to flood risk in between 1985 and 2015. Parallel to this, the share of population in flood-prone areas between 2005 and 2020 has duplicated. This increase in exposure to floods combine with deficient provision of basic infrastructure services (e.g., drainage system) further worsen potential economic losses and services interruption associated to floods. Extreme rainfall events already negatively impact local economic activity at the city-level as an analysis of Night-Time Lights (NTL) between 2012-2021 reveals.

Climate change has already altered G5 climate and an additional increase in mean temperature is projected, while changes to rainfall patterns are more uncertain. The mean temperature in G5 during the period 1991-2020 is 0.6 degrees above the mean during 1961-1990. Changes to mean precipitation between these two periods are less clear and not statistically significant. However, changes to extreme values of the precipitation distribution suggest more frequent extreme rainfall and less pronounced rain deficits. Climate projection from the IPCC AR6 point out to similar evolution in the future: under the RCP8.6, temperature over the G5 could be 4^{o}C higher than the 1961-1990 mean during the second half of the century, while change in precipitation are less clear.

This changing climate will further intensify climate-related risk in both rural and urban areas. Higher mean temperature will increase water needs of crops and vegetation, intensifying evapotranspiration and, eventually, for a given level of rain deficit, will exacerbate the drought impacts detailed above. These

156 Density levels at the city-level seem to be in line with regional standards although further analysis will be required on this.

157 World Bank Global Electrification Database from "Tracking SDG 7: The Energy Progress Report" led jointly by the custodian agencies: the International Energy Agency (IEA), the International Renewable Energy Agency (IRENA), the United Nations Statistics Division (UNSD), the World Bank and the World Health Organization (WHO). https://data.worldbank.org/indicator/EG.ELC.ACCS.UR.ZS?locations=ZG-BF-TD-NE-ML-MR

158 WHO/UNICEF JMP. Accessed 26 October 2021. https://washdata.org

impacts, mainly rural, could further fuel rural-urban migration. In any case, cities will continue expanding, with growth rates of built-up areas projected to peak around 2030 under various SSP scenarios. Although changes to precipitation patterns are not clear, flood-related losses will increase because of higher exposure, compound existing urban challenges. Sea level rise is also expected to threaten the future development of coastal cities in Mauritania: the value of buildings in areas affected by sea-level rise could be multiplied by 3 in 2100. Eventually, exploiting the historic variations of climate, the relationship between temperature deviations and GDP/capita growth rate has been quantified and evidence that, based on the mean temperature of the last five years, an increase of 1°C reduces G5 Sahel GDP/cap by -1.7%. Projections under a scenario where adaptation process are absent estimate that losses will be approx. twice as high under RCP8.6 VS RCP2.6, underscoring the decisive impact of global mitigation efforts for climate-related losses in G5 Sahel.

Preliminary policy options (to be further developed and aligned with other sectors and Urban/Land/DRM inputs)

- Improve the understanding of drought and flood risk to optimize risk reduction strategies, enhance food security actions and develop adaptative social protection systems (cf SPJ GP).
- Enforce risk-informed urban planning and appropriate land use regulation to guide climate resilient investments into housing and infrastructure at the city-level.
- Enhance early warning systems, preparedness as well as post-disaster response to limit the impacts of climate-related shocks.
- Develop resilient agriculture practices (cf Agriculture GP).

2.2 Cross-Cutting Supplemental Notes

2.2.1 Growth and Jobs Policy Agenda in the Sahel

With a young and rapidly growing population and workforce, the G5 Sahel economies have not been able to invest enough in human capital to match demographic growth. As a result, few jobs offer decent incomes and a high proportion of the young are unemployed, which in turn contributes to further fragility.

Other key constraints to more and better job creation in the Sahel are the lack of economic diversification and structural transformation and a difficult business environment. Highlights of policy recommendations from recent economic analyses (country SCDs, CEMs, CPSDs) are presented below.

In Burkina Faso, higher investment from the private sector is essential to support growth. The 2019 CPSD estimated that 300,000 additional jobs need to be created annually to absorb the growing youth population. Jobs can be created by: (i) alleviating critical enabling sector bottlenecks, including through private sector solutions in energy, transport and logistics, and professional skills; (ii) diversifying agriculture beyond cotton to cereals, fruits and nuts, oilseed crops, livestock, and others that offer comparative advantages; (iii) leveraging the catalytic sectors to stimulate agriculture and develop the critical enabling sectors – ICT applications and mining value chains; and (iv) striving toward greater regional integration.

As depicted in the forthcoming Chad Country Private Sector Diagnostic (CPSD), Chad is suffering from the confluence of three challenges: weak political and economic governance as a result of elite capture, endemic fragility, and extreme exposure to climate change. these conditions led to failure to harness significant oil resources since 2000—in spite of relative internal stability—and perpetuated the country's

status as the poorest performer on the human development index—particularly women and girls—while making only limited progress on poverty reduction. Chad also remains the least electrified country in the world. The situation has further deteriorated as a result of COVID-19 which struck as the country appeared to be on the verge of a rebound – with GDP contracting by 1.6 percent in 2020 (4.6 percent per capita), following a 3.2 percent expansion in 2019. Chad, as a result of the dual effect of the persistent COVID-19 pandemic and the sharp collapse of oil prices in 2020, finds itself with very limited fiscal, monetary and financial buffers. Hence the need to unleash the potential for greater private investment in sectors that can drive structural transformation, notably in livestock, sesame seed and gum Arabic as well as cotton production – the historic cash crop. This can be done by addressing sector-specific and cross-cutting constraints that hinder growth in the chosen value chains, such as (i) strengthening traceability, quality grading and certification for exports; (ii) improving access to critical infrastructure, such as electricity (with off-grid/mini-grids offering solutions for rural electrification), transport and logistics (in particular along the N'Djamena Douala Corridor), water and irrigation, as well as digital services; (iii) deploying digital finance and other risk mitigation instruments for SME lending; and (iv) improving the general investment climate with a focus on streamlining/digitizing land and tax administration. Developing a regulatory vision for private participation in the health and medical facility sector could also provide opportunities for the private sector to contribute to filling Chad's human capital gap.

In Mali, a private sector–driven development trajectory is crucial for generating job opportunities for a labor force that is estimated to grow by 235,000 workers every year, with more than half of the country's population younger than age 24. To support this potential, the 2022 Mali CPSD proposes addressing constraints in five key sectors (agribusiness, energy, transport and logistics, digital infrastructure and services, and financial services). In particular, the CPSD identifies specific agribusiness value chains such as mango, fonio, livestock, sesame and cotton where Mali has a comparative advantage, and which can drive export diversification and structural transformation.

Mauritania: Despite significant increases in natural resource wealth, economic development in Mauritania remains weak. The 2020 Mauritania Country Economic Memorandum (CEM) discusses the country's over-reliance on non-renewable natural resources and the impact on growth, exports, and fiscal revenues, all of which are dependent on extractives. The CEM emphasized the need to diversify the economy and to manage urbanization in order to promote robust growth and job creation. To achieve diversification, the CEM highlights the importance of (i) promoting a more-market oriented economy, via export-oriented trade policy and local entrepreneurship; (ii) enhancing production factors, through education and skills, improved infrastructure, and maximized land use; (iii) improving planning and strengthening institutions, with better allocation to local governments and improving urban planning; and (iv) better managing natural resources and adopting a more market-based exchange rate policy.

