GROUNDSWELL AFRICA

DEEP DIVE INTO **INTERNAL CLIMATE MIGRATION** IN SENEGAL

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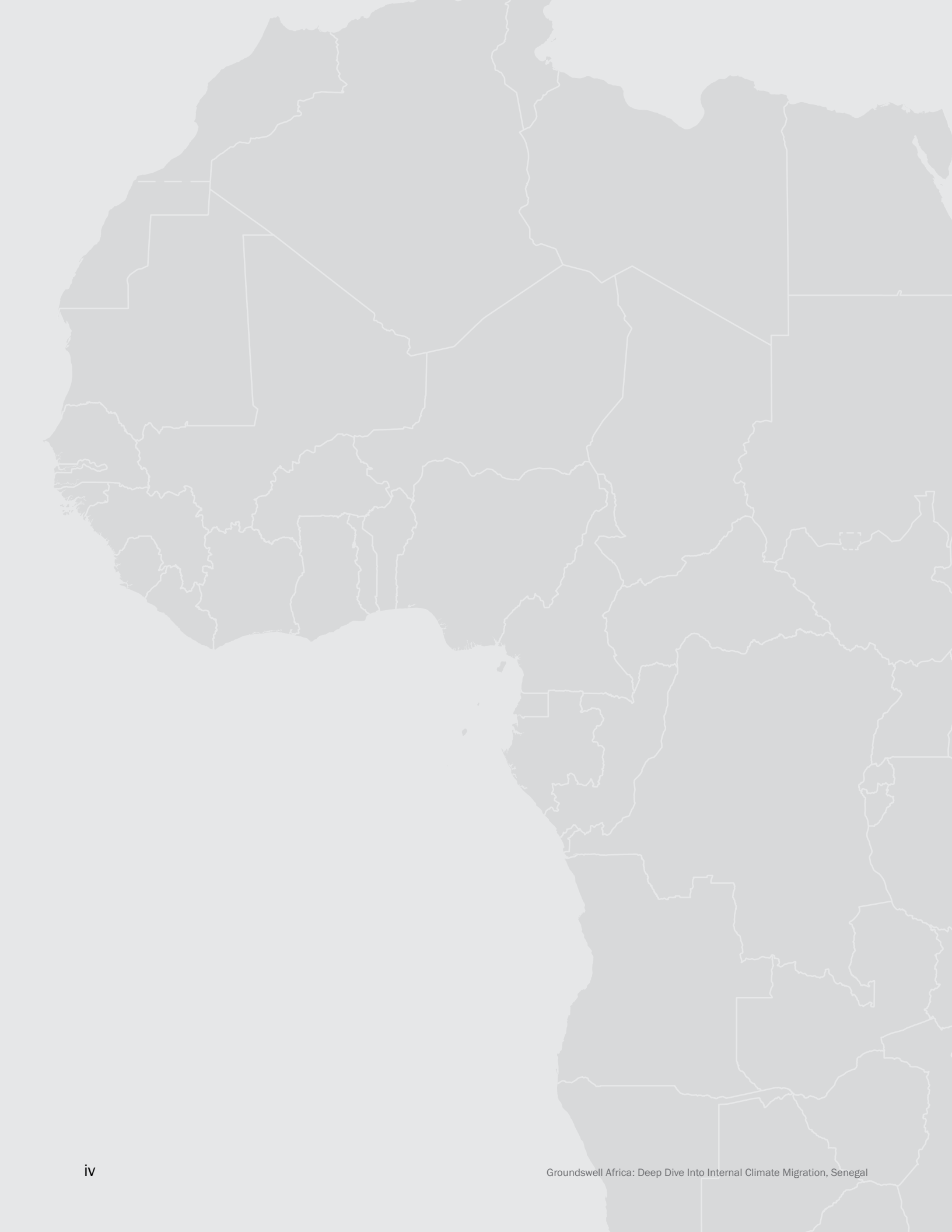

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Glossary

Adaptation: Process of adjustment to actual or expected climate change and its effects. In human systems, adaptation seeks to moderate or avoid harm or exploit beneficial opportunities. In some natural systems, human intervention may facilitate adjustment to expected climate change and its effects.

Adaptive capacity: Ability of systems, institutions, humans, and other organisms to adjust to potential damage, take advantage of opportunities, and respond to consequences of climate impacts.

Adapt in Place: The cost of relocation in response to actual or expected climate change and its effect can often be high. Adapt in place is the process of adjustment without relocation.

Agro-pastoralism: Combination of agriculture, crop-based livelihood systems, and pastoralism (see also pastoralism).

Anthropogenic biome: Anthropogenic biomes describe the terrestrial biosphere in its contemporary, human-altered form using global ecosystem units defined by patterns of sustained direct human interactions, for example, rainfed croplands.

Attractiveness: Desirability of a locale based on a number of factors including but not limited to economic opportunity, transportation infrastructure, proximity to family, the presence of social amenities, environment, and intangibles such as place attachment.

Biodiversity: Variety of plant and animal life in the world or in a particular habitat or ecosystem.

Biome: Large naturally occurring community of flora and fauna occupying a major habitat (for example, forest or tundra; see also anthropogenic biome).

Climate change: A change in the state of the climate that can be identified (for example, using statistical tests) by changes in the mean and/or the variability of its properties, and that persists for an extended period, typically decades or longer. It refers to any change in climate over time, whether due to natural variability or as a result of human activity.

Climate change–induced migration (shorthand internal climate migration): In this report, climate change-induced migration is movement that occurs within countries that can be attributed largely to slow-onset impacts of climate change on livelihoods owing to shifts in water availability, crop and ecosystem productivity, flood risk, or sea level rise compounded by storm surge. The model also includes non-climate factors: demographic factors (median age and sex) and conflict.

Climate in-migration hotspot: For the purposes of this study, climate in-migration hotspots are areas that will see increases in population in scenarios that take into account climate impacts relative to a population projection that does not take climate impacts into account. These increases can be attributed to in-migration, the "fast" demographic variable. Areas were considered to have increases in population when at least two of the three scenarios modelled had increases in population density in the highest 5th percentile of the distribution.

Climate migrant/migration (shorthand internal climate migrant/migration): In this report, climate migrants are people who move within countries because of climate change-induced migration (see above). The modeling work captures people who move at spatial scales of over 14 kilometers within a country, and at decadal temporal scales. Shorter distance or shorter-term mobility (such as seasonal or cyclical migration) is not captured.

Climate out-migration hotspot: For the purposes of this study, climate out-migration hotspots are areas that will see decreases in population in scenarios that take into account climate impacts relative to a population projection that does not take climate impacts into account. These decreases can be attributed to out-migration, the "fast" demographic variable. Areas were considered to have decreases in population when at least two of the three scenarios modelled had decreases in population density in the highest 5th percentile of the distribution

Climate risk: Potential for consequences from climate variability and change where something of value is at stake and the outcome is uncertain. Often represented as the probability that a hazardous event or trend occurs multiplied by the expected impact. Risk results from the interaction of vulnerability, exposure, and hazard.

Coastal erosion: Erosion of coastal landforms that results from wave action, exacerbated by storm surge and sea level rise.

Coastal zone: In this report, the coastal zone is land area within 5 kilometers of the coastline.

Conflict: Armed conflicts between groups. Armed Conflict Location & Event Data Project (ACLED) covers violent activity that occurs both within and outside the context of a civil war, particularly violence against civilians, militia interactions, communal conflict, and rioting. It is one of the nonclimate factors included in the model.

Country Partnership Framework (CPF): Strategic document that guides the World Bank Group's (WBG) country programs. The CPF identifies the key objectives and development results through which the WBG intends to support a member country in its efforts to end extreme poverty and boost shared prosperity in a sustainable manner.

Crop Productivity: Crop yield in tons per hectare on an annual time step.

Deforestation: Conversion of forest to non-forest.

Demographic dividend: The potential for economic growth made possible from shifts in a population's age structure.

Disaster Risk Reduction: The practice of reducing disaster risks through systematic efforts to analyze and reduce the causal factors of disasters.

Displacement: Forced removal of people or people obliged to flee from their places of habitual residence.

Distress migration: Movements from the usual place of residence, undertaken when an individual and/or their family perceive that there are no options open to them to survive with dignity, except to migrate. This may be a result of a rapid-onset climate event, other disasters, or conflict event, or a succession of such events, that result in the loss of assets and coping capacities.

Environmental mobility: Temporary or permanent mobility as a result of sudden or progressive changes in the environment that adversely affect living conditions, either within countries or across borders.

Extreme heat event: Three or more days of above-average temperatures, generally defined as passing a certain threshold (for example, above the 85th percentile for average daily temperature in a year).

Extreme weather event: Event that is rare at a particular place and time of year. Definitions of rare vary, but an extreme weather event would normally fall in the 10th or 90th percentile of a probability density function estimated from observations. The characteristics of extreme weather vary from place to place in an absolute sense. When a pattern of extreme weather persists for some time, such as a season, it may be classified as an extreme climate event, especially if it yields an average or total that is itself extreme (for example, drought or heavy rainfall over a season).

Flood Risk: The risk of inundation from flooding owing to extreme precipitation events, indicated in this modeling work by flood extent.

Forced migration: Migratory movement in which an element of coercion exists, including threats to life and livelihood, whether arising from natural or man-made causes (for example, movements of refugees and internally displaced persons as well as people displaced by natural or environmental disasters, chemical or nuclear disasters, famine, or development projects). Forced migration generally implies a lack of volition concerning the decision to move, though in reality motives may be mixed, and the decision to move may include some degree of personal agency or volition.

GEPIC: The GIS-based Environmental Policy Integrated Climate crop model (see Appendix A of Rigaud et al. 2021a).

Gravity model: Model used to predict the degree of interaction between two places and the degree of influence a place has on the propensity of a population in other locations to move to it. It assumes that places that are larger or spatially proximate will exert more influence on the population of a location than places that are smaller and farther away.

Gross domestic product (GDP): The monetary value of all finished goods and services made within a country during a specific period.

HadGEM2-ES: Climate model developed by the Met Office Hadley Centre for Climate Change in the United Kingdom (see Appendix A of Rigaud et al. 2021a).

Hazard: The potential occurrence of a natural or human-induced physical event or trend or physical impact that may cause loss of life, injury, or other health impacts, as well as damage and loss to property, infrastructure, livelihoods, service provision, ecosystems and environmental resources.

Immobility: Inability to move from a place of risk or not moving away from a place of risk due to choice.

In-kind transfers: Unlike a cash transfer, it refers to the specific goods and services that migrants send back home.

Internal climate migrant (migration): In this report, internal climate migrants are people who move within countries because of climate change-induced migration (see above). The modeling work captures people who move at spatial scales of over 14 kilometers within a country, and at decadal temporal scales. Shorter distance or shorter-term mobility (such as seasonal or cyclical migration) is not captured.

Internal migration (migrant): Migration that occurs within national borders.

International migration (migrant): Migration that occurs across national borders.

IPSL-CM5A-LR: Climate model developed by the Institut Pierre Simon Laplace Climate Modeling Center in France (see Appendix A of Rigaud et al. 2021a).

Labor mobility: The geographical and occupational movement of workers.

Land degradation: The deterioration or decline of the biological or economic productive capacity of the land for present and future.

Landscape approach: A framework that advances multiple land uses and sustainable landscape management to ensure equitable and sustainable use of land.

LPJmL: A global water and crop model designed by Potsdam Institute for Climate Impact Research to simulate vegetation composition and distribution as well as stocks and land-atmosphere exchange flows of carbon and water, for both natural and agricultural ecosystems.

Median Age: The age that divides a population into two numerically equal groups; that is, half the people are younger than this age and half are older.

Micro-watershed management: The management of land, water, biota, and other resources for ecological, social, and economic purposes with use of the micro-watershed as the unit of intervention (500-1000 ha).

Migration: Movement that requires a change in the place of usual residence and that is longer term. In demographic research and official statistics, it involves crossing a recognized political/administrative border.

Migration cycle: The three stages of migration process which can be leveraged for adaptation i.e., adapt in place, enable mobility and support to host and migrant communities.

Mitigation (of climate change): Human intervention to reduce the sources or enhance the sinks of greenhouse gases.

Mobility: Movement of people, including temporary or long-term, short- or long-distance, voluntary or forced, and seasonal or permanent movement as well as planned relocation (see also environmental mobility, labor mobility).

Nationally Determined Contributions (NDCs): The non-binding national plans by each country to reduce national emissions and adapt to the impacts of climate change enshrined in the Paris Agreement.

Net Primary Productivity (NPP): Estimation of the productivity of a location's natural biome, including grassland biomes.

Other internal migrant: In this report, the term other migrant is used in reference to migrants who move within countries for reasons other than climate impacts.

Peri-urban: An area immediately adjacent to a city or urban area.

Planned relocation: People moved or assisted to move permanently away from areas of environmental risks.

Radiative forcing: Measurement of capacity of a gas or other forcing agent to affect the energy balance, thereby contributing to climate change.

Rainfed agriculture: Agricultural practice relying almost entirely on rainfall as its source of water.

Rapid-onset event: Event such as cyclones and floods which take place in days or weeks (in contrast to slow-onset climate changes that occur over long periods of time).

Representative Concentration Pathway (RCP): Trajectory of greenhouse gas concentration resulting from human activity corresponding to a specific level of radiative forcing in 2100. The low greenhouse gas concentration RCP2.6 and the high greenhouse gas concentration RCP8.5 employed in this report imply futures in which radiative forcing of 2.6 and 8.5 watts per square meter, respectively, are achieved by the end of the century.

Resilience: Capacity of social, economic, and environmental systems to cope with a hazardous event, trend, or disturbance by responding or reorganizing in ways that maintain their essential function, identity, and structure while maintaining the capacity for adaptation, learning, and transformation.

Riparian areas: The lands that occur at the. interface between terrestrial and aquatic ecosystems.

Salinization: The accumulation of water-soluble salts in the soil which leads to substantial negative impact on plant productivity.

Sea level rise: Changes in climate parameters (temperature, precipitation, and associated impacts, such as water availability and crop production declines) that occur over long periods of time—in contrast to rapid-onset climate hazards, such as cyclones and floods, which take place in days or weeks.

Sex Ratio: The number of males per 100 females in the population.