Niger: Economic development in Niger requires structural changes that would allow the country to sustain a continuing increase in income and social welfare. While recent GDP growth performance has been relatively robust, it has not led to the fundamental changes required to achieve a prolonged period of income growth in the fastest growing country in the world. The 2022 Niger CEM proposes targeted pathways to achieve these changes. Five priorities are highlighted: (i) leveraging new technologies to promote agricultural productivity; (ii) fostering the development of digital finance; (iii) promoting sound local content policies in the extractive sector; (iv) managing oil revenues in a transparent and fiscally responsible way; and (v) strengthening the disaster risk management framework and establish a disaster risk financing strategy.

2.2.2 FCV Considerations

Key issues in the sector

Over the last 2 decades, the Sahel region has become increasingly fragile with waves of conflict destabilizing the region. Currently, all G5 Sahel countries (Mali, Niger, Burkina Faso, Chad, Mauritania) are either actively in conflict, dealing with its aftermath, or confronted with security challenges, causing populations' displacement inside or across domestic borders among other effects.

Initially led by the presence of violent extremist groups, the conflicts have now become more localized with communal tensions driving fragility in areas previously unaffected by violence. Existing multidimensional exclusion, perceptions of injustice, marginalization and inequality, and a lack of confidence in governments' capacity to ensure justice, security and inclusive policies have emerged as key drivers of conflict. The manifestations of violence are many, ranging from violent extremism to banditry, insurrections, communal conflict or vigilantism.

Initially located in Northern Mali, insecurity has spread into central Mali, Northern Burkina Faso and Western Niger. These patterns now threaten to spread further West in Mali and Burkina Faso, and to coastal countries. Besides the Central Sahel, the ISWAP and JAS insurgencies which started in 2009 in Maiduguri under the colloquial name Boko Haram, have rapidly spread from North East Nigeria to Cameroon, Niger and Chad.

IDA19 provides $8.5 billion in IDA financing for G5 Sahel countries, a record increase in resources made available to this region, in alignment with the WB strategy for Fragility, Conflict and Violence. Four out of the five Sahel countries are eligible to the IDA19 Prevention and Resilience Allocation (PRA), which provides additional funding for countries facing risks of high-intensity conflict.

Unpacking the link between climate change (CC) and conflict in the Sahel

There is an emerging consensus that CC exacerbates conflict and fragility. A now abundant scholarly literature explores the drivers and enablers of chronic political instability and security challenges in the Sahel. Predatory/kleptocratic forms of governance (national or local), state repression, deficiencies of dispute-settling mechanisms or the judiciary feature among them. Climate change, by putting additional stress on the livelihoods and economic space of essentially rural communities interacts with these features, entertains and exacerbates fragility, as now amply discussed by the literature exploring the CC/conflict nexus.[1] Therefore, any relevant analysis and macro-modelling of the Sahelian countries' development trajectories should take on board their structural political fragility and the chronicity of their internal conflicts that damage their economy as well as the specific role that climate change may play in entertaining. Put differently, climate change may harm economies directly (e.g., through destruction of assets in increasingly frequent natural disasters) but also indirectly by prolonging and exacerbating already existing institutional fragilities and conflicts.

The Sahel does display some of the institutional challenges likely to amplify the negative effects of CC and to reduce the impact of mitigation and adaptation policies. It is marked by deep institutional fragility, with institutions that have a limited footprint outside of capital cities and struggle to show a positive presence across regions. Resource competition is in practice poorly regulated, with limited ability from states and local governments to ensure an inclusive and equitable management of land, water and pastoral resources. Corruption, land speculation, patronage and rent seeking has shaped patterns of marginalization and inequality that have in turn fueled violent mobilization. In addition, resource competition is impacted by political and policy choices, including those that have largely favored farming over herding in agro-pastoral areas over decades, especially in the Central Sahel. No analysis can afford to ignore such institutional challenges, that will undoubtedly impact the potential reach and impact of mitigation and adaptation policies.

Suggested ways of integrating FCV in the macro-modelling

The G5 is an ad hoc grouping of countries that exists institutionally because of common security challenges. These challenges cannot be ignored in the modeling effort. In addition to the fact that large parts of those countries' territories, especially rural areas, are not controlled by the state, the recognized dependence of

Sahelian economies on pastoralism pleads for factoring in the risk of destructive herders/farmers conflicts. Besides conflict, institutional fragilities will diminish the impact of mitigation measures: one does not deliver policies in fragile environments in the same was as in established, uncontested institutional settings. Below are a few suggestions for integration of the FCV dimension in the CC-MFMod.

Economic damages:

- Occurrence of violent events. Impacts on the frequency and intensity of violent conflict (ACLED) due to increased competition over natural resources[2].
- Security expenditure
- History of conflicts / coups / political risks
- Share of IDPs/refugees in population

Impact of adaptation/mitigation scenarios:

- Institutional fragility as measured by the CPIA (fragility hampers the impact of adaptation/mitigation policies and investments)
- Portion of territories outside of state control (which will not be reached by policies and investments)

Potential policy and operational recommendations

Political economy aspects. In the CCDR CN, the states are essentially represented as benevolent. However, the states do not necessarily want to empower all categories of the population, especially those that are not part of its clientele. Typically, pastoralist communities are often at odds with modern state-making efforts that tend to privilege sedentary populations across West Africa. As CC does not hit all sections of the society in the same way, imbalanced policies could eventually make some communities more vulnerable. Also, G5 Sahel countries' primary short-term priority is stabilization and restoring security. How to render this compatible with the long-term horizon needed for CC mitigation? Should we to consider the policies that exist already and see how they can realistically be transformed positively through concrete efforts to move away from the "Business as usual scenario" (after establishing its main tenets)?

Rebuilding the social contract. Adaptation and resilience to climate change is an opportunity to contribute to build a new, more inclusive social contract in the Sahel countries. Achieving this will require, in addition to sector-specific changes and investments, to look at ways to improve **coherence between public policies** (e.g., agricultural development, livestock (e.g., ranching vs pastoralism), food security, governance, social protection, land management).

Spatial analysis. CCDR recommendations will need to be tailored to different territorial realities, including in terms of state presence and conflictuality. As such, it would be helpful to spatialize the analysis and identify hotspots at the subnational level for CC impact on livelihoods, which can then be compared to FCV hotspots. Another key question is whether there is a need to rebalance investments in favor of underserved and vulnerable agro-pastoral areas.

Inclusive and participative management of natural resources at the local level will be key to mitigating the risks of conflict over resources.

Preparedness to shocks (in line with IDA20 priorities) including preparedness to upcoming **displaced populations flows** (climate migration, rural-urban migration, forced displacement) especially in urban and border areas will be key to build resilience.