Shared Socioeconomic Pathway (SSP): Scenarios, or plausible future worlds, that underpin climate change research and permits the integrated analysis of future climate impacts, vulnerabilities, adaptation, and mitigation. SSPs can be categorized by the degree to which they represent challenges to mitigation (greenhouse gas emissions reductions) and societal adaptation to climate change.

Slow-onset climate change: Changes in climate parameters (temperature, precipitation, and associated impacts, such as water availability and crop production declines) that occur over long periods of time—in contrast to rapid-onset climate hazards, such as cyclones and floods, which take place in days or weeks.

Storm surge: The rise in seawater level during a storm, measured according to the height of the water above the normal predicted astronomical tide.

Stressor: Event or trend that has important effect on the system exposed and can increase vulnerability to climate-related risk.

Sustainable livelihood: Livelihood that endures over time and is resilient to the impacts of various types of shocks including climatic and economic.

Systematic Country Diagnostic (SCD): World Bank tool to identify the most important challenges and opportunities a country faces in advancing towards the twin goals to end extreme poverty and boost shared prosperity in a sustainable manner.

System dynamics model: A model which decomposes a complex social or behavioral system into its constituent components and then integrates them into a whole that can be easily visualized and simulated.

Tipping element: Subsystems of the Earth system that are at least subcontinental in scale and can be switched—under certain circumstances—into a qualitatively different state by small perturbations.

Tipping point: Particular moment at which a component of the earth's system enters into a qualitatively different mode of operation, as a result of a small perturbation.

Transformation: The strategies that can reduce the root cause of vulnerability to climate induced migration.

Urban transition: The shift from rural to urban and from agricultural employment to industrial, commercial, or service employment.

Vulnerability: Propensity or predisposition to be adversely affected. Vulnerability encompasses a variety of concepts and elements including sensitivity or susceptibility to harm and lack of capacity to cope and adapt.

Water Availability: The water sector model outputs represent river discharge, measured in cubic meters per second in daily/monthly time increments.

WaterGAP2: The Water Global Assessment and Prognosis (WaterGAP) version 2 global water model developed by the University of Kassel in Germany (see Appendix A of Rigaud et al. 2021a).

Abbreviations

ACF	Action contre la Faim (Action Against Hunger)
BAU	Business as Usual
ACLED	Armed Conflict Location and Event Data
ACReSAL	Agro-Climatic Resilience in Semi-Arid Landscapes
AESZ	Agro-Ecological Sub-Zonal
AfCFTA	African Continental Free Trade Area
AU	African Union
CCDR	Country Climate Development Report
CFAF	Communauté Financière Africaine Franc (African Financial Community Franc; currency)
CIESIN	Center for International Earth Science Information Network
CMIP5	Coupled Model Intercomparison Project Phase 5
CPF	Country Partnership Framework
CVI	Coastal Vulnerability Index
ECOWAS	Economic Community of West African States
ERGP	Economic Recovery and Growth Plan
FAO	Food and Agricultural Organization of the United Nations
GCM	Global Compact for Safe, Orderly, and Regular Migration
GDP	Gross Domestic Product
GHGs	Greenhouse Gases
GIS	Geographic Information System
GRID	Global Report on Internal Displacement
HCI	Human Capital Index
IADD	Institut Africain de Développement Durable (African Institut for Sustainable Development)
ICT	Information and Communications Technology
ICZM	Integrated Coastal Zone Management
IDMC	Internal Displacement Monitoring Centre
IDP	Internally Displaced Person
ILO	International Labor Organization
IOM	International Organization for Migration
IOM-DTM	International Organization for Migration - Displacement Tracking Matrix
IPCC	Intergovernmental Panel on Climate Change
ISIMIP	Inter-Sectoral Impact Model Intercomparison Project
ITC	International Transhumance Certificate
IUCN	International Union for Conservation of Nature
LECZ	Low Elevation Coastal Zone
MACS	Migration and Climate-informed Solutions
MOE	Ministry of Environment
NAPA	National Action Plan for Adaptation to Climate Change
NDC	Nationally Determined Contribution
NDP	National Development Plan
NPP	Net Primary Productivity
OCHA	United Nations Office for the Coordination of Humanitarian Affairs
ODI	Overseas Development Institute
PAP	Priority Action Plan
PEWS	Pastoral Early Warning System
PSE	Plan Senegal Emergent
RCPs	Representative Concentration Pathways
RGPHAE	Recensement Général de la Population et de l'Habitat, de l'Agriculture et de l'Elevage (General Census of Population and Housing, Agriculture and Livestock)
SCAPP	Strategy for Accelerated Growth and Shared Prosperity (SCAPP)
SCD	Systematic Country Diagnostic

SDGs	Sustainable Development Goals
SEZ	Special economic zones
SLR	Sea level rise
SSPs	Shared Socioeconomic Pathways
SST	Sea Surface Temperatures
UN DESA	United Nations Department of Economic and Social Affairs
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNFCCC	United Nations Framework Convention on Climate Change
UNHCR	United Nations High Commissioner for Refugees
UNICEF	United Nations Children's Fund
WACA	West Africa Coastal Areas
WDI	World Bank Development Indicators
WIM	Warsaw International Mechanism

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Foreword

Senegal has seen strong development over the last decade, with its economy increasingly providing exciting opportunities to its young and rapidly growing population. The country has a long history of mobility—driven particularly by economic opportunities, trade, environmental degradation, and nomadic pastoralism—that has had a strong impact also on the modern Senegalese way of life.

Today, there is a new challenge that the country has to face: climate change is already a reality. Senegal has witnessed rising temperatures, erratic rainfall, flooding, rising sea level, and coastal erosion–all of which put additional pressures on communities, particularly the most vulnerable.

This report shows that without concrete climate and development action, Senegal could see up to one million people moving by 2050 as a consequence of slow-onset climate factors. Its coast, affected by rising sea levels and storm surge, could see a dampening of the traditional rural-to-urban migration towards urban centers like Dakar. People have already started to move away from the coastal zone, which is already stunningly visible in the case of Saint-Louis. Such hotspots of out-migration can be expected to intensify and spread along Senegal's coast, posing new challenges for residents and policymakers. At the same time, other areas of the country, like the border region with Gambia, will attract a growing number of people due to relatively more favorable conditions. Often these places suffer already from a lack of access to infrastructure and services, a situation that could be aggravated if not carefully manage.

This deep dive calls for far-sighted, inclusive, and resilient development to reduce the adverse consequences of internal climate migration. At the same time, it points out the opportunities that lie in harnessing the potential of rural-to-urban and urban-to-rural migration. Generating climate-resilient livelihoods and diversifying to green jobs can usher in social and economic transformations that can drive economic growth and prosperity.

Climate migration is the human face of climate change. The World Bank-financed Saint-Louis Emergency Recovery and Resilience Project, which assists the relocation of thousands of households living in the coastal erosion high risk zone, is a reminder that it is not too early to plan and prepare for the escalating and intensifying impacts of climate change. Our commitments to Senegal's poverty goals make such action an imperative.

Nathan Belete,
Senegal Country Director

Simeon Ehui,
Regional Director for Sustainable Development
Western and Central Africa

Vincent Tremeau / World Bank

Executive Summary

MESSAGE 1:

Senegal is a highly mobile country where the potency for climate change to drive internal climate migration will amplify in the coming decades.

The World Bank's Groundswell reports set out the potency for climate change to drive internal climate migration (Rigaud et al. 2018, Clement et al. 2021), with Sub-Saharan Africa being the most affected. An expanded and deeper analysis applied to the Groundswell Africa report, focusing on West African countries, reaffirms this pattern (Rigaud et al. 2021a). The recent study projects that by 2050, without concrete climate and development action, West Africa could see up to 32.0 million people moving within their countries as a consequence of slow-onset climate impacts, such as water stress, drops in crop and ecosystem productivity, and sea level rise compounded by storm surge. These spatial population shifts could represent up to 4.06 percent of the total population of West African countries in 2050. Understanding the scale and the patterns of these climate-induced spatial population shifts is critical to inform policy dialogue, planning, and action so as to avert, minimize, and better manage climate-induced migration for dignified, productive, and sustainable outcomes.

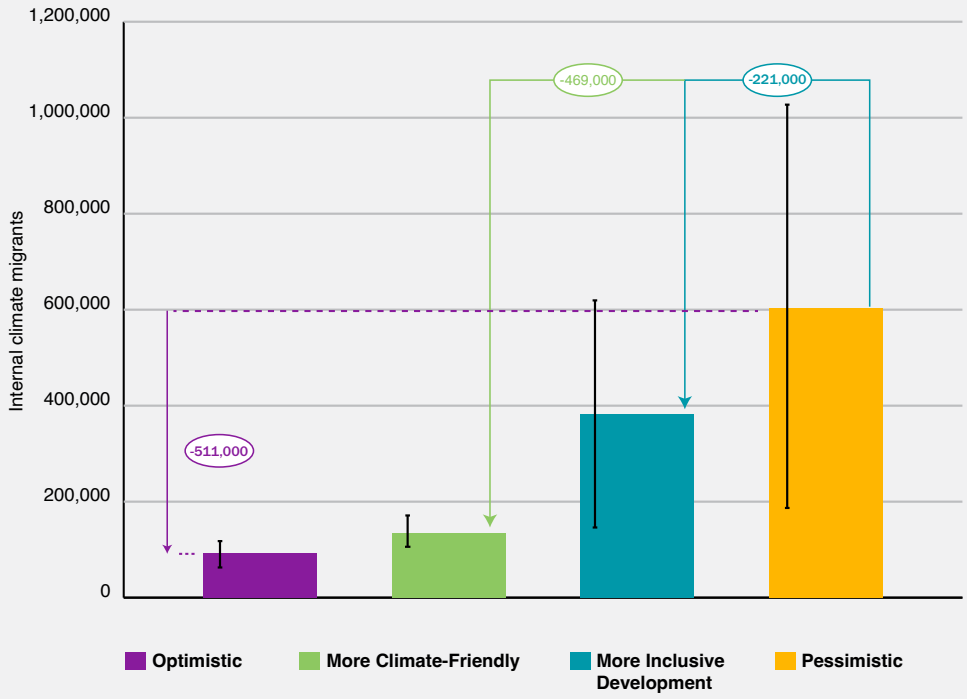
Senegal has a long history of mobility, and migration patterns have historically been dynamic. Movements from rural areas to coastal cities are common, exhibiting a clear east-west divide in population density. Dakar has been the main reception area, driven in part by economic opportunities, including the fishing industry, but internal migratory movements have been unequal across the country. Recent data also show population movement occurring in Senegal because of worsening environmental conditions linked to climate change. Increased water scarcity, reduced pasture availability, and changes in harvesting seasons are causing more frequent tensions between farmers and pastoralists.

Climate change is a reality in Senegal and is projected to affect most of the sectors of the economy directly dependent on healthy ecosystems and natural resources. Senegal is likely to experience rising temperatures, erratic rainfall, increasingly intense rainfall events, flooding, and coastal erosion because of heightened storms and sea level rise. Mobility is frequently used as a coping strategy to address both ex-ante and ex-post risks, especially by the most vulnerable portions of the population. With water becoming increasingly scarce, farmers are expanding their fields into pastoral regions and transhumance corridors, and pastoralists are leaving their villages with their herds earlier in the year

to deal with drought. This often leads to increased tensions between herders and farmers. Migration is a common practice among Niominka fishermen: they move within the country and toward neighboring countries to pursue fish abundance in areas of upwelling, such as The Gambia, Guinea-Bissau, and Mauritania (Sadio et al. 2016).

By 2050, internal climate migration in Senegal could reach up to 1.0 million. This figure will represent 3.33 percent of the population at the high end of the pessimistic scenario, which combines high emissions with unequal development. Under alternative scenarios—the more inclusive and climate-friendly—the scale of climate migration would be reduced. The greatest gains are realized under the optimistic scenario, which combines low emissions with moderate development pathways—and could see a reduction in the number of internal climate migrants of around 85 percent. This underscores the critical need for both inclusive development and low emissions to modulate the scale of climate migration—with the greatest gains achieved through early action. These results are the outcome of the enhanced version of the pioneering Groundswell modelling approach applied to West African countries (Box ES.1).

Figure ES.1 Projected Total Internal Climate Migrants in Senegal by 2050



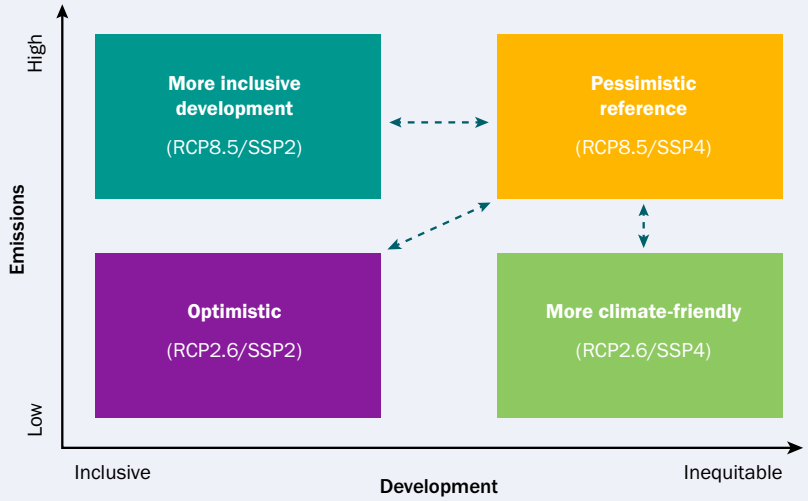
Note: The whiskers represent the lowest and the highest number of internal climate migrants in that scenario.

Box ES.1 An Enhanced Groundswell Model—Applied to the West Africa Groundswell Study

The results described in this study are based on the application of an enhanced version of the pioneering Groundswell model (Rigaud et al. 2018). New features include the optimistic scenario, and additional climate (net primary productivity, flood risk) and nonclimate factors as variables.