Knowledge gaps / needs for deeper dives

Additional research and a discussion on the main channels through which conflict and the impact of CC on conflict can lead to economic damages and how to model them would be useful.

2.2.3 Gender and Climate Change

As we confront increasing climate-induced shocks and transition to a carbon-neutral world, a gender lens is essential for sustainable development and green growth. Climate change will have a major impact on human wellbeing, with women and men facing different vulnerabilities and risks and varied capabilities to adapt. Climate change will heighten existing gender equality gaps shaped through formal institutions and context-specific gender norms in employment and income levels, access to and control over productive assets and natural resources, access to services, skills and capacity, mobility, as well as agency and decision-making power. Women also face barriers to equally benefit from opportunities from green growth including in employment, leadership opportunities, and access to newly created assets through climate action.

Addressing the underlying factors that contribute to the gender-differentiated impacts of climate shocks is instrumental to the call of the WBG Climate Change Action Plan for an integration of climate and development in country-driven approaches. Aligning climate and development efforts necessarily involves addressing gender inequalities. Gender equality and the empowerment of women and girls contribute to the twin goals of eliminating poverty and boosting shared prosperity and can have catalytic and multiplying impacts when addressed meaningfully with climate actions.

In the Sahel, women are facing disadvantages across all dimensions of well-being. Most women are trapped in low-paid and informal jobs, with the majority working in the agricultural sector, which is particularly vulnerable to climate change and conflict. Many women who work in agriculture in rural areas are unpaid, and the potential of raising income from agriculture becomes harder as women's access to markets for selling goods has been restricted by conflict, undermining livelihood security and resilience (Tarif & Grand 2021). Moreover, very few women are empowered within their households. Around 63 percent of women in Mali do not participate in any important household decisons at all (DHS 2018). Additionally, incidence and acceptance rates of GBV are high: Two out of every five women in Mali report that they have experienced either physical violence or both physical and sexual violence (DHS 2018). Overall, overrepresentation in the agricultural sector, limited decision-making capacities and high incidence rates of GBV strongly constrain women's opportunity to sustain their livelihoods, function productively in the society and contribute to economic growth and poverty reduction.

Those gender disparities are being aggravated by both climate change and conflict. Indeed, evidence indicates that droughts have worsened across the Sahel with the potential to exacerbate violence and conflict in the region. Not only have droughts become more severe and more widespread across the region, but there is also a significant increase in the variation of conditions. Preliminary analysis by the Poverty team indicates the many of the observed conflicts are occurring in these areas with increased variation, and not only those areas with high drought *per se*.

Economic and population growth

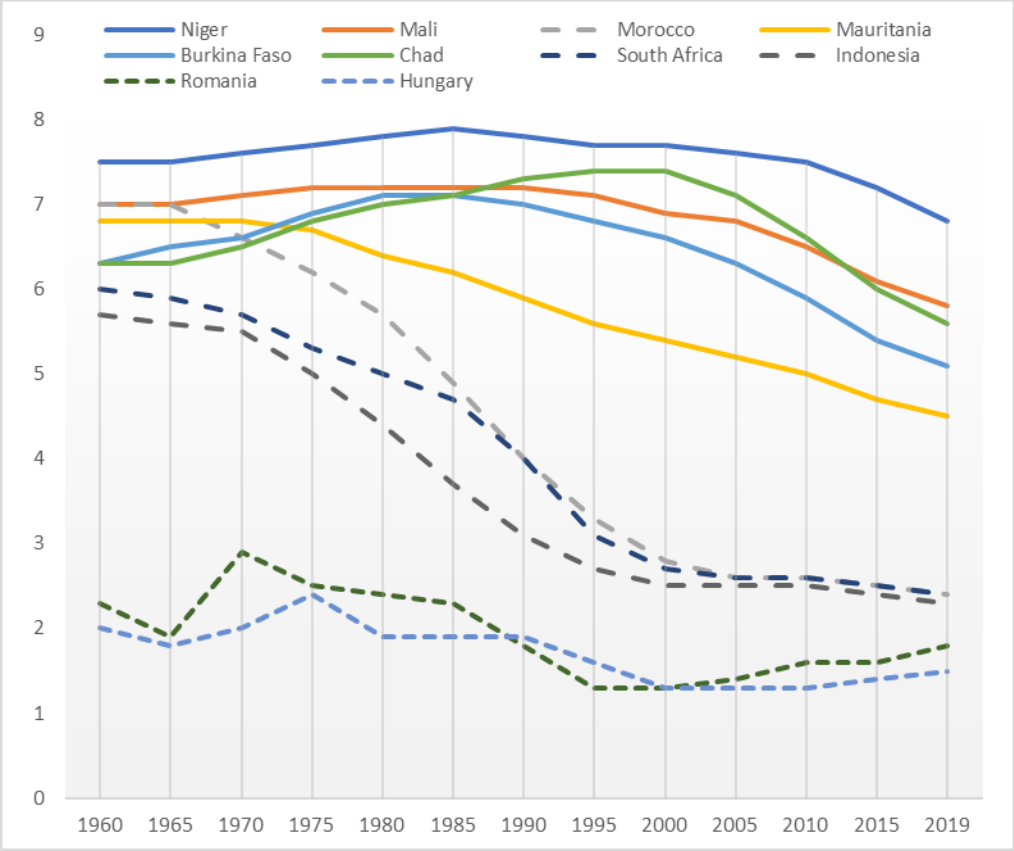
Fostering human capital is essential to growth. Education, especially girls' education, promotes economic growth, including women's empowerment and mortality reduction. Lutz et al. (2014) suggest that the demographic dividend is explained by improvements in educational attainment. As per the World Bank's Human Capital Index (HCI) human capital is a necessary condition for economic growth. In the five Sahel countries, HCI ranges from 0.30 in Chad to 0.38 in Burkina Faso and Mauritania.[1] This means that the future GDP per worker in Sahel countries could be 2.6-3.3 times as high if the country reached the benchmark of complete education and health. High fertility rates could limit countries' ability to ramp up investment in human capital as household resources are distributed across more children, lowering the amount of human capital investment—in both education and health— parents can allocate to each child.

Given the urgency of the growth agenda, investing in human capital of both men and women and fostering the economic empowerment of women is critical for the Sahel. Economic growth is essential to ensure enough

resources for the country to adapt to climate change and to increase welfare. Despite efforts by governments to promote human capital accumulation, Sahelian countries present high fertility rates, low rates of school enrollment, limited access to health care, and a high prevalence of precarious employment with persistent gender disparities. In 2020, for example, in Niger, a girl who started school at age four was expected to have five years of education by age 18, compared to about six years (5.9) for boys. A similar trend is observed for other Sahelian countries where, for example, the total number of years of education that girls in Chad could expect to have by age 18 is 4.4 compared to 6.2 for boys. However, in Burkina Faso, girls' and boys' expected years of education are 7.