A scenario-based approach—reflecting different combinations of future climate change impacts and development pathways—is used to characterize the scale and spread of climate migration by 2050

Projecting Internal Climate Migration under Four Plausible Scenarios



Note:

1. The scenarios are based on combinations of two Shared Socioeconomic Pathways—SSP2 (moderate development) and SSP4 (unequal development)—and two Representative Concentration Pathways —RCP2.6 (low emissions) and RCP8.5 (high emissions).
2. Estimates of climate migrants are derived by comparing these plausible climate migration (RCP-SSP) scenarios with development only (SSP) or the "no climate impact" scenarios

The expanded model provides a more granular analysis and is better placed to inform policy dialogue and action. To estimate the scale of internal climate migrants a population gravity model was used to isolate the portion of future changes in population distribution that can be attributed to climate change as a proxy for climate migration. To capture the effects of slow onset climate factors on internal migration, the methodology used state of the art simulations for crop, water, net primary productivity (NPP), flood risk models, and sea level rise with storm surge. Non-climate factors were considered, including demographic variables (sex and median age) and conflict. This expanded model was also used to analyze internal climate migration in the Lake Victoria Basin Countries (Rigaud et al. 2021b).

MESSAGE 2:

Internal climate migration will ramp up by 2050, and the share of these migrants as a percentage of the total population in Senegal could be one of the highest for West African countries.

For Senegal, all the four modelled scenarios display an upward trend in climate migration, but with important variation between scenarios. The number of internal migrants could see anywhere from a 2.7-fold increase (under the optimistic scenario) to a 4.6-fold increase (under the pessimistic scenario) between 2025 and 2050. At the same time, the trajectory for the pessimistic scenario depicts a sharp upward acceleration in 2045–2050 with escalating climate impacts. The latest science and projections from the United Nations Intergovernmental Panel on Climate Change (IPCC)'s Sixth Assessment Report (2021) on warming and impacts could challenge the prospects of reducing the scale of climate migration.

Compared with other countries in West Africa, Senegal ranks one of highest in terms of the percentage of internal climate migrants relative to its total population by 2050. Senegal's 3.33 percent of internal climate migrants as a percentage of the total population under the pessimistic scenario is followed by Niger and Cape Verde of 30.26 and 6.02 percent. São Tomé and Príncipe (0.09 percent) and Guinea (0.27 percent) rank the lowest. The uncertainty of the future trends in water and crop models account for some of this difference, alongside coastal impacts. No country is immune, but the scale of climate migration depends on the demographic, economic, and climate trends in each country. Early action targeting resilient development aspects—related to the management of climate-related stresses and reducing global emissions—is critical to reducing the scale of climate migrants.

Climate-induced migration could emerge as a dominant type of internal migration in Senegal by 2050. By comparing population projections with and without climate factors, the assessment shows that by 2050 the number of internal climate migrants could outpace the number of people who migrate internally because of development reasons. These projections indicate Senegal's sensitivity to climate and the potency to drive future mobility.

A more focused analysis of the 5-kilometer coastal belt indicates high levels of out-migration toward the hinterland. By 2050, Senegal could have up to 206,000 coastal climate out-migrants. This movement can be explained by sea level rise impacts, compounded by storm surge, which will result in loss of habitable land. While the capital, Dakar, and other centers of economic activity in the coast of Senegal will continue to grow because of their economic opportunities, their population growth will likely be dampened by climate-induced migration. This scale of out-migration is second only to Nigeria—a more populous country—which could see close to 1 million internal migrants from its coastal belt. Early, farsighted, and inclusive action to reinforce these coastal areas with green and gray infrastructure, where appropriate, and comprehensive coastal zone planning is essential.

MESSAGE 3:

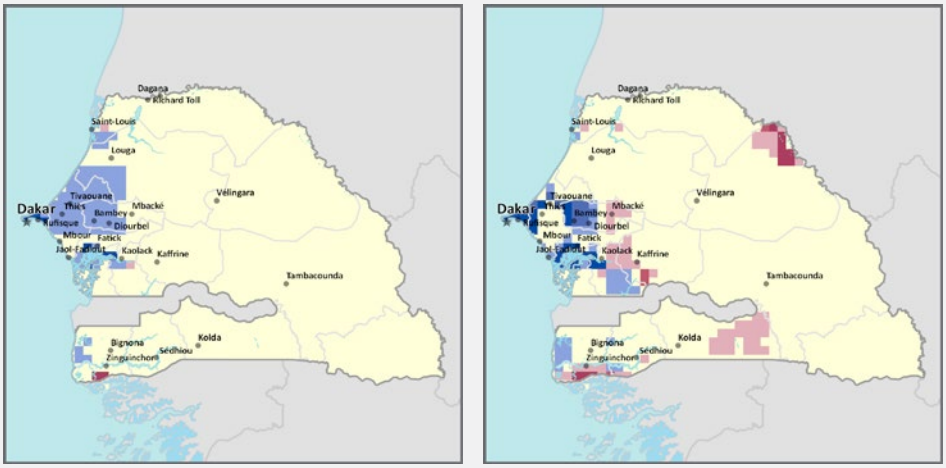
The emergence of internal climate migration hotspots in Senegal–and their convergence with both impoverished areas and centers of economic growth–requires holistic and farsighted approaches to ensure sustainable and durable outcomes.

Climate in- and out-migration hotspots in Senegal could emerge as early as 2030 and continue to increase in strength and spread geographically (figure ES.2, panels a and b). These plausible hotpots represent areas where population movements are considered high certainty across the scenarios modeled. These shifts are in response to the changing viability of ecosystems and landscapes to support livelihoods due to changing water stress and drops in crop and ecosystem productivity. In Senegal, climate in-migration hotspots could be concentrated near the town of Matam on the Senegal River (near the border with Mauritania), near Ziguinchor on the Guinea Bissau border, in eastern Diourbel and western Kaffrine, and south of the border near The Gambia—all areas that have high poverty rates. Focusing on these hotspots and considering the spatial dimension of the challenge will be critical to build resilience and readiness across timescales.

Figure ES.2 Projected Hotspots of Climate In- and Out-Migration in Senegal by 2030 and 2050

a. 2030

b. 2050



IN-MIGRATION

- High certainty in high levels of climate in-migration
- Moderate certainty in high levels of climate in-migration
- Low certainty in high levels of climate in-migration

OUT-MIGRATION

- High certainty in high levels of climate out-migration
- Moderate certainty in high levels of climate out-migration
- Low certainty in high levels of climate out-migration

Note: High, moderate, and low certainty reflects agreement across all four, three, and two scenarios modeled respectively. In- and out-migration hotspots are thus areas in which at least two scenarios concur on density changes. Data is for the top and bottom 5th percentile differences in the density distribution for climate in- and out-migration, respectively.

Climate out-migration hotspots are likely to be concentrated in the west central areas, including Dakar, Thies, Fatick, and Kaolack, all of which coincide with low poverty levels. These trends run counter to the historical migration patterns, which have been toward Dakar from inland areas. Indeed, coastal areas have been a major attraction for rural Senegalese seeking better opportunities. However, floods have displaced thousands of people living on the coast over the past decades (Dakar, Saint-Louis), a situation made worse by rapid urbanization and population growth, insufficient drainage, and rising groundwater tables. Sea encroachment and coastal erosion have also intensified, causing a shrinking of the shoreline, damage to livelihoods, and loss of viability for local communities, especially poorer groups residing in low-lying areas (Rufisque-Bargny). Early and farsighted attention to these emerging hotspots resiliencies important to ensure sustained economic growth and prosperity.

Water stress, crop and NPP losses, and sea level rise are key factors that will influence patterns and scale of internal climate migration in Senegal over the next decades. Generally, areas that see positive deviations in water and crop productivity experience more in-migration, as represented through spatial population distribution shifts. The coefficient for water availability in rural areas is around 2.7 to 2.8 times higher than that of crop production and NPP, illustrating the importance of water availability as a driver of migration. Senegal is almost certain to become drier (decrease in water availability) in the western coastal areas, and under some climate models, the whole country would become drier by 2050. Several models show continued declines in crop production in the northern part of the country and around the Saloum Delta area (Fatick, Kaolack). Sea level rise, compounded by storm surge, included as a spatial mask, will lead to people moving out of inundated and inhabitable areas. In the context of nonclimate factors, higher median age is associated with migrant-attracting urban areas in West African countries, dampening the effect of water stress, which would otherwise drive climate out-migration.

The climate migration hotspots in Senegal are not predestined, but the agreement across the scenarios on climate in- and out-migration underscores the need for farsighted and anticipatory approaches to avert, minimize, and plan for the consequences and opportunities of climate-induced migration. These approaches may require adapt in place measures to protect communities and assets and provide basic services and job opportunities. Managed retreat will be needed in areas that pose high levels of climate risks to enable and support mobility. Action has to span the entire migration life cycle: adapt in place, enable mobility, and postmigration support mechanisms, and consider spatial and temporal scales.

MESSAGE 4:

Global responsibility for swift action to cut greenhouse gas emissions is an imperative and critical for significantly reducing the scale of internal climate migration.

Concerted action at the global level to reduce greenhouse gas (GHG) emissions is an imperative to reduce the climate pressures that drive people to migrate. Commitments to cut GHG emissions globally are off-track to meet the Paris targets and there is an increased urgency for collective global action on this. The latest IPCC report (IPCC 2021) finds that the global average temperature increase will exceed 1.5 °C by the end of the decade unless there is a deep reduction in GHG emissions in coming decades. Without immediate, rapid, and large-scale reductions in GHG emissions, limiting warming may be beyond reach (IPCC 2021). Extreme events are also on the rise and climate-related risks for natural and human systems are higher, with disproportionate impacts on the poorest and most vulnerable (IPCC 2021; UNEP 2020). Current emissions from Sub-Saharan Africa are small but countries are stepping up action on this front. Senegal has committed to unconditionally reduce its GHG emissions by 3, 4, and 4 percent by 2020, 2025, and 2030 (Sénégal Ministere de l'Environnement et du Développement Durable 2015).

Most importantly, however, we need collective global action from high emitting countries to cut their GHG emissions, and avert an escalation of climate impacts that will continue to drive climate migration, even as we recognize that some of these impacts are already locked in. Major GHG emission countries must find direct and indirect ways to complement Senegal's efforts on climate-induced migration.

MESSAGE 5:

Inclusive, resilient, and green development can be nurtured into a positive force through a focus on a core set of policy areas informed by domains of action.

Internal climate migration cannot be divorced from development, and as the human face of climate change, it must be addressed in a holistic, end-to-end manner. The Migration and Climate-informed Solutions (MACS) framework (figure ES.3) brings together domains of action, buttressed by core policy areas, to reduce the scale of climate-induced migration, usher in social and economic transformations, and reduce vulnerabilities. Applying this anticipatory approach will ensure that Senegal's economy is braced not just for the challenges but also the opportunities of climate migration.

The core policy areas, as advocated by the Groundswell report, remain critically important:

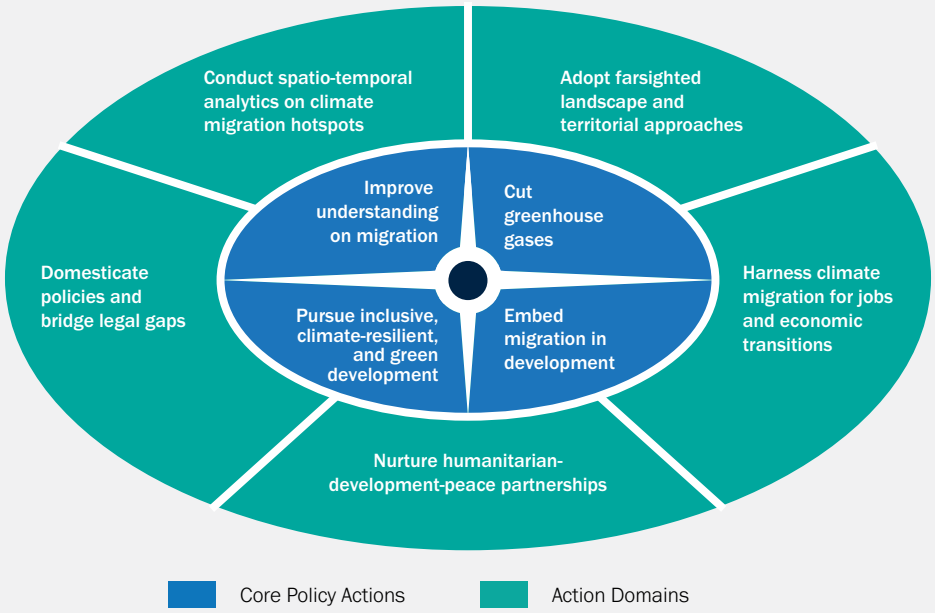
1. Cut GHGs now.
2. Pursue inclusive, climate-resilient, and green development
3. Embed climate migration in development planning.
4. Invest in an improved understanding of migration.

The diversity of contexts in Senegal where internal climate migration will play out calls for focused attention and solidarity, which can be guided by five action domains to avert migration driven by adverse impacts of climate change. These include:

- Conduct spatio-temporal analytics to understand the emergence of climate migration hotspots.
- Adopt farsighted landscape and territorial approaches.
- Harness climate migration for jobs and economic transitions.
- Nurture humanitarian-development-peace partnerships.
- Domesticate policies and bridge legal gaps.

Action must be pursued through dedicated local and national action and regional cooperation, as appropriate.

Figure ES.3 Migration and Climate-informed Solutions (MACS)[a]



Source: Rigaud et al. 2021a.

a. MACS was derived as part of the two Groundswell Africa regional reports: *Groundswell Africa: Internal Climate Migration in West African Countries* (Rigaud et al. 2021a) and *Groundswell Africa: A Deeper Dive into Internal Climate Migration in the Lake Victoria Basin Countries* (Rigaud et al. 2021b).

Box ES.2 MACS Framework

The MACS framework is the outcome of the World Bank's efforts through the Groundswell reports (Rigaud et al. 2018; Clement et al. 2021) and subsequent deeper dives via Groundswell Africa (Rigaud et al. 2021a and 2021b) to better understand the implications of climate-induced migration and mainstream this phenomenon into development plans, programs, and policies. It stems from the result of the abovementioned modeling exercise, contextualized against current and historical mobility patterns, peer reviewed literature, and multi-stakeholder consultations. A portfolio review of the design features of 165 World Bank projects operating at the climate-migration-development nexus further informs this framework (Rigaud et al. 2021c). MACS is flexible and adaptive, based on the premise that climate migration is linked to broader development challenges across spatial scales. It can guide policymakers and practitioners by offering critical information and insights related to development and policy implications of climate-induced internal migration. This reflects the call for anticipatory approaches over larger time and spatial scales to avert and minimize the adverse consequences of climate-induced migration and harness opportunities brought forth by migration.