Fertility rates are high and have only been declining very slowly. Over the last 60 years, while other countries, such as Morocco and Indonesia, have seen declining fertility rates, Sahelian countries, especially Niger, continues to exhibit high rates, among the highest in the world (Figure 2-42).

Figure 2-42 Fertility rates 1960-2019



Source: Gender Data Portal

Responses to climate shocks could hinder fertility reduction. One coping mechanisms for households to mitigate the consequences of climate shocks is to send children to marriage early, contributing to increased fertility. In Sub-Saharan Africa, including the Sahel countries, Corno et al. (2020) find that in response to drought-induced income loss, households rush to marry their daughters to receive the bride price. Child marriage is widely considered a violation of girls' human rights. It curtails the opportunities provided to girls and their children. The evidence of the negative impacts of the practice on a wide range of outcomes is clear, and the practice has large economic costs as well (World Bank 2017) Moreover, droughts can reduce the marginal value of agricultural labor. In Madagascar, Dessy et al. (2020) find that droughts reduce the value of women's agricultural labor, but not of men's, and thereby reduce young women's marginal cost of a child and increase the fertility of young women. Child marriage and early childbirths have large economic costs globally. By reducing the annual rate of

population growth, ending child marriage and associated childbirths could lead to welfare benefits globally of $566 billion (PPP) by 2030.

At the same time, fertility impact the ability of countries to harness the demographic dividend and to counteract climate change. Population growth has a sizable effect on climate change. Using a dynamic CGE model, O'Neill et all 2010 suggest that with low population growth path, 16-29% carbon emissions can be reduced—a sizable impact to avoid dangerous climate change. Shi 2003 finds that the elasticity of carbon emission with respect to an increase in population is more than unitary: one percent increase in population is associated with 1.42 percent increase in carbon emissions. The elasticity is twice as high in lower-middle income countries than in higher-income countries.

Women's economic empowerment, with a particular focus on girls' education, access to quality reproductive, child and maternal health services, and the creation of economic opportunities, could facilitate this demographic transition (). In Nigeria, for example, Osili and Long (2008) showed that education substantially reduced female fertility. Gebre's (2020) results in the Malawi context confirmed these findings. She shows that the 1991 free primary education reform increased the age at first marriage, which correlates with fertility and increased birth spacing - indicators associated with infant mortality. Education impacts not only women but also men's number of children. Godefroy and Lewis (2018) find that the free education policy in Mali reduced men's fertility and propensity to work in the agricultural sector. Interventions such as the Sahel Women's Empowerment and Demographic Dividend (SWEDD) projects aim to improve the empowerment of adolescent girls and women while enabling them to have easy access to quality reproductive, child, and maternal health services. In Niger, for example, the SWEDD project provided girls with scholarships that included housing and school fees. In evaluating the impact of this intervention, Giacobino et al. (2022) find that this intervention increased the educational outcomes of adolescent beneficiaries and their well-being. These SWEDD beneficiaries in Niger are more likely to postpone marriage and have higher career aspirations.

Box 2-1 Sahel Women's Empowerment and Demographic Dividend Project

Countries' capacity to build human capital – improve learning and productivity – and accelerate the demographic transition depends on their ability to reach and change the potential of their youth, including the most vulnerable segments of that population. Across 10 countries in the Sahel region, recent analysis suggests that more than 14 million adolescent girls are at risk of child marriage, teenage pregnancy and early school drop-out. That amounts to 80 percent of all girls 10-19 years old in those countries. High adolescent fertility in the Sahel is accompanied by high maternal mortality and malnutrition, low level of education and productivity, and low prevalence of modern contraceptive methods.

Expanding adolescent girls' and women's learning and earning prospects, and ability to effectively achieve their desired fertility, is key for addressing demographic challenges, achieving human development goals, and facilitating transition to low-carbon growth paths. 1% increase in population is associated with 1.42% increase in carbon emissions. The elasticity is twice as high in lower-middle income countries than in higher-income countries. A CGE model suggests that with low population growth path, 16-29% carbon emissions can be reduced—a sizable impact to avoid dangerous climate change.

The World Bank's Sahel Women's Empowerment and Demographic Dividend (SWEDD) is a nine-country project in Sub-Saharan Africa aiming to accelerate the demographic transition by addressing both supply- and demand-side constraints to family planning and to reproductive and sexual health. The projects target girls and women aged 8 to 24 who are at high risk for early marriage and early childbearing and support them with age-appropriate and evidence-based interventions. All the projects fall into one or more of three windows of eligible interventions. The first window, empowering girls, includes life skills and sexual and reproductive health knowledge projects that build adolescent girls' capacity to lead healthy and productive lives. The second window focuses on improving economic opportunities through support for income-generating activities. The third group of projects falls under the window of keeping girls in school and includes projects to improve girls' school enrollment and retention.

Voice and agency

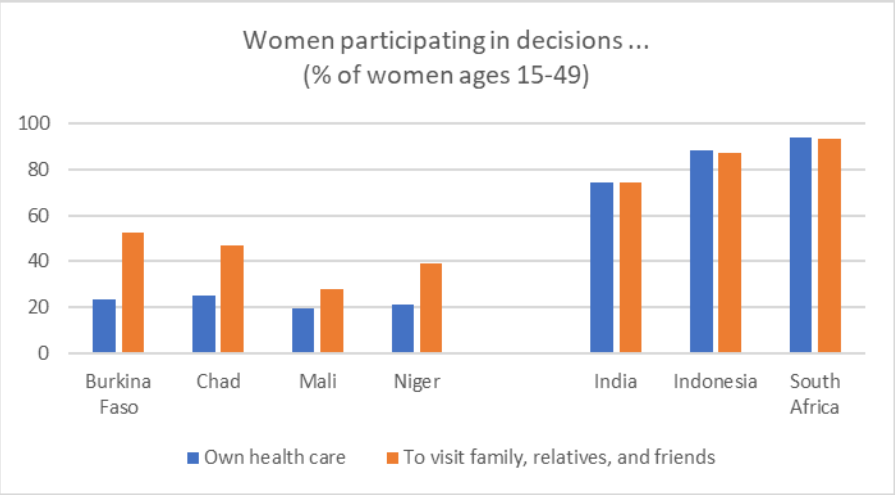
Mobility constraints can affect the ability to adapt to climate change the men and women have. For example, women often do not have equitable access to modes of transportation or financial assets needed to be able to migrate. Thus, women have fewer options for livelihood adaptation in the context of climate change. Research in Burkina Faso shows that investments in short-term migration to urban or other rural areas is a preferred adaptation strategy by agro-pastoralist households (Deshingkar, 2012), however, women were less likely to migrate over short-term periods (Kima et al., 2015).

Studies document that men more often than women migrate for work purposes due to environmental degradation from rural to urban areas. Women left behind by male migrants may experience more autonomy and have greater decision-making power, as well as additional income in the form of remittances (FAO 2003). However, male outmigration can exacerbate the poverty of rural women (Bhatta et al. 2015; Chindarkar 2012; Omolo 2010). Migrating men may contribute little to family incomes, increasing the workload for women (Brody, Demetriades & Esplen 2008). Moreover, in the events of male urban migration, it may be difficult for female-headed households to retain control over land and other productive assets because of restrictions on women's property and land rights.