The right set of climate and development policy, underpinned by the MACS framework and in alignment with country's development vision and plans, can help avert adverse outcomes while harnessing the opportunities of climate-induced migration. The Plan Senegal Emergent (PSE)—Senegal's National Development Plan—and the World Bank's Systematic Country Diagnostic (SCD) and Country Partnership Framework (CPF) provide important platforms to prepare, plan, and respond to climate migration in Senegal. These include job diversification, land management, landscape programming, climate change resilience, and resource and environmental risk management. These platforms present untapped opportunities to further mainstream and embed climate migration and policies through a multisectoral response that ensures short- and medium-term positive and sustainable environment, development, and social outcomes

for Senegal. Two examples of World Bank operations addressing some of the key dimensions of mobility in a context of a changing climate are (i) the Saint-Louis Emergency Recovery and Resilience Project, which supports planning for relocation of populations and for strengthened urban and coastal resilience in greater Saint-Louis, and (ii) the Storm Water Management and Climate Change Project, which builds drainage infrastructure in peri-urban areas of Dakar and other coastal zones prone to flooding. Senegal's Nationally Determined Contributions (NDCs) provide ample opportunity to embed mitigation policies in performance standards, such as carbon pricing, urban and land use planning, and innovations.

The development community is not starting from zero. The World Bank (Rigaud et al. 2021c) carried out a portfolio review to draw actionable insights from 165 World Bank projects operating at the climate-migration-development nexus with commitments amounting to US$197.5 billion (from 2006 to 2019). The portfolio review findings show that a more systematic and anticipatory approach in designing projects geared toward addressing climate migration is possible. Increasingly, projects not only address migrants' direct needs but also provide for enabling interventions (early warning systems and social safety nets) and address underlying causes of mobility by investing in environmental restoration. There is a need to step up these measures with great vigor and urgency—acting in partnership and engagement of those directly affected.

MESSAGE 6:

Senegal must act boldly and urgently on internal climate migration—delaying action will raise the stakes considerably.

The call for action on internal climate migration is clear and compelling. The potential scale of the issue, trends, and emergence of climate migration hotspots as early as 2030 should have major implications on conceiving effective responses. The domains of action set out in the MACS framework provide a pragmatic and farsighted approach to addressing internal climate migration—delaying action will raise the stakes considerably. They can bolster the delivery of the core policies to reduce, avert, and minimize distress-driven internal climate migration.

Investing in iterative scenario modeling, grounded in new data and development progress, will be crucial to support decision-making. Such investments should try to facilitate long-term planning, such as in adaptive capacity, to secure climate resilience. This will require not only action at the international and national level but also locally.[1] The Sahel Irrigation Initiative Support Project and the Senegal River Basin Climate Change Resilience Development Project, both ongoing operations supported by the World Bank, illustrate climate-smart approaches to natural resource management.

Landscape and territorial approaches will enable early planning and action across spatial and time scales in climate in- and out-migration hotspots. Climate change can change the desirability and comparative advantage of land and natural resource degradation, and this could have implications on migration patterns. A holistic approach to addressing the underlying causes of the adverse consequences of climate migration, the role of land and water degradation, and the ability to support livelihood in the face of both slow- and rapid-onset climate factors and their interlinkages is important in Senegal. Mapping emerging hotspots and understanding climate impacts and their adverse consequences on community livelihoods will be key. Senegal's coastal area is crucial to the country's economic activity and the main destination of internal migrants. Yet it is highly vulnerable to climate change and extreme events. Dakar attracts high tourism flows and has significant infrastructure investments but is highly exposed to natural hazards. Hosting

1 The findings of this report can serve as a useful guidance tool to hold on-the-ground dialogue with stakeholder groups and develop concrete policy response that caters to the particularities of local context.

23.2 percent of the total population concentrated in 1 percent of the country's territory, Dakar is projected to see a dampening of its population growth due to climate out-migration as early as 2030 due to sea level rise, compounded by storm surges. In such cases, early action to fortify coastal assets with green and gray infrastructure must be optimized through adapt in place options, while considering participatory planned relocation as part of longer-term solutions. Further analysis of climate change impacts on landscape, terrestrial, and marine ecosystems, and natural habitats with community-focused planning, is a step forward. Supporting Integrated Coastal Zone Management (ICZM) plans and analyzing adaptation options are good entry points for communities, such as in the Casamance estuary, to address the delicate balance between the coastline and riverine estuaries and potentially avoid loss of land and livelihoods due to severe marine erosion.

Climate-induced migration provides opportunities to foster climate smart jobs and support economic structural transformation in Senegal. With more erratic rainfall patterns and a projected decrease in agricultural productivity, there is an opportunity to absorb the labor and large youth bulge into value-added end-to-end agriculture, and nurture transitions to nonagricultural and less climate-sensitive sectors for both climate migrants and hosting communities. This approach would support Senegal's overall strategy to develop site-specific growth poles (zones économiques spéciales) and industrial or multiservice hubs with high potential for employment, including green economy jobs and increased regional integration. Boosting secondary cities in Senegal and enhancing greater linkages between rural and urban spaces through better physical and virtual connectivity will provide opportunities for migrants and contribute to reducing spatial and territorial inequalities. Creating and incentivizing shifts away from highly vulnerable coastal areas through growth poles cities are proven solutions.

Cooperation among the development, humanitarian, and peace communities working across the mobility continuum could support Senegal to achieve holistic and durable solutions to climate-induced migration and displacement. This approach can benefit from the comparative advantage of different actors to strengthen local capacity. Ultimately, holistic approaches can reduce risk and vulnerability through well-aligned short-, medium- and longer-term contributions by humanitarian and development actors. World Bank financing instruments and other technical support modalities provide support to climate migrants, and there is potential for further support focusing on development opportunities and policies for the safe movement of people and provide viable options for in situ adaptation.

A well-defined, equitable, and implemented legal architecture brings clarity, protects affected individuals and communities, and reconciles international funding and local decision-making. It ensures that migration acts as a force of good for all strata of the society. Ensuring that existing legal frameworks are in line with the Kampala Convention and international frameworks such as the Guiding Principles on Internal Displacement will bolster the legal architecture to address climate-induced migration.

While a potent and daunting challenge, climate-induced migration presents an opportunity for Senegal to advance socioeconomic goals. It presents a policy challenge that cannot be wished away but should be tackled holistically and effectively through evidence-based, participatory action. Climate-friendly, inclusive development can significantly reduce the scale of migration and serve as the first line of defense. The country can embark on a green, resilient, and inclusive path for development by exploiting new economic opportunities and recognizing that these structural transformations will need to take place in a context of climate change and internal climate migration. Foresighted and transformative action, across the migration cycle, will go a long way to ease people out of vulnerability and help secure the foundations of a peaceful, stable, and secure Senegal.

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Chapter 1

Introduction

Climate change has emerged as a potent driver of migration. In 2018, the World Bank launched the flagship report *Groundswell: Preparing for Internal Climate Migration* (Rigaud et al. 2018), which projected that without concrete climate and development action, more than 85 million people could be forced to move within their countries in Sub-Saharan Africa by 2050. In the same study, West Africa is projected to have up to 54.4 million internal climate migrants by 2050 under the pessimistic scenario. The Groundswell report underscored that early and concrete inclusive development undertaken at local and national level, coupled with global action to reduce greenhouse gas emissions, could reduce the number of climate migrants significantly, by as much as 80 percent in the case of Sub-Saharan Africa.

Recent natural hazards and disasters have led to significant displacements in Sub-Saharan Africa. In 2020, around 4.3 million people in Sub-Saharan Africa had to flee their homes due to natural hazards, according to the latest Internal Displacement Monitoring Center (IDMC) Global Report on Internal Displacement (GRID) (IDMC 2021). In addition, there were also 6.8 million new internal displacements associated with conflict and violence in 2020 (IDMC 2021). Countries in West Africa are exposed to a variety of natural and potentially damaging events. High tides, storms, and heavy precipitation are responsible for both "slow" but permanent processes (such as coastal erosion) and rapid but temporary phenomena (such as coastal and riverine flooding). Other natural disasters in West Africa include intense drought and extreme temperature fluctuations.

In Senegal, the total number of new displacements due to disasters in 2020 was estimated at 3,300. In contrast, the total number of Internally Displaced Persons (IDP) due to conflicts as of December 31, 2019, was estimated at 8,400 (IDMC GRID 2021). Flooding is a recurrent annual event in Senegal affecting between 100,000 and 300,000 people (OCHA 2013). The economic cost of extreme weather events, exacerbated by poor urban planning, is overbearing for countries in the region. In 2009, floods caused more than $103 million in damages and losses in and around Dakar (World Bank 2012b).

West Africa has one of the highest rates of human mobility in the world owing to a long history of trade (trans-Saharan and intra-regional), nomadic pastoralism, dry season migration for livelihood diversification, legacies of colonialism (labor expropriation from the interior towards coastal plantations), and economic linkages to former colonial powers. Migration has been greatly facilitated by an enabling policy framework, the free movement protocol of the Economic Community of West African States (ECOWAS), which enshrines the ability of West African citizens to live and work in any country of the region. The region has also experienced and is likely to continue to experience some of the worst impacts of climate change, including rising temperatures, erratic rainfall, increasingly intense rainfall

events, flooding, and coastal erosion owing to heightened storms and sea level rise. When coupled with the high dependence of most coastal countries on the agriculture and fisheries sectors, a growing coastal tourism sector, as well as the high concentration of people and assets along the coast, the economy and livelihoods of West African countries are highly vulnerable to climate variability and change.

While climate-induced migration is a reality, it does not have to be a crisis. Governments and development partners can no longer assume that the evolution of population distributions will remain unchanged. Productive systems may reach limits to adaptation as climate impacts become more severe over the course of this century, which may result in shifts in population distribution as mostly rural agriculturalists move from highly impacted areas towards regions with better conditions for the crops and livestock on which they depend. More importantly, in areas where development deficits and adapt-in-place opportunities persist, the chances for internal migration may be accelerated as people move to secure livelihood options in areas that are more viable.

Understanding when, where, and how climate migration will unfold is critical for countries and communities to pursue the right policies and targeted action. It is recognized that the drivers of displacement in the region are a complex overlap of social, political, economic, and environmental factors, particularly slow-onset hazards such as drought, desertification, coastal erosion, and land degradation. Policy decisions made today will shape the extent to which the effects of climate change will be positive for migrants and their families. Inaction would mean missing a vital opportunity to reconfigure where, when, and how climate-resilient investments are made in support of robust economies.

1.1 SCOPE, OBJECTIVE, AND METHODOLOGY

Scope and Objective

West Africa is one of the regions in the world that has been most frequently identified as a hotspot of current and future climate impacts (Muller et al 2014; Niang et al 2014; Turco et al 2015). Major impacts identified in the literature include rising temperatures, heat waves, erratic rainfall (delays in monsoon onset or dry periods during the rainy season), increasingly intense rainfall events, flooding, and coastal erosion owing to heightened storms and sea level rise.

As climate change affects precipitation and temperature in West Africa, this has consequences on livelihoods, particularly where these are climate sensitive—including the agriculture, pastoral, and livestock-related sectors. West Africa faces the distinct possibility of increasing rates of mobility both within countries and across international frontiers. While recent economic growth in the region has fueled migration to urban areas, it also has made rural areas more viable than in the past due in part to the agriculture-led nature of this growth. Understanding the scale of internal climate migration and the patterns of people's movements is critical to countries so they can plan and prepare.

The objective of this Senegal-focused report is to convey the potency of climate-induced migration within Senegal to inform policy makers about the urgency for near and far-sighted planning, policy, and as an integral part of the development responses.[2] The report provides a quantitative and qualitative understanding of plausible migration scenarios and proposes core policy direction and domains for action to better anticipate and prepare for the issue. The importance of overarching policies that embed climate risks and opportunities, as well as climate migration into national and local development planning are paramount.

2. This report draws from *Groundswell Africa: Internal Climate Migration in West African Countries* (Rigaud et al. 2021a) but undertakes a deeper dive on the analysis.

Methodology

This Senegal study, as part of the West Africa study, applied the Groundswell model described in the World Bank report, Groundswell: Preparing for Internal Climate Migration (Rigaud et al. 2018) with several enhancements that are described below.

The Groundswell model uses a combination of empirical modelling and qualitative assessments of climate migration trends at the national and local levels to lay out a set of future climate scenarios.

The key elements of the Groundswell methodology (Box ES.1) are the following:

- The Groundswell uses a **population gravity model** that isolates the portion of future changes in population distribution, accordingly to the perceived attractiveness of different locales, to **slow-onset climate factors** over time.
- It develops **plausible scenarios** to characterize the **scale and spread of climate migration** using representation concentration pathways (RCPs) and shared socioeconomic pathways (SSPs) that include assumptions about future urbanization rates, education levels, and technological change.
- The SSPs span possible future development pathways for the world and describe trends in demographics, human development, economy, lifestyles, policies, institutions, technology, the environment, and natural resources. The SSP2 (moderate development pathway) and SSP4 (unequal development pathway) used in the model reflect the degree to which the scenarios represent challenges to mitigation (greenhouse gas [GHG] emissions reductions) and societal adaptation to climate change. SSP2 represent moderate challenges for both, and SSP4 represents high challenges for adaptation, low for mitigation (O'Neill et al. 2014).
- Results are **contextualized** against current and historic mobility, peer-reviewed literature, and multistakeholder consultations to further inform patterns of migration and the proposed response framework.

The expanded methodology used for this study includes the following enhancements:[3]

(i) Four scenarios

The Groundswell methodology used three scenarios based on SSPs and RCPs: the pessimistic (reference), more inclusive development, and climate friendly. The enhanced model adds a fourth, optimistic scenario, which combines low emissions (RCP 2.6) and an inclusive development pathway (SSP2).

The selected development scenarios include a "moderate development" and an "unequal development" scenario. Under the moderate development scenario, low- and middle-income countries are characterized by moderate population growth, urbanization, income growth, and education. Under the unequal development scenario, low- and middle-income countries follow different pathways. Low-income countries have high population growth rates and urbanization, and low GDP and education levels. Middle-income countries have low population growth rates, high urbanization, moderate GDP, and low education levels. Inequality remains high both across and within countries, and economies are relatively isolated, leaving large, poor populations in developing regions highly vulnerable to climate change with limited adaptive capacity.

The climate migration forecasts are also based on two emissions scenarios. The lower emissions scenario is a world in which temperatures peak at 0.25°–1.5°C above recent baseline levels by 2050 and then stabilize through the end of the century (IPCC 2014). This is the world of the Paris Agreement, in which countries work together to reduce greenhouse gas emissions to zero within the next 15–20 years (Sanderson et al 2016). In the higher emissions scenario, temperatures rise by 0.5°–2°C by 2050 and by 3°–5.5°C by 2100.

3. For full details on the enhancements, see Rigaud et al. 2021a.

(ii) Slow and rapid onsets

For the first time, the Groundswell model used actual climate impact models for agriculture and water resources to understand how these would affect future population distributions, as well as sea level rise compounded by storm surge (Rigaud et al. 2018). The expanded model also includes another slow-onset impact (ecosystem impacts) and rapid-onset events (such as flood risk projections), in addition to data related to conflict areas.

(iii) Coefficients

The enhanced model includes model coefficients that show the influence of the variable on the observed deviation between observed population change and projected population change (spatial shifts) based on historical calibration of climate signal from 1990–2000; and 2000–2010. The variables are crop production, water availability, net primary productivity (NPP), median age, sex ratio, conflict-related fatalities, and flood risk. Crop productivity and net primary productivity are not included in the calibration for urban populations because these would not be hypothesized to have an impact in those areas, since their populations are not directly dependent on cropping or animal husbandry.

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The coefficients for the West Africa countries in Table 1.1 represent the average of the coefficients across the two decades for Mauritania, Guinea, and Sierra Leone—the only three countries that had population data that met the criteria needed to undertake the calibration. Note that sea level rise is not considered a driver of migration, but rather is inserted as a spatial mask in the modeling work, to move populations out of inundated areas.

Table 1.1 Coefficient Values for West African Countries, Representing an Average of the Calibrations Using Historical Data for Mauritania, Guinea, and Sierra Leone

Indicator (Driver)	(Parameter) Coefficient		Units
	Urban cells	Rural cells	
Crop production	n/a	0.400	5-year deviation from historic baseline
Water availability	1.696	1.071	5-year deviation from historic baseline
Net primary productivity*	n/a	0.380	5-year deviation from historic baseline
Median age	0.617	0.078	Median age of the population in years
Sex ratio	0.024	0.006	(Males/females) ratio
Conflict-related fatalities	-0.025	-0.003	Number of recorded fatalities
Flood risk	0.147	0.020	5-year likelihood of flood event

* Net primary productivity, which is intended to reflect impacts on pastoral populations, is only included in the model where crop production is not present; n/r = not relevant.

Among the climate impacts, *water availability* is the strongest factor, particularly in urban areas, positively correlated with population change—meaning increasing water availability results in increasing attractiveness and vice versa. The coefficient for water availability in rural areas is around 2.7–2.8 times higher than that of either crops or NPP. Other things being equal, areas with better water availability (as measured by the deviation from historic baseline) are projected to have relatively large positive population changes. In rural areas, larger values in crop yields or NPP are also positively correlated with larger population change. The magnitude of the coefficient crop and NPP coefficients are smaller, so their effect is not as strong as water availability.

Demographic variables of median age and sex (gender) distribution, introduced in this study's enhanced model, affect the climate migration projections through their relationship with population change (as derived through the spatial autoregressive calibration), and through their interaction with the climate drivers. In West Africa, the demographic variables mitigated or dampened climate migration. Results imply that while high median age tends to draw migrants to urban areas, which offer better economic opportunities, declines in water availability repel migrants, thereby offsetting each other. In short, when demographic effects are working against climate impacts, there are fewer migrants in West Africa. In contrast, in the Lake Victoria Basin (LVB) countries, the alignment between these factors means that they amplify the impact of climate (Riguad et al. 2021b).

Spatial data on conflict occurrence was obtained from the Armed Conflict Location & Event Data Project (ACLED) database, downloaded in September 2018 (Raleigh et al. 2010).[4] A spatial layer was developed of the point locations of every conflict event for the 10 years spanning 2009 to 2018, and the values at each point were the number of fatalities, determined using spatial kriging (a form of interpolation). As expected, conflict-related fatalities are negatively correlated with population change, decreasing attractiveness, again with a stronger effect in urban areas. While the coefficients are small, the range in values is the largest among all layers (from 1 to 259), which means its relative impact in conflict areas is large.

4. See http://www.acled.org. Raleigh, C., A. Linke, H. Hegre and J. Karlsen (2010). Introducing ACLED-Armed Conflict Location and Event Data. Journal of Peace Research, 47(5) 651-660. https://doi.org/10.1177/0022343310378914

Finally, flood risk is positively associated with population change, and once again, the effect is larger in urban areas. Clearly floods do not attract populations; rather it is likely that this reflects the location of many urban areas in coastal areas and flood plains, which are historically prone to flooding.

(iv) Sea level rise and storm surge

The analysis for sea level rise (SLR) is based on projections to 2050 based for the RCP2.6 and RCP8.5 scenario, augmented with an increment to account for storm surge (table 1.2). The modeling results reflect loss of habitable land for each coastal grid cell linearly interpolated for five-year time steps. Storm surges amplify loss of habitability in the near-term through erosion of coastal landforms that results from wave action. According to Dasgupta et al. (2007), "Even a small increase in sea level can significantly magnify the impact of storm surges, which occur regularly and with devastating consequences in some coastal areas."

Table 1.2 Projected Rise in Sea Level Under Low and High Representative Concentration Pathways (Meters Above Current Mean Sea Level)[5]

	RCP 2.6			RCP 8.5		
Year	Lower	Middle	Upper	Lower	Mid	Upper
2030	0.092	0.127	0.161	0.098	0.132	0.166
2050	0.157	0.218	0.281	0.188	0.254	0.322
Storm surge increment	0.89–0.9			1.68–1.85		

Source: CIESIN 2013; Church et al. 2013

(v) Flood models used in the gravity model

The original Groundswell modeling did not include flood hazards. The addition of flood hazards for West Africa is born out of a recognition that it has an important impact on displacement, even if its impacts are highly localized. The flood hazard layer is based on projected flood depth simulated by a global flood model CaMa-Flood (Yamazaki et al. 2011) version 3.4.4. It primarily represents riparian (along rivers) and not coastal flooding, although it does capture rivers emptying into the ocean. Potential coastal flooding is better captured by the sea level rise mask (below). The input required by this global flood model is daily runoff simulated by multiple global hydrological models participating in the ISIMIP2b (Frieler et al. 2017) project. These hydrological models are formed by four bias-corrected climate model outputs (temperature, precipitation, radiation, etc.) from the Coupled Model Intercomparison Project phase 5 (CMIP5; Taylor et al. 2012).

The flood hazard data were used to aid in calibration of the model by establishing a baseline relationship between the return rate of 100-year flood events and spatial patterns of observed population change (along with multiple additional drivers). This relationship contributed to projections of future spatial population change. Note that paradoxically, flooded areas tend to attract population in the gravity model, since riparian areas were historically more accessible and often host urban areas. Thus, up to a point, flood risk will tend to attract new migrants rather than repel them.

5. Both the 1- and 2-meter sea level rises are based on NASA Shuttle Radar Topography Mission data, as modified by the Center for International Earth Science Information Network for the Low Elevation Coastal Zone (LECZ) version 2 data set (CIESIN 2013). The increment for storm surge was 0.85–0.9 meters, for a total of 1 meter; under RCP8.5, the increment was 1.68–1.85 meters, for a total of 2 meters.

(vi) Time and resolution

Scenarios were run in decadal increments from 2010 to 2050, calibrated on data from 1990 to 2010. The future population projections incorporating climate impact scenarios were compared to future population projections without climate impacts to derive estimates of climate migration for 14-kilometer grid cells. Scenarios in the enhanced model run in 5-year increments from 2010 to 2050 and are performed on population data at 1-kilometer resolution; climate migration analysis is carried out at 1 kilometer in the near coastal zone and 14 kilometers elsewhere.

1.2 OUTLINE OF THE REPORT

This country report is divided into four chapters. This first chapter underscores the potency of climate-induced migration and displacement in Sub-Saharan Africa and lays out the scope, objectives, and methodology as applied to Senegal. Chapter 2 sets out the development, demographic, migration, and climate context for Senegal, including an overview of historic migration patterns and a brief snapshot of environment-related migration and displacement. Chapter 3 presents the modeling results and plausible future climate migration scenarios from 2020–50—as spatial shifts in future population projections in response to climate impacts. Chapter 4 presents and discusses core policy directions and a set of key domains of action that can be leveraged to foster concrete climate and development action that encompasses near and far-sighted approaches to avert, minimize, and manage internal climate migration and displacement for sustainable growth and resilient and inclusive outcomes.

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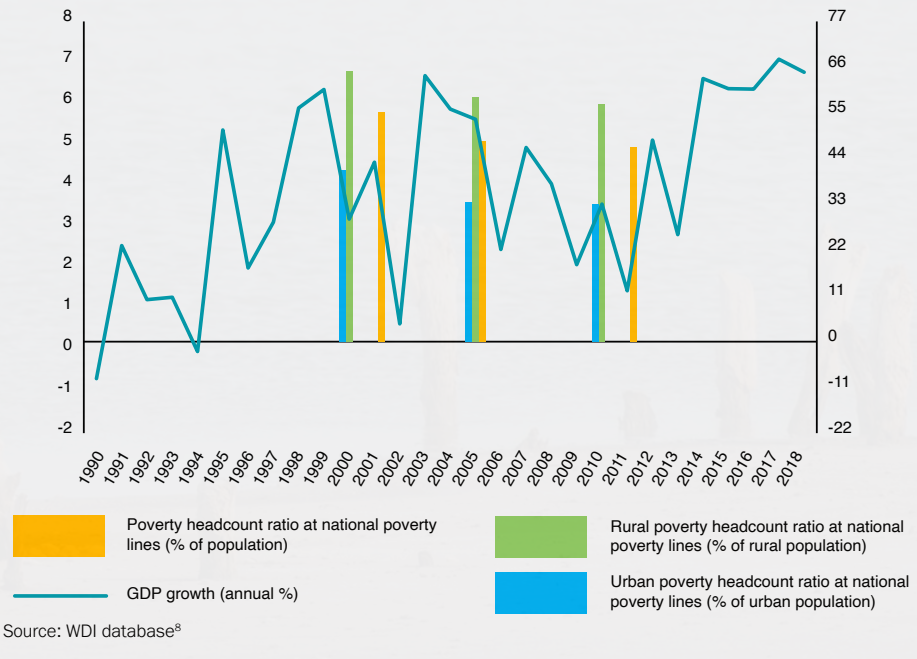
Chapter 2

Country Context

2.1 POPULATION AND DEVELOPMENT CONTEXT

Located in the westernmost part of Africa, and classified as a lower-middle income country, Senegal has experienced steady economic growth and poverty reduction since 2014 (figure 2.1). This remarkable development over the past decade marks a strong departure from earlier periods of slow and volatile growth.[6] This evolution is, for the most part, the result of prudent fiscal policies and reforms, strong export performance and product diversification, and a favorable international environment (World Bank 2018b). The country has witnessed rural development, agriculture modernization, the emergence of the oil and gas industries, and increasing employment in the services sector (Van den Broeck and Maertens 2017). Endowed with relatively good agro-ecological conditions, Senegal has exhibited high urbanization rates, with almost half of its population living in cities.[7]

Figure 2.1 Socioeconomic Trends



Source: WDI database[8]

6. See the World Bank Development Indicators (WDI) database, https://datacatalog.worldbank.org/dataset/world-development-indicators
7. According to the country's administrative map, there are 14 regions in Senegal with 45 departments, 110 communes, and 320 rural communities.
8. See the World Bank Development Indicators (WDI) database, https://datacatalog.worldbank.org/dataset/world-development-indicators

Senegal's population is young and could double by 2050. The total population was 15.9 million in 2017, with an average annual growth rate of 2.8 percent, and a median age of 18.1 years in 2015 (UN DESA 2019). This rate is high when compared with the global average rate of 1.1 percent for 2015–20, but close to Africa's average rate of 2.5 percent (UN DESA 2019). In mid-2019, 62 percent of the population was less than 25 years old (UN DESA 2019). With a population estimated at 33.1 million in 2050, the Senegalese population is expected to double in just 30 years (UN DESA 2019). Population growth in Senegal is slowing down gradually with growth rates projected to be close to percent in 2050. As population growth declines and life expectancy increases, median age is projected to reach 25 years in 2050. In terms of gender distribution, the sex ratio (males per 100 females) was 94.7 in 2015, lower than the global ratio of 101.7 and the African ratio of 99.7 (UNDESA 2019).