In Sahelian countries, the prevalence of gender norms, including those related to mobility, make women more vulnerable to shocks than men. In Nigeria, in times of drought-induced agricultural income shocks, the migration of men from the household to locations with more economic opportunities is one of the ways households mitigate the risks of the shock (Dillon et al., 2011). Similarly, Henry et al. (2004) in Burkina Faso found that men are more likely than women to practice rural to rural migration as a strategy to diversify income sources during periods of job scarcity induced by climate change. While women are left behind in the family, the migration of men to areas of high economic opportunity could be explained by gender norms related to mobility constraining women from moving and the possibility that women are less skilled in non-farm work. Leaving women behind in areas affected by climate change could further exacerbate their living conditions, reducing their decision-making power in the family. For example, in Mali, while men's migration is perceived as a strategy to mitigate the impacts of climate change, women, left behind, become more vulnerable in the absence of men because they must carry out men's daily activities in addition to their daily chores (Djoudi and Brockhaus, 2011).

Inhibitive social norms may also limit women's mobility to access reproductive and maternal health care services even when they are within distance. In Mali, women cannot travel outside her home in the same way as men by law (WBG 2022). Women in the Sahel countries report having less voice in decisions making on their own health care and to visit family and friends than women in India, Indonesia and South Africa, with the difference being significantly large as it pertains to their own health care (Figure 2-43)

Figure 2-43 Women's participation in decision making within the household



Source: Demographic and Health Surveys, retrieved from Gender Data Portal using latest data since 2010

The stress induced by reduced household purchasing power resulting from climate shocks could increase gender-based violence. Using data from 19 African countries, including Cameroon and Chad, Epstein et al. (2020) show that drought increased intimate partner violence, including physical and sexual violence in the household. As drought reduces household income, it could lead to stress and depression related to the survival of household members, thus making the partner violent. This study also finds that adolescent girls and unemployed women are more likely to be victims of intimate partner violence in times of climate shocks. Evidence suggests that non-autonomous women in the household are at risk of experiencing these types of violence during resource scarcity. These results are consistent with the findings by Díaz and Saldarriaga (2020) that the increase in Intimate Partner Violence in Peru following a drought was due to (i) the loss of women's employment affecting their bargaining power in the household and (ii) the increase in alcohol consumption by the partner due to the stress caused by the loss of income. Kelly et al. (2021) found that forced displacement, including that induced by natural disasters and conflict, also increased intimate partner violence in Liberia and Colombia.

Employment

Women are more likely to be in vulnerable employment than men. As might be expected based on their low education levels, almost all individuals living in Sahelian countries have vulnerable, non-formal employment that does not guarantee them social protection against shocks. In Niger, almost all women in 2019 were in vulnerable employment (98%) compared to 91.6% of men. Trends in employment vulnerability suggest that women's employment status in Niger exacerbates over time. Indeed, while the proportion of women in vulnerable employment in 1991 was 86.5 percent, this proportion increased by more than 11 percentage points in 2019, while the situation for men remained more or less stable. Similarly, in Chad, were about 99% of women were in vulnerable employment in 2019 compared to 88.6% of men. These trends are like those in other Sahelian countries and generally exceed the average for sub-Saharan Africa, suggesting the acuteness of the problem in this region.

Women tend to concentrate in natural-resource based livelihoods, such as agriculture, that are climate-sensitive. Globally, over time, as men move to manufacturing and services jobs, more agricultural work is being carried out by women (WBG Climate Change Group 2017). This feminization of agriculture makes them even more vulnerable to economic, social, and cultural marginalization (Najjar 2021). Existing gender biases in agriculture result in female farmers producing less than their male counterparts due to barriers for women in accessing and owning land, accessing and using agricultural inputs and extension services.

Women in the Sahel overwhelmingly rely on the agricultural and food economies. In West Africa, approximately 70% of women's labor is in the food economy, with most of that work being off-farm sectors (Pepper, 2019). These off-farm sectors are particularly gendered: women make up 88% of food-away-from-home (e.g., restaurant service), 83% of food processing, and 72% of food marketing labor (Allen et al., 2018). Climate change related events imply the need for agricultural and pastoralist households to adapt changing crops or primary livestock sources and breeds, or by diversifying livelihood strategies. When men migrate to urban areas women become de facto heads of household and are left with the responsibility of ensuring agricultural activities continue. This requires a change in roles and responsibilities within the household and may challenge traditional gender roles within the village. If structures and norms outside the home exclude women from participation in traditionally male roles and spaces, they may be unable to necessarily connect to the critical resources or information required to respond to a changing climate. (McOmber 2020)

Increased migration due to climate change and conflict affects women's roles in agriculture and related activities, which in turn affects their productivity and gender equity. Women are performing more farm labor in agrarian societies due to the increasing outmigration of men, and this feminization of agriculture appears to have more drawbacks than benefits for women (Najjar 2021). Particularly, women in agriculture have little opportunity to work in well-paying positions and face multiple challenges as farmers, being vulnerable to poverty and food insecurity (Brody, Demetriades & Esplen 2008; Glazebrook, Noll & Opoku 2020; Mitchell, Tanner & Lussier 2007).

Poverty and unequal access to assets (e.g., a vehicle) are among other important economic reasons, which explain lower mobility of women during crises. Women and men often do not have equal opportunities for mobility, to a large extent, due to inequalities in assets. Women often do not own any means of transportation or cannot afford to utilize one. Constraints to mobility limit women's options for livelihood adaptation in the context of climate change. Research in Burkina Faso shows that investments in short-term migration to urban or other rural areas are a preferred adaptation strategy by agro-pastoralist households (Deshingkar, 2012). However, women were less likely to migrate over short-term periods (Kima et al., 2015; McOmber, 2020).

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2.2.4 Human Development Country Climate Vulnerability Index

Climate change is recognized as one of the greatest threats to the World Bank Group's (WBG) core mission to end extreme poverty and promote shared prosperity. Current climate-related extremes already affect millions of people, putting food and water security at risk, impeding agricultural supply chains and threatening flood many coastal cities. Without sufficient action to take measures to adapt and to strengthen resilience, climate impacts could conservatively push an additional 100 million people into poverty by 2030. Climate change will affect all, but the greatest impacts will be borne by the most vulnerable in society.

Background

In 2015, WBG client countries committed, through their Nationally Determined Contributions (NDCs), to limit global warming to less than 2°C and if possible, to keep temperatures under 1.5°C[1]. These contributions are now being updated in the second round of NDCs[2].

In 2016, The WBG developed a *Climate Change Action Plan 2016-2020*[3] (CCAP) to support countries to meet these contributions. The CCAP scaled up client driven climate action, integrated across WB operations to support activities that deliver the WB's core mission building by on the WB's comparative advantage. This was updated in 2021 and the second *CCAP 2021–2025*[4] aims to advance the climate change aspects of the WB's Green, Resilient, and Inclusive Development (GRID) approach, to pursue poverty eradication and shared prosperity with a sustainability lens. The CCAP includes an HD commitment (through a reference to the WBG Adaptation Plan) to 'support climate hot-spot countries with human development engagements (education; health, nutrition, and population; social protection and jobs) to effectively implement resilience strategies'.