Despite contribution to GDP below 20 percent, agriculture continues to be a major employer in the country, accounting for approximately 31.5 percent of total employment (Table 2.1).[9] Long-term growth in agriculture has been slow and volatile, subject to climatic shocks linked to changing rain patterns. More recently, Senegal's agriculture has witnessed signs of incipient diversification, with significant increase in the sales of fresh horticulture produce for exports and a growing role for irrigated products (World Bank 2018b). Senegal's diversification has relied on producing more cash crops to generate revenues from exports. Other sectors like fisheries, livestock, or forestry employ a significant number of people in Senegal. For example, the artisanal fisheries sector employs 17 percent of the working population.[10]

However, the country still shows high and increasing levels of inequality. According to the World Development Indicators (WDI),[11] the GINI Index value for Senegal was 40.3 in 2010, up from 39.2 in 2005. Senegal is one of the least developed countries in the world, with 47 percent of the population living under the national poverty line and a score of 154 out of 186 on the Human Development Index (HDI) (World Bank 2020c). In addition, national figures mask noticeable within-country differences in development achievements. For example, poverty levels are higher in the southern and eastern areas of the country, which are less densely populated and more rural rainfed dominated areas. Looking ahead, the projections show that the combined impacts of COVID-19, conflict, and climate change will disproportionately affect Sub-Saharan Africa and the poorest segments of the population in particular (after South Asia).[12]

Based on the Human Capital Index (HCI) benchmarking calculations, Senegal was ranked 121 out of 157 countries in the global HCI. The global index shows how shortfalls in health and education among children today will reduce the productivity of the next generation of workers. A child born in Senegal today will be only 42 percent as productive when she grows up, as she could have been if she enjoyed complete education and full health. This is higher than the average for Sub-Saharan Africa region but lower than the average for lower middle-income countries. Between 2010 and 2020, the HCI value for Senegal increased from 0.39 to 0.42.[13]

9. See the World Bank Development Indicators (WDI) database, https://datacatalog.worldbank.org/dataset/world-development-indicators
10. See the World Bank Development Indicators (WDI) database, https://datacatalog.worldbank.org/dataset/world-development-indicators
11. See the World Bank Development Indicators (WDI) database, https://datacatalog.worldbank.org/dataset/world-development-indicators
12. According to the Poverty and Shared Prosperity report (World Bank 2020c), "nowcasts of the pandemic's global poverty impacts through 2021 suggest that Sub-Saharan Africa will be the second most severely affected region (after South Asia), with 26 million to 40 million more of its people falling into extreme poverty. Whereas the region accounts for slightly more than 10 percent of the global population with high flood risks, it is home to more than half of the global poor facing high flood risks."
13. See the Human Capital Index (HCI) database: https://databank.worldbank.org/data/download/hci/HCI_2pager_SEN.pdf?cid=GGH_e_hcpexternal_en_ext

Table 2.1 Development Indicators

Population	
Population (millions)	15.9
Annual population growth (%)	2.8
Population in 2050 under SSP2 (millions)	24.3
Population in 2050 under SSP4 (millions)	30.5
Urban share of population (%)	47.2
Employment in agriculture (% of total employment) (2019)	31.5
Employment in artisanal fisheries sector (% of working population) (2017)	17.0
Households in agriculture (% of total number of households in 2013)	32.5
Households in livestock (% of total number of households in 2013)	13.2
Households in fishing (% of total number of households in 2013)	1.0
GDP	
GDP (current $ billions)	24.1
Annual GDP growth (%)	6.8
GDP per capita (current $)	$1,522.00
Value added of agriculture (% GDP)	16.6
Poverty	
Poverty headcount ratio at $1.90 a day (PPP. 2011) (% of population) (2011)	38.0
Climate and disaster risk indices	
ND GAIN Index (2017)	
Rank (lowest rank: 181)	131
Score (best score: 76)	39.9

Note: except when noted, data is for 2018.

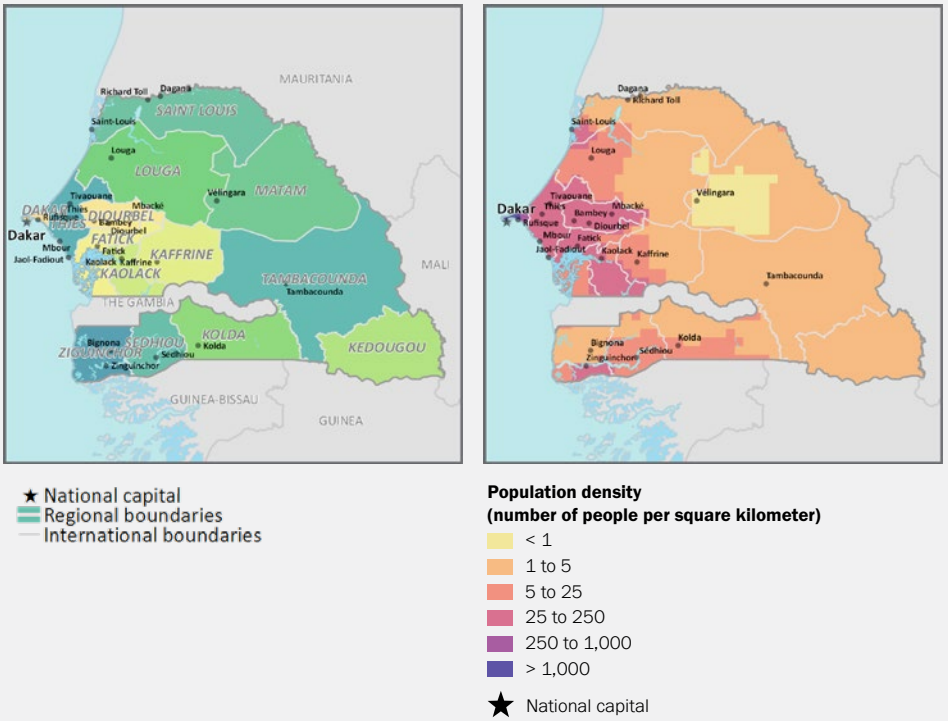
Source: WDI database[14]

Note: The ND-GAIN Country Index, a project of the University of Notre Dame Global Adaptation Initiative (ND-GAIN), summarizes a country's vulnerability to climate change and other global challenges in combination with its readiness to improve resilience. A higher score is better. For more information on ND-GAIN, see: https://gain.nd.edu/

Population distribution is highly unequal, with almost a quarter of the population clustered in and around Dakar, the national capital (figure 2.2). Internal migration, fueled by the concentration of economic activities and opportunities in the coastal areas, has played a large role in creating this pattern (IADD 2019). However, despite the concentration of population in the national capital, Senegal has yet to complete the urban transition,[15] as 53 percent of its population still lived in areas classified as rural in 2017. Recent projections indicate the transition will be complete by 2025, the outcome of a high annual urbanization rate of more than 3 percent until 2040 (the world rate is below 2 percent) (UN DESA 2018). Population density around Velingara in the Matam region is low as the area is a dry savanna, which harbors the Ferlo Nord and Ferlo Sud wildlife reserves and is home to the Fulani people.

14. See the World Bank Development Indicators (WDI) database: https://datacatalog.worldbank.org/dataset/world-development-indicators
15. The term indicates that a country population is moving to a predominantly urban population. It is not an assessment of the quality of urban living (UNFPA 2007).

Figure 2.2 Reference Map and Population Density, 2010



Senegal has witnessed relatively limited structural transformation of its economy. The country has experienced some level of productivity increase within sectors, and a shift from agriculture into informal trade and commerce partly due to the urbanization process, but very limited shifts to sectors with high and growing productivity, such as high value-added services, manufacturing, or technology-led industries. While the unemployment rate in Senegal is rather low at 6.1 percent in 2015 it is accompanied by a high rate of time-related underemployment. Underemployment is more prevalent in rural areas, where 40 percent of the population works in highly seasonal rainfed agriculture. As much as 92 percent of the workforce is employed in the informal labor market (World Bank 2018b).

Employment has not managed to lift people out of poverty, in particular the poor. Since 2011, employment has picked up, but the jobs created have been of very poor quality and mostly concentrated in commerce, a sector characterized by high informality and low (and decreasing) productivity, partially due to the inadequate skill levels of the labor force. In 2015 inactivity was still very high (at 58.5 percent) and so was underemployment (at 29.5 percent in rural and 10.3 percent in urban areas). Young adults aged 15–34 are among the most affected, showing the highest unemployment rate at 9 percent, as well as high inactivity and underemployment rates, respectively, at almost 60 and 22 percent (World Bank 2018b).

2.2 MIGRATION PATTERNS

Migration patterns have historically been dynamic in Senegal. Indeed, given its geographical location in West Africa, Senegal can be considered simultaneously a country of origin, destination, and transit. Pastoralism, which is inherently mobile, has seen increasing levels of mobility as a coping adaptation strategy in Senegal to address severe weather conditions such as prolonged droughts particularly those of 1970s and 1980s (Grechi and Agustoni 2017). The first massive migration from the countryside to the cities and then to Europe and France, the former colonial power, goes back to the 1970s, and is connected to the incidence of a very severe drought (Grechi and Agustoni 2017). Climate events thus already played a major role in the first great move of populations abroad (Grechi and Agustoni 2017).

In Senegal, migration and mobility also involves shifting the location of productive assets, whether family, labor, or herds. This coping strategy corresponds to traditional and local adaptive farm management practices whereby during periods of harsh weather conditions, farmers move cultivation to new lands in a different agro-ecological zone or at higher elevation (USAID 2014). Well-established migrants' systems tend to reduce the exposure of local communities to environmental stress but is increasingly leading to conflicts between pastoral and sedentary communities due to competition for increasingly scarce resources—particularly water.

Three broad categories of migration/mobility patterns can be identified for Senegal: internal migrants (mostly circular or short-term), regional (cross-border)/international migrants (medium to long-term, possibly permanent) and environment-driven mobility (mostly seasonal but potentially medium to long-term).

2.2.1 Internal migration

Internal mobility flows in Senegal are driven by a mix of push and pull factors including economic factors (new industrial activities such as gold mining opportunities; better living conditions; supplemental sources of income including remittances; greater food security); social-demographic factors; religious and sociopolitical factors; and environment and climate factors (recurrent droughts; declining land availability, land degradation and salinization which result in low profitability of agriculture; coastal erosion; extreme weather events; floods and tidal waves). Table 2.2 lists key internal migration factors and areas most affected (IADD 2019).

Table 2.2 Key Internal Migration Factors and Areas of Destination or Origin in Senegal

Internal Migration Factors	Push and pull aspects	Areas most affected (destination/ origin) by internal migration flows
Economic pull factors	Industrial activities	Dakar, Thies
	Fisheries and tourism	Thies, Mbour
	Mining activities	Thies, Kedougou
	Agriculture and ranching	Fleuve Delta, Niayes
Transport infrastructure pull factors	Highway network	Thies, Mbour
	Maritime transport	Casamance
Sociopolitical	Sociopolitical factors (armed conflicts) (push)	Ziguinchor, Sedhiou, Kolda
Socio-demographic context push	Age and gender composition (young women more affected)	Mobility from rural to urban areas
Natural environment and climate push factors	Recurrent droughts (including land degradation and salinization)	Ferlo area (Senegalese Sahel) to the regions of Fatick, Kaolack, Tambacounda, Kolda
	Coastal erosion and extreme weather events	Dakar, Petite Côte (Mbour, Jaol Fadiout), the Saloum Islands, Casamance, Saint-Louis
	Floods and tidal waves	Dakar, Fatick, Kaffrine, Kaolack, Saint-Louis, Thies, Kolda and Ziguinchor

Source: IADD 2019

Internal migration is an important determinant of population distribution in Senegal. In 2013, of the total population of around 13 million, Senegal had close to 1.9 million internal migrants (people born outside their place of residence), equivalent to 14.6 percent of the total population (Agence Nationale de la Statistique et de la Démographie, ANSD 2014). Movements from rural areas to coastal cities are dominant, with a majority of young migrants. Farmers have been attracted by the booming fishing industry on the coast in the 1970–1980 period as a result of fisheries policies (fishing agreements with Mauritania), drop in agricultural revenues, motorization of fishing boats, new transport infrastructure, and currency devaluation in 1994 of the FCFA (Franc, Communauté Française Africaine). Dakar is the main reception area with 43 percent of all internal migrants, followed by Diourbel and Thies (ANSD and IOM 2018). The capital hosts 23.2 percent of the total population, concentrated on 1 percent of the country's territory and causing remarkable urbanization challenges (World Bank 2019). In addition, internal migrants also move to areas where new land (the southern border of the Central Plateau) or gold mining opportunities (the south-east corner of the country) are available (Ionesco et al 2017).

Although internal migration is following an upward trend, the intensity of the internal migratory movements is unequal across regions. Between 2002 and 2011, various country surveys indicate that internal migration flows in Senegal have increased by almost a quarter (23.86 percent) (World Bank 2019). According to the 2013 national demographic census (ANSD 2014), Dakar, Diourbel, Thies, and Tambacounda have been the most attractive zones for mobile populations while the regions with the greatest deficits are Kaolack and Ziguinchor, the latter due in part to the Casamance separatist conflict and the departure of young people to seek work opportunities in major cities like Dakar.

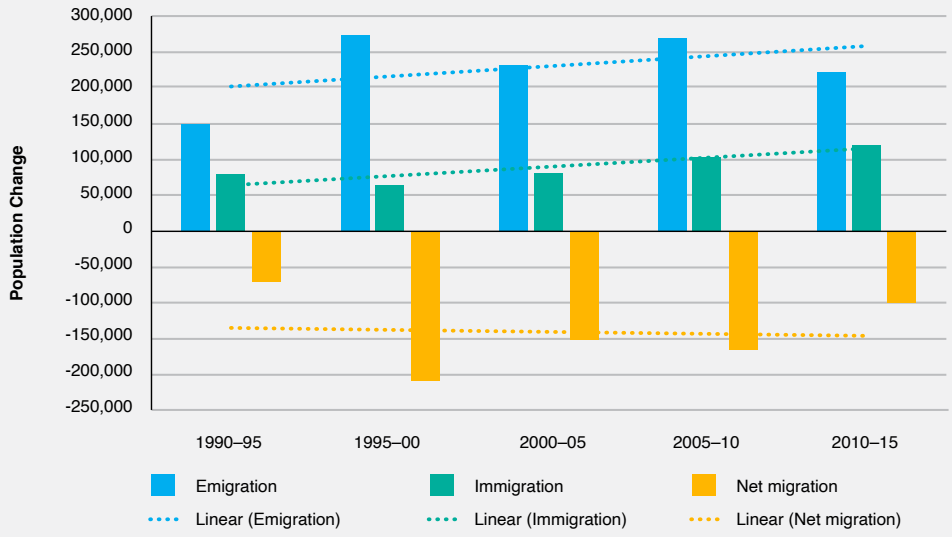
2.2.2 Cross-border and international migration

Inter-regional mobility is a hallmark of West Africa and Senegal is no exception. Indeed, regional and international migration is a common experience for the working age population, particularly young adults, in urban and rural areas (ANSD and IOM 2018). Emigration from Senegal displayed a slight upward trend in the 1990–2015 period. The five main destinations in the 2000–2015 period were Europe (France, Italy and Spain), neighboring countries (The Gambia and Mauritania), and Côte d'Ivoire, with an increasing proportion of emigrants going to Europe (Abel and Cohen 2019; IADD 2019). The main sending areas within Senegal include Dakar, Matam, Saint-Louis, Diourbel and Thies (ANSD and IOM 2018). In times of hardship, remittances play a critical role as a supplemental source of incomes for communities, and are mostly used for food consumption. Remittances represent 9.1 percent of Senegal's GDP in 2018, with urban areas accounting for more than 70 percent of these flows, and Dakar receiving one-third of all remittances (Ionesco et al 2017).