In order to achieve the HD CCAP commitment it is vital to be able to prioritize the countries according to climate vulnerability. The WBG already completed important background work in this area through the publication of the *Geographic Hotspots for World Bank Action on Climate Change and Health*[5] in 2017. This publication described a method to identify the countries most at risk and determine their preparedness for coping with climate impacts. The analysis was based on the Notre Dame Global Adaptation Initiative (ND-GAIN) as this was considered the most robust methodology for characterizing health vulnerability due to climate change. The Geographic Hotspots work considered a total of four potential indices[6] from which the ND-GAIN was selected as the most suitable.

Compiled by the University of Notre Dame, USA, the ND-GAIN country index measures climate vulnerability and adaptation readiness based upon compiled indicators. A total of 45 indicators were developed following analysis of survey data and literature and a process of consultation with scholars, adaptation practitioners, and global development experts. The index itself is composed of two key dimensions of adaptation: vulnerability and readiness. Thirty-six indicators contribute to the vulnerability score whilst nine indicators contribute to readiness. The vulnerability dimension measures a country's exposure, sensitivity, and capacity to adapt, by considering the following six sectors – Food, Water, Health, Ecosystem service, Human habitat, and Infrastructure. The readiness dimension measures a country's ability to adapt, by considering the following three components – economic readiness, governance readiness and social readiness. Both the vulnerability and the readiness scores take the simple mean of the sector scores with all measures weighted equally. Further detail on the data sources used for each indicator are available on the ND-GAIN website[7].

Methodology

The list of HD country climate vulnerability presented in this document builds on the 2017 *Geographic Hotspots* work. It takes the global ND-GAIN index for a country rather than focusing on health specific indicators, within the NDGAIN as was employed in the *Geographic Hotspots.* This broader approach allows results to be generalized across HD. To ensure even greater robustness, the results of the ND-GAIN index were combined with the latest 2020 Human Capital Index (HCI). The combined measure from these indices

ensures that WB supported activities can be focused on reducing the threat to Human Capital in those countries most at risk from the changing climate.

Given that all countries in the world are climate vulnerable to some extent, the list of countries below should be seen as a tool aimed to be used to assist in the prioritization of client country support at the global level. While the HD commitment refers to "hotspot" countries, activities in any of the countries below can count for the commitment although prioritization can be made across regions and countries focusing on activities in the most vulnerable when it comes to choosing, for example, whether to carry out an in depth vulnerability and adaptive capacity assessment. Finally, it is important to highlight that since this analysis sits at the country level the figures necessarily mask a heterogenous variety of sub-national vulnerable groups influenced by geography as well as other demographic, economic, cultural, and historic factors.

The method and results below represent the second iteration of the World Bank HD climate vulnerable countries list. This 2022 version uses updated figures from the HCP and the NDGAIN and replaces the first list drawn up in 2019.

Approach

1. A total of 182 countries are included in the WB's HD country climate vulnerability index.
2. A full list of countries with corresponding scores from the **ND-GAIN** indicators[8] was compiled.
3. The list of countries participating in the Human Capital Project (HCP) was then compiled and scores for the human capital index **(HCI)** extracted.
4. ND-GAIN scores were combined with the HCI to give an **equally weighted mean combined score**. The list of 182 countries were ranked according to the combined score.
5. Nineteen countries[9] not participating in the HCP simply received the respective NDGAIN score and were ranked accordingly.
6. Eleven jurisdictions[10] not participating in the NDGAIN were not included in the analysis at all. They are shown at the bottom of the list with the ranking they would have received based solely on their HCI (shown in brackets).
7. Four jurisdictions[11] were listed in the NDGAIN but without a score and were also not included in the HCI. These were not included in the list at all.
8. Top 35 countries are highlighted in yellow for reference purposes.

Table 2-31 Global list of HD country climate vulnerabilities (G5 countries in bold)

Country	Rank	HCI 2020 value	NDGAIN 2019 value	Mean HCI and NDGAIN score
Central African Republic	1	0.292	28.942	0.291
Chad	2	0.300	28.397	0.292
Eritrea	3		31.155	0.312
Guinea-Bissau	4		31.948	0.319
Niger	5	0.316	33.091	0.323
Liberia	6	0.319	33.752	0.328
Mali	7	0.318	35.009	0.334
Somalia	8		33.941	0.339
Congo, Dem. Rep.	9	0.366	32.276	0.345
Sudan	10	0.377	32.713	0.352
Yemen, Rep.	11	0.373	34.682	0.360
Nigeria	12	0.361	37.057	0.366

Afghanistan	13	0.400	33.503	0.368
Angola	14	0.362	37.447	0.368
Uganda	15	0.384	35.583	0.370
Sierra Leone	16	0.363	37.747	0.370
Burundi	17	0.386	35.464	0.370
Mozambique	18	0.362	38.111	0.372
Madagascar	19	0.392	35.994	0.376
Burkina Faso	20	0.384	37.633	0.380
Ethiopia	21	0.383	37.878	0.381
Guinea	22	0.371	39.320	0.382
Syrian Arab Republic	23		38.455	0.385
Eswatini	24	0.373	39.792	0.385
Congo, Rep.	25	0.419	35.568	0.387
Benin	26	0.400	37.593	0.388
Côte d'Ivoire	27	0.380	39.671	0.388
Malawi	28	0.413	36.706	0.390
Tanzania	29	0.390	39.087	0.390
Mauritania	30	0.382	40.023	0.391
Comoros	31	0.405	38.204	0.393
Pakistan	32	0.406	38.336	0.395
Cameroon	33	0.397	39.247	0.395
Equatorial Guinea	34		39.663	0.397
Haiti	35	0.447	35.401	0.400
Zambia	36	0.397	40.513	0.401
Rwanda	37	0.380	42.476	0.402
Papua New Guinea	38	0.429	37.749	0.403
Venezuela, RB	39		40.564	0.406
Gambia	40	0.422	39.206	0.407
Bolivia	41		40.752	0.408
Zimbabwe	42	0.467	34.900	0.408
Lesotho	43	0.400	42.538	0.413
Bangladesh	44	0.464	36.537	0.415
Senegal	45	0.420	41.050	0.415
Togo	46	0.432	41.037	0.421
Iraq	47	0.408	43.562	0.422
Solomon Islands	48	0.420	42.452	0.422
Myanmar	49	0.478	36.694	0.422
Turkmenistan	50		42.230	0.422
São Tomé and Principe	51		42.427	0.424
Djibouti	52		42.559	0.426
Libya	53		43.032	0.430

Korea, Democratic People's Rep.	54		43.089	0.431
Lao PDR	55	0.457	40.531	0.431
Vanuatu	56	0.455	41.080	0.433
Cambodia	57	0.492	38.340	0.437
Belize	58		43.931	0.439
Honduras	59	0.481	40.379	0.442
Gabon	60	0.458	43.171	0.445
Micronesia, Federated States of	61	0.506	38.684	0.446
Guatemala	62	0.461	43.500	0.448
Timor-Leste	63	0.454	44.309	0.449
Ghana	64	0.450	44.923	0.450
Namibia	65	0.446	45.399	0.450
Botswana	66	0.414	48.954	0.452
South Africa	67	0.425	47.960	0.453
Nicaragua	68	0.508	41.254	0.460
Cuba	69		46.104	0.461
India	70	0.494	43.020	0.462
Nepal	71	0.505	42.011	0.462
Guyana	72	0.495	43.097	0.463
Spain	73	0.307	62.725	0.467
Kenya	74	0.547	39.117	0.469
Maldives	75		47.037	0.470
Egypt	76	0.494	45.027	0.472
Tonga	77	0.531	41.773	0.474
Suriname	78		47.450	0.474
Bhutan	79	0.475	47.590	0.476
Philippines	80	0.516	43.603	0.476
Lebanon	81	0.515	44.301	0.479
Dominican Republic	82	0.503	46.432	0.484
Tajikistan	83	0.504	46.898	0.487
Bahamas	84		49.375	0.494
El Salvador	85	0.546	45.187	0.499
Panama	86	0.502	50.067	0.501
Algeria	87	0.535	47.106	0.503
Indonesia	88	0.540	46.735	0.504
Paraguay	89	0.528	48.234	0.505
Cabo Verde	90		50.766	0.508
Fiji	91	0.509	50.872	0.509
Jamaica	92	0.535	48.559	0.510
Morocco	93	0.504	52.180	0.513
Samoa	94	0.548	47.798	0.513
Brazil	95	0.551	48.421	0.518

Tunisia	96	0.517	52.450	0.521
Ecuador	97	0.594	44.923	0.522
Sri Lanka	98	0.598	46.420	0.531
Jordan	99	0.553	51.353	0.533
Bosnia and Herzegovina	100	0.580	50.248	0.541
Antigua and Barbuda	101	0.596	49.025	0.543
Colombia	102	0.604	48.406	0.544
Moldova	103	0.584	50.684	0.545
Peru	104	0.605	48.649	0.546
Kuwait	105	0.563	52.928	0.546
Dominica	106	0.545	54.898	0.547
Argentina	107	0.602	49.276	0.547
Trinidad and Tobago	108	0.603	49.250	0.548
Mexico	109	0.613	48.454	0.549
Iran	110	0.593	50.417	0.549
Romania	111	0.584	51.658	0.550
Azerbaijan	112	0.578	52.632	0.552
North Macedonia	113	0.557	55.386	0.556
Kyrgyz Republic	114	0.597	52.496	0.561
Uzbekistan	115	0.623	50.153	0.562
Albania	116	0.634	50.099	0.568
Saudi Arabia	117	0.576	55.949	0.568
Thailand	118	0.609	52.845	0.569
Grenada	119	0.565	57.431	0.570
Armenia	120	0.579	56.534	0.572
Seychelles	121	0.633	51.689	0.575
Uruguay	122	0.599	55.173	0.575
Mongolia	123	0.614	53.656	0.575
St. Lucia	124	0.603	54.841	0.575
St. Kitts and Nevis	125	0.586	57.222	0.579
Georgia	126	0.569	59.020	0.580
Oman	127	0.608	55.151	0.580
Viet Nam	128	0.690	47.058	0.580
Barbados	129		58.037	0.580
Ukraine	130	0.631	52.993	0.581
Bahrain	131	0.652	51.652	0.584
Costa Rica	132	0.629	54.940	0.589
Bulgaria	133	0.614	56.521	0.590
Malaysia	134	0.611	57.112	0.591
Mauritius	135	0.622	56.658	0.594
Serbia	136	0.677	51.593	0.596
Montenegro	137	0.633	56.229	0.598

Brunei Darussalam	138	0.626	57.943	0.603
Qatar	139	0.638	57.404	0.606
Turkey	140	0.649	56.493	0.607
Kazakhstan	141	0.629	58.663	0.608
China	142	0.653	57.204	0.613
Slovakia	143	0.665	58.087	0.623
Hungary	144	0.683	57.368	0.628
Chile	145	0.652	61.442	0.633
Croatia	146	0.710	56.653	0.638
United Arab Emirates	147	0.673	61.211	0.643
Russian Federation	148	0.681	60.907	0.645
Greece	149	0.690	60.293	0.646
Belarus	150	0.700	59.716	0.649
Malta	151	0.709	59.133	0.650
Latvia	152	0.707	59.961	0.653
Lithuania	153	0.706	61.664	0.661
Italy	154	0.728	60.495	0.666
Israel	155	0.734	60.774	0.671
Cyprus	156	0.756	58.761	0.672
Poland	157	0.753	61.538	0.684
United States	158	0.702	67.149	0.687
Luxembourg	159	0.686	68.879	0.687
Czech Republic	160	0.752	63.306	0.693
Belgium	161	0.760	63.729	0.699
Portugal	162	0.769	63.204	0.700
Estonia	163	0.777	64.043	0.709
Slovenia	164	0.775	65.770	0.716
Ireland	165	0.793	64.241	0.718
Iceland	166	0.745	70.600	0.726
France	167	0.763	68.875	0.726
Germany	168	0.751	70.561	0.728
Austria	169	0.747	71.478	0.731
Netherlands	170	0.790	67.688	0.733
Australia	171	0.770	69.864	0.734
Denmark	172	0.755	71.558	0.735
Canada	173	0.798	68.184	0.740
Korea, Republic of	174	0.799	68.111	0.740
Switzerland	175	0.756	72.446	0.740
Japan	176	0.805	67.879	0.742
United Kingdom	177	0.783	70.231	0.743
New Zealand	178	0.776	71.626	0.746
Sweden	179	0.795	72.197	0.759

Finland	180	0.796	73.287	0.764
Norway	181	0.771	76.218	0.767
Singapore	182	0.879	71.239	0.796
Not ranked due to lack of NDGAIN value (only HCI score is available)				
Kosovo	Not ranked (116)	0.567		0.567
West Bank	Not ranked (128)	0.580		0.580
Palau	Not ranked (132)	0.588		0.588
Macao	Not ranked (182)	0.796		0.796
Hong Kong	Not ranked (183)	0.813		0.813
South Sudan	Not ranked (3)	0.307		0.307
Marshall Is.	Not ranked (51)	0.423		0.423
Tuvalu	Not ranked (62)	0.448		0.448
Kiribati	Not ranked (84)	0.493		0.493
Narau	Not ranked (91)	0.508		0.508
St Vincent and the Grenadines	Not ranked (99)	0.533		0.533

2.2.5 Social Intermediaries

In 2019, World Bank completed a study on strengthening citizen engagement capacities of social intermediaries in Mali and Niger. In Mali and Niger, the state's penetration across the countries' territories is weak, and in its absence, traditional and other informal structures play a significant role in organizing life at the community level. They regulate village life, control and regulate the governance of community's natural resources, and settle disputes. As a result, non-state actors such as traditional chiefs, religious authorities, and civil society organizations etc. become important social intermediaries playing a significant role in impacting relations between state and citizens and therefore social accountability.