On the other hand, immigration to Senegal has been considerably smaller than emigration during the same period (2000–2015), resulting in steady negative net international migration (figure 2.3). The net migration rate was estimated at -1.27 migrants per 1000 population for the 2015–2020 period (UN DESA 2019). Based on IOM figures, immigrants in 2015 represented 1.6 percent of the total population (UN DESA 2019). Immigrants to Senegal came mainly from Mauritania, Guinea, Mali, Guinea-Bissau, and Sierra Leone. As of September 30, 2020, and according to the UNHCR, there were 14,347 refugees in Senegal, almost all of them (14,114) from Mauritania.[16]

16. See UNHCR's Senegal website: https://data2.unhcr.org/en/country/sen

Figure 2.3 International Migration Trends in Senegal



Source: Abel and Cohen 2019

2.2.3 Environment-driven migration

Senegal is particularly exposed to the effects of climate change because it is both a Sahelian and a coastal country (Alex and Gemenne 2016; USAID 2014). It is vulnerable to climate-induced migration due to the prevalence of relative poverty and agricultural dependence (Gray and Wise 2016; Hummel 2016; USAID 2014).

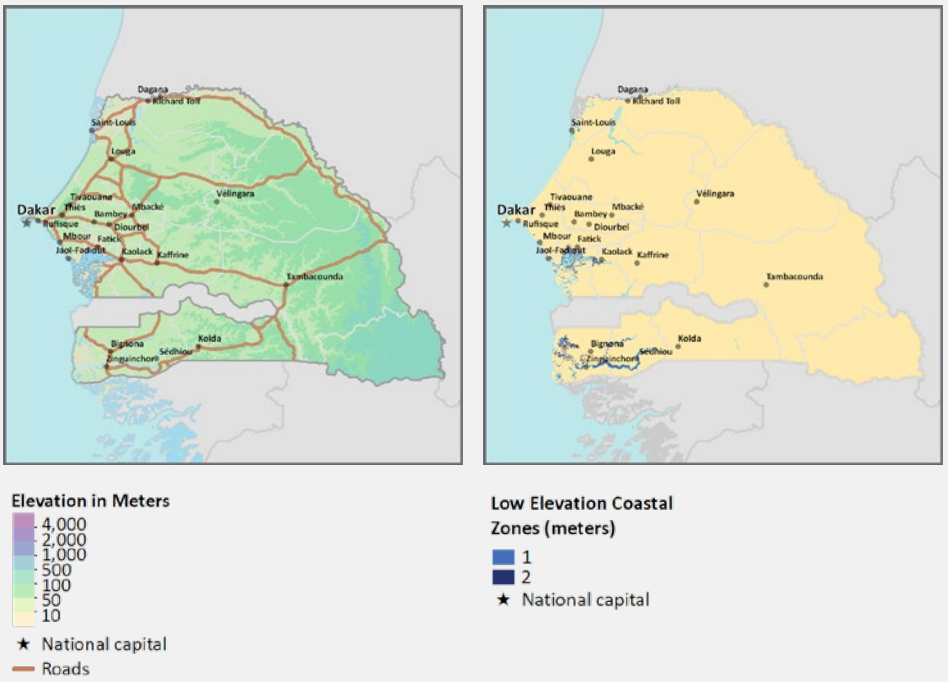
The main environmental and climate drivers of mobility include changes in fish stock availability, coastal erosion, sea level rise, tidal waves and flooding, rising temperatures, land degradation, and desertification (IADD 2019). Droughts and rain variability have been linked to the degradation of agro-pastoral systems and the consequent decline in productivity, which in turn triggers the internal migration of highly vulnerable groups (such as pastoralists and nomad farmers) from rural areas to the coastal zone (IADD 2019). Both men and women tend to seek lands closer to water, and this shift in location can be accompanied by changes in crops, market orientation, and other factors (USAID 2014).

Sensitivity to climate is higher among livestock-dependent households compared with mixed-system households, in particular in the north-east (the Sahelian zone). As water becomes increasingly scarce and the population grows, farmers expand their area of cultivation into pastoral regions and transhumance corridors, while pastoralists leave their villages with their herds earlier in the year (before the end of the harvest season) to cope with excessive drought. Although pastoralists bring essential services along the road including soil fertilization and the selling of goods such as milk and meat, this altered dynamic creates tensions between migrant herders and sedentary farmers, which may be amplified by ethnic or political rivalries (World Bank 2020e).

Decreases in the fish catch potential along the coast are directly impacting the lives of fishermen and their families. Declining fish populations and biodiversity caused by overfishing have forced artisanal fishers in Senegal to fish further out in sea or seek work as fishing laborers (IOM 2019). Migration is a common practice among Niominka fishermen who move within the country and towards neighboring countries to pursue fish abundance in areas of upwelling (Gambia, Guinea-Bissau, Mauritania) (Sadio et al 2016). The number of migratory fishermen has increased over time, as local populations and internal migrants arriving to coastal zones turn to this particular type of mobile fishing enterprise as a viable livelihood. However, socioeconomic status, demographic characteristics (age, gender), retirement status

and the degree of dependence on natural resources influence the vulnerability and probability of migration among these "urban fishermen households" (Zickgraf 2018). Climate change is likely to have a significant impact on Africa's marine fisheries by as early as 2050. Indeed, changes in water and air temperature, wind regimes, and precipitation will impact the productivity of the fisheries sector and the distribution of species, already threatened by overexploitation practices. However, at higher latitudes, catch potential is projected to decrease only moderately or even increase (e.g., in the waters off Senegal, The Gambia, and Cabo Verde) (World Bank 2019a).

Figure 2.4 Elevation Map (left) and Low-Elevation Coastal Zone (right)



Severe coastal erosion in several locations has pushed people to move and relocate away from the coast (figure 2.4). The cities of Dakar and Saint-Louis are particularly exposed to flooding due to sea level rise (IADD 2019b). Since 1989, floods have displaced around 300,000 people in the capital city (Alex and Gemenne 2016), particularly in rapidly growing coastal flood plains to the north. Saint-Louis is designated by UN-Habitat as the city most threatened by sea level rise in Africa. In Rufisque-Bargny, sea encroachment has been present for many years but that it has greatly intensified over the past decade. The area is characterized by sea level rise and a rough sea with waves of more than 2 meters that has destroyed buildings located on the seafront (World Bank 2013a). In Rufisque, the neighborhoods of Keury Kaw and Keury Souf are the most affected by coastal erosion. This phenomenon has led to a decrease in the number of landings and to a growing number of fishermen who migrate towards other fishing areas or transition to other economic activities. Ultimately, the exposure and vulnerability of Senegal's coastal activities and infrastructure to climate change-related risks and the fact that coastal areas are the preferred destinations increase the probability of secondary migration of internal migrants, including those affected by environmental factors.

Recent data covering the last decade (2010–2020) shows population movements occurring in Senegal as a result of worsened environmental conditions linked to climate change. As part of the scale-up of the Pastoral Early Warning System (PEWS) developed by Action contre la Faim (ACF, Action Against Hunger), initiated in 2010, a series of pastoralism surveillance bulletins, maps, and alerts have been generated for several countries in Africa (ACF 2016). The analysis is generated based on a combination of satellite and field data, using geospatial technologies and supported by the Data Innovation Fund. The

data collected measures biomass and surface water production and accessibility together with livestock conditions. Findings from the pastoralism surveillance bulletins indicate that since 2010, there are records of population movements (herders) in Senegal as a result of degraded environmental conditions (including drier conditions) and that those movements happen earlier than usual. Before the onset of COVID-19 in March 2020, some of the key findings include: (i) lack of pasture all over the region, (ii) drying up of most surface water bodies, and (iii) early movements of herders in Mauritania and Senegal due to huge biomass deficits. With the onset of COVID-19, some pastoralists have not been able to gather around markets causing lost opportunities and diminished access to services, while others have been stuck at borders with their herds, unable to return to their homes.[17]

2.3 CLIMATE CONTEXT AND IMPACTS

2.3.1 Historical, current, and future climate

A coastal country bordering the Atlantic Ocean, Senegal's climate is determined by the movement of the Intertropical Convergence Zone. The year is split into a dry season beginning around October and lasting through May, and a long rainy season running from June through September.[18]

Sahelian rainfall is characterized by high variability on inter-annual and inter-decadal timescales, which can make long-term trends difficult to identify.[19] The majority of Senegal is tropical and forested, experiencing an average rainfall of up to 1200 millimeters/year, although precipitation is highly variable (MOE 2006). Northern Senegal, in the Sahel, is arid and sees less than 300 millimeters of rainfall per year. In recent years, the country has witnessed noticeable variability in rainfall patterns. The rainy seasons are growing shorter, and the dry seasons are longer, sometimes lasting up to nine months (from October to June).

Climate trends since the 1960s include an increase in average temperatures and a decline in rainfall. Between 1960 and 1990, the average annual temperature was 27.8°C (82°F) with highs up to 35°C (95°F), but the average temperature has risen by 0.9°C in the past 50 years with higher rates of warming in the north and more pronounced between October and December. In terms of precipitation, although rainfall levels have partially recovered since the mid-1990s, they have not recovered their pre-1970 levels and remain 15 percent below the long-term average. The rainfall decline is most significant in the southern region during the wet season (June–September) (USAID 2017).

Rising temperatures and sea level rise are two major stressors along Senegal's coast. Senegal's hydrologic environment renders its low-lying coastal areas highly susceptible to flooding from saltwater, particularly near the Senegal River and the Saloum Delta. Rising sea levels and increasingly intense storm surges exacerbate flooding and its impacts, particularly on vulnerable populations. According to the World Bank's 2011 *Climate Risk and Adaptation Country Profile* for Senegal (World Bank 2011), sea level rise threatens 74 percent of households in coastal areas. Recently developed areas low lying areas to the north-east of Dakar in the Departments of Pikine and Guediawaye have been affected by frequent coastal flooding, particularly during floods of 2005, which cut off the area from other parts of Dakar (Wade et al 2009). The combination of sea level rise and decreased precipitation will increase the saltwater intrusion in a number of coastal aquifers, especially around Dakar and in the Saloum estuary (Niang et al 2014). Climate projections reveal that a sea level rise up to 1 meter by 2100 could destroy over 6,000 km2 of land (approximately 8 percent of the total land area of Senegal), causing environmental degradation and soil erosion (World Bank 2011).

17. "TeaTalks" with Ousmane Diagana and Caroline Plante, November 2020, World Bank.
18. See World Bank Climate Change Knowledge Portal for Senegal: https://climateknowledgeportal.worldbank.org/country/senegal
19. See World Bank Climate Change Knowledge Portal for Senegal: https://climateknowledgeportal.worldbank.org/country/senegal/climate-data-historical

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Urbanization, lack of efficient drainage systems, and settlement of depressions and wetlands have reduced natural resilience to flooding. Of the 3.5 million inhabitants of the Senegal River basin, 85 percent live near the river, relying on dams for floodwater management, agriculture, freshwater, and electricity (UNESCO 2003). But the dams have also damaged the neighboring ecosystem, contributed to the spread of water-borne diseases, and led to the displacement of local populations. Floods regularly impact significant portions of the country, but droughts can have severe repercussions, particularly in the arid and semi-arid Sahelian regions of northern and central Senegal.

Coastal erosion is particularly severe in the Saint-Louis area, where the artificial breach created to protect the historical city during the flooding of the Senegal River in 2003 has accelerated erosion of the sand spit up to 3.7m per year (Ndour et al 2018). Further south, in the Saloum estuary, it is expected that with a 1-meter sea level rise 27 percent of the mangrove and wetland complex will be lost owing to inundation.

In Senegal, temperatures are projected to increase by 1.3–2.7°C by the 2050s and up to 4.3°C by 2100 (World Bank 2020a). The projected rates of warming are faster in the north and interior, and during the dry season. Substantial increases in the frequency of 'hot' days and nights are expected, with more rapid increases in the south and east. Uncertainties exist about whether rainfall will increase or decrease, but overall increases in heavy rainfall events are expected.

Projected climate changes include rising sea level of up to 1 meter by 2100. For flooding, the most exposed areas include the cities of Saint-Louis and Dakar, and the Casamance region. The most exposed areas to erosion include N'Dar-Toute-Saint-Louis, Fas Boue, Boro Deunde, Kayar, M'Bour-Saly Portudal, Kafoutine-Casamance, Ngalou Sam Sam, Palmarin, and Dijffer (World Bank 2020a).

2.3.2 Climate impact on key sectors

In key production areas, high rainfall variability at inter-annual and inter-decadal scales affects agricultural production and, as a consequence, food security. Agriculture remains volatile and highly dependent on weather conditions. The agriculture sector still supports two-thirds of the poor and contracts significantly in the wake of repeated droughts. Agriculture has the highest elasticity of poverty to growth, followed distantly by commerce (World Bank 2018b).

Shocks are an important determinant of downward transitions into poverty, particularly when climate-related. A recent study conducted within the framework of the Senegal Systematic Country Diagnostic (SCD) (World Bank 2018b) revealed that the biggest impact on welfare decrease is caused by climate-related shocks: covariate rainfall shocks result in between 30 and 47 percent drops in welfare. These impacts are more pronounced in rural areas, where large parts of the population rely on rainfed agriculture and therefore 32 percent are considered vulnerable to falling (deeper) into poverty (World Bank 2018b).

Crops

Rainfall is the key factor that determines agricultural production, as less than 5 percent of land cultivated is under irrigation in Senegal (CIAT/BFS/USAID 2016). This is significant, as agriculture employs more than 70 percent of the Senegalese workforce and is the backbone of the rural economy (World Bank 2013). The agriculture and livestock sector are Senegal's main economic activity, representing approximately 17 percent of GDP (CIAT/BFS/USAID 2016). The great majority of farmers in Senegal are smallholders with plot size less than 5 ha. Although *maraîchage* (vegetable gardening) constitutes a small portion of the overall agriculture production, it is important to food security and as a livelihood activity for women (CIAT/BFS/USAID 2016). Traditional social and religious norms tend to determine women's use of and rights to land and resources. Women could be displaced to areas of lower quality if men claim the need for space (CIAT/BFS/USAID 2016).

Climate change is expected to magnify challenges to smallholder agriculture, which is already stressed by overexploitation of land, degraded soil, and limited extension services. Cereals like millet and sorghum are key subsistence crops, while groundnuts, a main cash crop, are grown on 40 percent of cultivated land and employ up to 1 million people. Groundnuts are sensitive to both rainfall variability and higher temperatures, and crop models project a 5–25 percent decrease in yields (USAID 2017). Rainfall has been inadequate and decreasing in some areas, affecting important growing regions near Thies and Diourbel (USAID 2017). Rice production has increased steadily since the 1990s as the area under cultivation has expanded significantly due to investments in irrigation infrastructure in the River Valley, which produces 70% of the domestic rice production (Colen, Demont, and Swinnen 2013).