The rapid pace at which societies are changing in terms of urbanization and the effects of climate change in Niger and Mali is putting enormous strain on formal or informal social intermediaries**.** Their role within communities is transforming rapidly, while also weakening their legitimacy and making them ineffective. An increasing number of population groups, especially youth, do not recognize either the legitimacy of the traditional/informal institutions or the state institutions. Also, the changing role of women in the economy is not yet fully reflected within either of these institutions. At the same time, these institutions have failed to adapt adequately to the needs of urban dwellers and the increasing urbanization. Therefore, the accountability relations between these social intermediaries and their communities seem to be strained by these societal changes that will continue to be aggravated by the negative effects of climate change. They, also, seem to be more and more out-of-sync with the expectations and needs of an increasing segment of their communities. These findings have significant operational implications for social accountability interventions and mainstreaming citizen engagement as well as the social dimension of climate change, thereby, requiring such interventions to be mandatorily premised on an in-depth understanding of social exclusion and societal dynamics as well as incumbent accountability relations within communities.

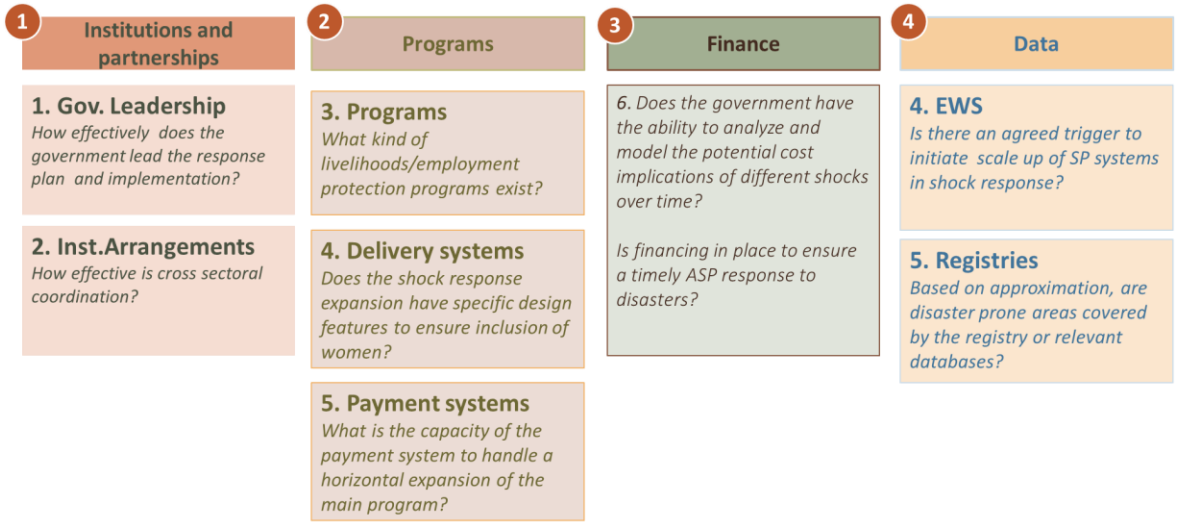
2.2.6 Stress Testing Social Protection Systems

A Stress Test Tool has recently been developed by the WB to assess the adaptiveness of social protection systems, in particular their ability to respond to shocks. The adaptiveness of a system in response to changing needs depends on how well a country is doing on each of the building blocks of a social protection system (Figure 2-44).

The first part of the Stress Test Tool examines the main sources of risk that are likely to require a large scale up of social protection in a given country and puts forward a number of ways to simulate the magnitude of potential impact on household welfare (and subsequent needs) of different shocks of varying intensities using household survey and historical shock data.

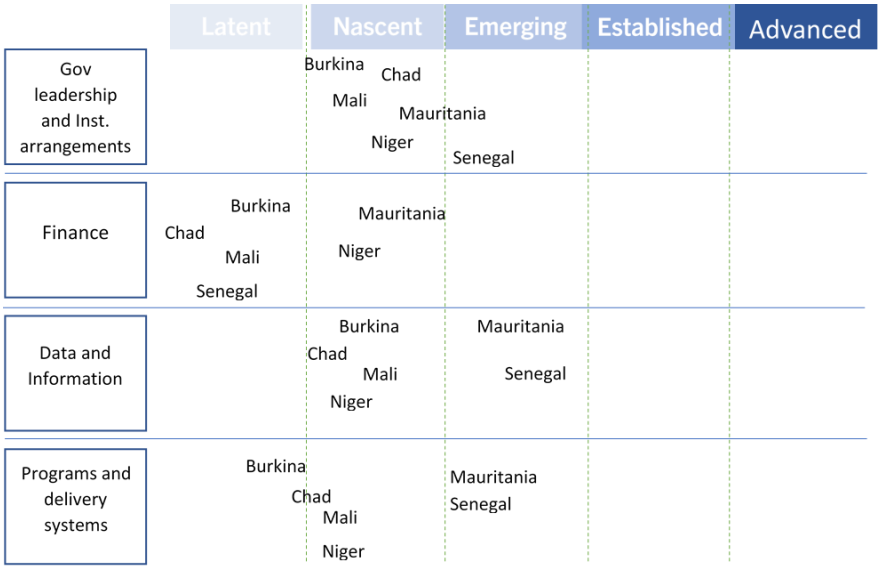
Part Two of the Stress Test Tool assesses the strength of a country's social protection system to adapt and build resilience. It does this by highlighting areas where investments could be made that would result in improving the social protection system prior to, during, and after the shock. The stress test tool has been rolled out across the Sahel and an overview of where each country stands in relation to the development of its ASP system is presented in Figure 2-45. Each building block is scored on a scale from latent to advanced based on the conversation and discussion around each question to decide on a score for each building block. The scores can be used to monitor a country's progress over time but the score themselves matters less than the conversation that will guide the next steps and recommendations to follow to strengthen and improve the SP system.

Figure 2-44 Four key building blocks of a social protection system



All six countries, the G5 and Senegal, have made progress in establishing key building blocks of social protection systems and embed shock responsive functions. The COVID-19 crisis has increased buy-in for ASP across governments over the last year. Several countries across the Sahel relied on ASP systems to protect poor and vulnerable households from the economic impact of the COVID-19 crisis such as Niger, Mauritania and Mali. Although the crisis led to an increased recognition of the role of ASP and an increased government leadership, it also highlighted areas of the system which need further work such as increasing coverage of social protection programs and of social registries, strengthening grievance and redress mechanisms, and improving coordination between social protection and emergency/disaster management actors. The dialogue on the importance of disaster risk financing has been initiated in most countries but mobilization and commitment of government funds to respond to shocks remains a major challenge, particularly with the deteriorating security situation in the region.

Figure 2-45 Overview of the stress test



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