Extreme events such as droughts amplify food insecurity, which already afflicts 16 percent of the population (2 percent are considered severe and 14 percent moderate). Severe droughts in 2002 and 2011 have heightened food insecurity for over 200,000 and 800,000 people, respectively. Food insecurity is distributed unequally across the country. For instance, 15 percent of rural households suffer from food insecurity compared to 8 percent of urban households (USAID 2017). The households most susceptible to food insecurity are those dependent on aid or begging, subsistence farmers, and livestock herders. Climate change is also linked to the surge in devastating insect outbreaks such as the desert locust, causing significant crop losses and weakening already fragile countries. Although the recent 2019-2020 desert locust crisis has predominantly affected East African countries, Senegal is also a country at risk of the desert locust threat (Kray and Shetty 2020). The country remains vigilant in monitoring its spread as it has witnessed destructive desert locust invasions in the past, such as in 2004 (NPR 2004)

Livestock

Livestock production also plays an important role in the country, representing a significant portion of agriculture GDP (between 50 and 75 percent) and two-thirds of employment in agriculture (World Bank 2018b). Livestock represents 29 percent of land use in Senegal (CIAT/BFS/USAID 2016). It is practiced extensively in the northern river alley and silvo-pastoral zones. Changes in the production of biomass, especially in the northern part of the country, are reducing forage production for livestock activity. Livestock-dependent households may be the most vulnerable to climate change as a reduction in precipitation may affect the quantity of pasture available, leading to competition over limited resources. Decreased (and more variable) rainfall in the Sahelian Ferlo region of northern Senegal tend to reduce optimal stocking density (loss in weight gain for cattle), lead to lower incomes for affected pastoralists, and negatively affect nutrition intake (less milk and meat) and local food security (World Bank 2012c). These farmers also tend to have fewer resources than “mixed-system” farmers.

Fisheries

Although Senegal is well known in the West African region as a traditional fishing nation, the sustainability of the sector remains challenged by decrease in fish catch due to unsustainable fishing practices, increased demand, and climate change. Changes in water and air temperature, ocean acidification, wind regime, and precipitation strongly impact the fisheries sector in terms of productivity and distribution of species. These changes in turn will have consequences on natural habitats such as mangroves. A drop in fish catch will lead to a decrease in the consumption of fishery products and the intake of animal proteins and ultimately a drop in the profitability of artisanal fishing units (Senegal Centre Suivi Ecologique 2010). Starting in 2030, projections show an overall drop in the level of catches and their estimated commercial value. A cumulative loss between 2020 and 2050 of 68 billion CFAF, equivalent to 3.23 percent of the average GDP for the period 1981–2005, has been estimated.

According to the latest World Bank report on fisheries in Africa, climate change is likely to have a significant impact on Africa's marine fisheries by as early as 2050, in particular for tropical countries (World Bank 2019a). However, catch potential is projected to decrease only moderately or even increase in the waters off Senegal, The Gambia, and Cabo Verde.

The artisanal fisheries sector currently employs 17 percent of the working population, and is characterized by a relatively low poverty rate but is threatened by overexploitation practices (USAID 2017; World Bank 2018b). The number of "migratory" fishermen entering neighboring coastal areas of Mauritania and Guinea-Bissau increased recently as the catch potential has decreased in the waters off the Senegal coast.

Forestry

Along with crops, livestock, and fisheries, forestry is another key natural endowment vulnerable to environmental and climate fluctuation. The total forestry area is estimated at 13,674,029 ha, including classified forests, protected areas, and other wooded land. The sector employs a small share of the total population, accounts for 8 percent of agriculture GDP, and registers a poverty rate of 17.7 percent (World Bank 2018b). In addition to illegal timber trafficking, the sector is particularly affected by desertification and forest degradation due to the effects of the climate change, with potential impacts on the loss of critical ecosystem services.

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Chapter 3

Modeling Results: Climate Migration Patterns and Trends

3.1 CLIMATE IMPACT PROJECTIONS[20]

Figures 3.1–3.3 present the average projected changes in water availability, crop production, and net primary productivity (NPP) for the 2010–2050 time period, respectively. Appendix A has projections from 2050-2100. These projections represent the inputs for the estimation of future population shifts induced by climate change as a proxy of climate migration. For further information on the methodology see Appendix A of Rigaud et al. 2021a.

Results suggest that Senegal is almost certain to become drier in the western/coastal areas, and that under some models (e.g., for the WaterGAP models under RCP8.5) the whole country will become drier—in some cases significantly so. Crop production is more mixed, as is the small area of NPP in the Ferlo area to the northwest. Across models, crops are projected to decline in the northern part of the country and around the Saloum Delta area (Fatick, Kaolack) during 2010–2050 (figure 3.2).

For NPP (biomass production), results vary depending on the models. However, under the high emissions scenario, the decrease in NPP would be accentuated and it would be the highest in the northern parts of the country. These areas have lower population density and lower poverty levels, but the local economy is heavily reliant on pastoralism (figure 3.3).

In this work, the population gravity model calibration found that the coefficients were highest for water availability. The coefficient for water availability in rural areas is around 2.7–2.8 times higher than that of either crops or NPP, respectively. This means that past shifts in water availability played a greater role than the other input variables in explaining shifts in population distribution. In addition, water availability is the only climate factor other than flood risk and sea level rise influencing future urban population distribution—meaning that it has a far greater influence on future population distribution than most other climate variables.

20. The tables and figures in chapter 3 are based on Rigaud et al. 2021a. *Groundswell Africa: Internal Climate Migration in West African Countries.*

Future flood hazards are higher and more extensive under higher emissions—along main rivers—including the Niger River Basin from Mali through to Nigeria, Sasandra River in Côte d'Ivoire, and the Lake Faguibine system in Mali, which experiences seasonal flooding. Figure 3.4 depicts the flood risk data for West Africa under RCP2.6 (left) and RCP6.0 (right) because these are the runs that the ISIMIP project had available at the time of the modeling. The model runs for RCP2.6 were used in the climate-friendly and optimistic scenarios and the model runs for RCP6.0 were used in the more equitable development and pessimistic scenarios. Flood risk is positively associated with population change, and the effect is larger in urban areas by an order of magnitude. Clearly, floods do not attract populations; rather it is likely that this reflects the location of many urban areas in coastal areas and flood plains, which are prone to flooding. A new World Bank Study "The Ebb and Flow: Water, Migration and Development" also found that on average, water deficits result in five times as much migration as do water deluges, even though floods are much more likely to gain national or international attention (Borgomeo et al. 2021; Zeveri et al, 2021).

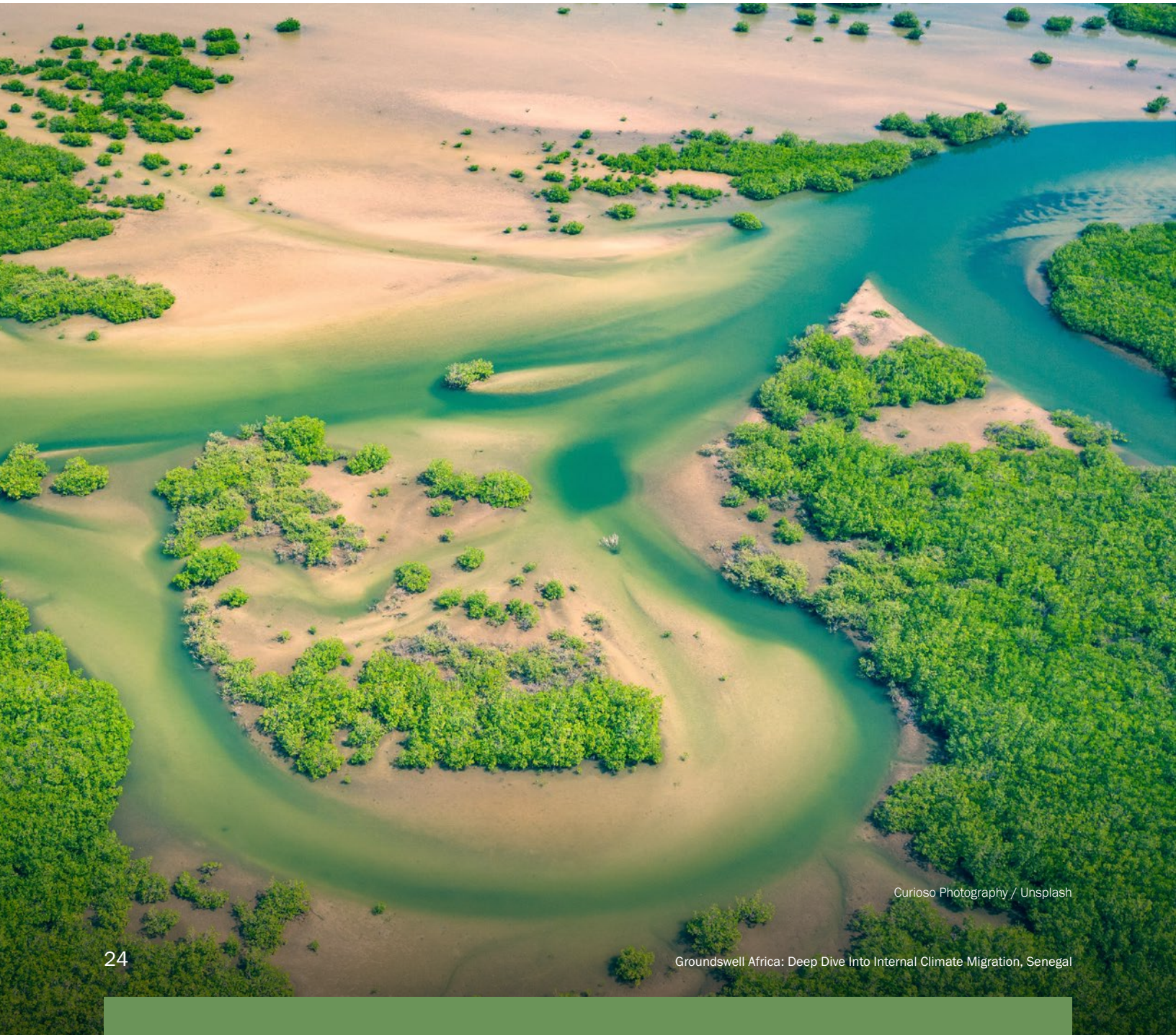

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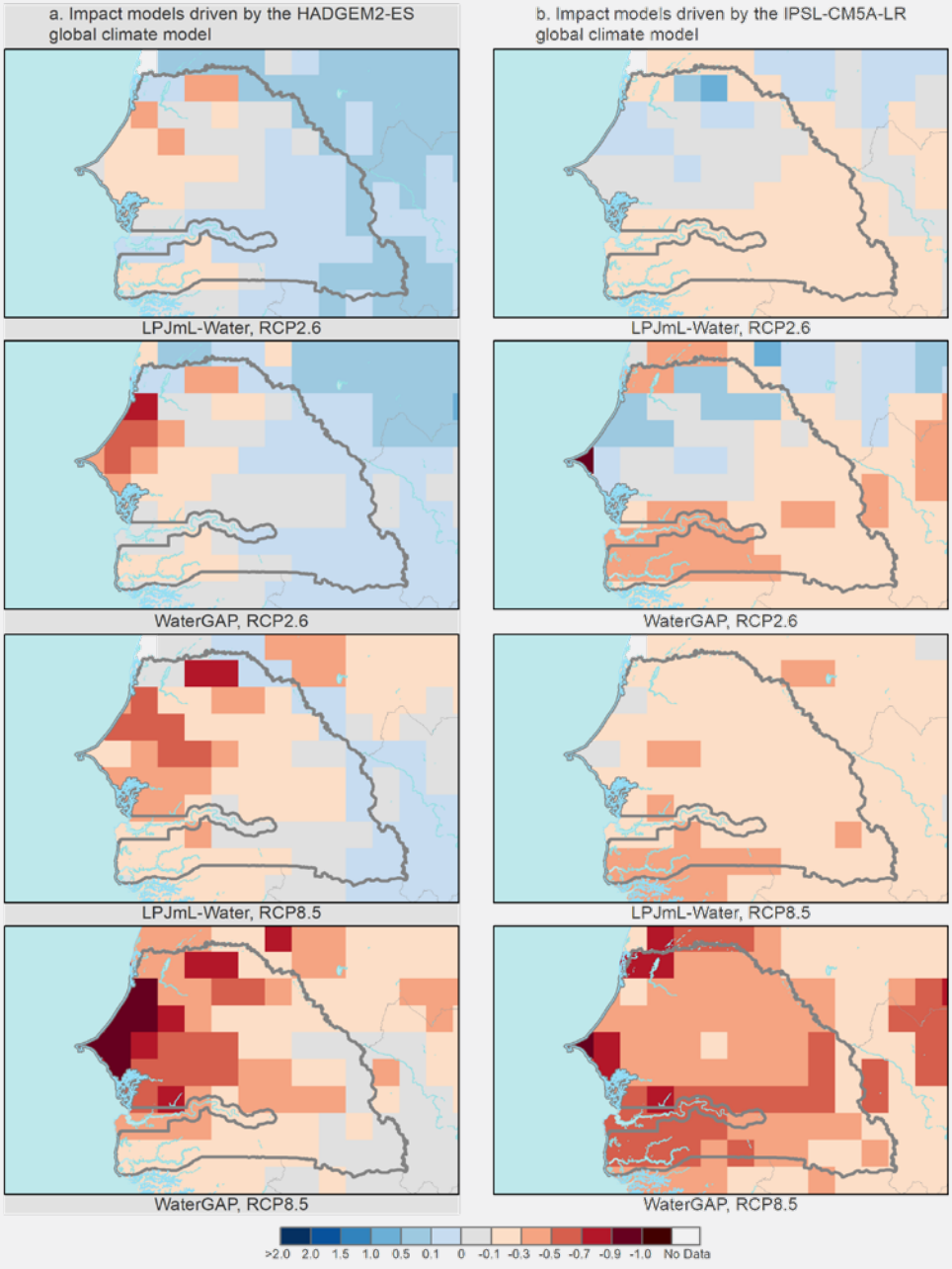
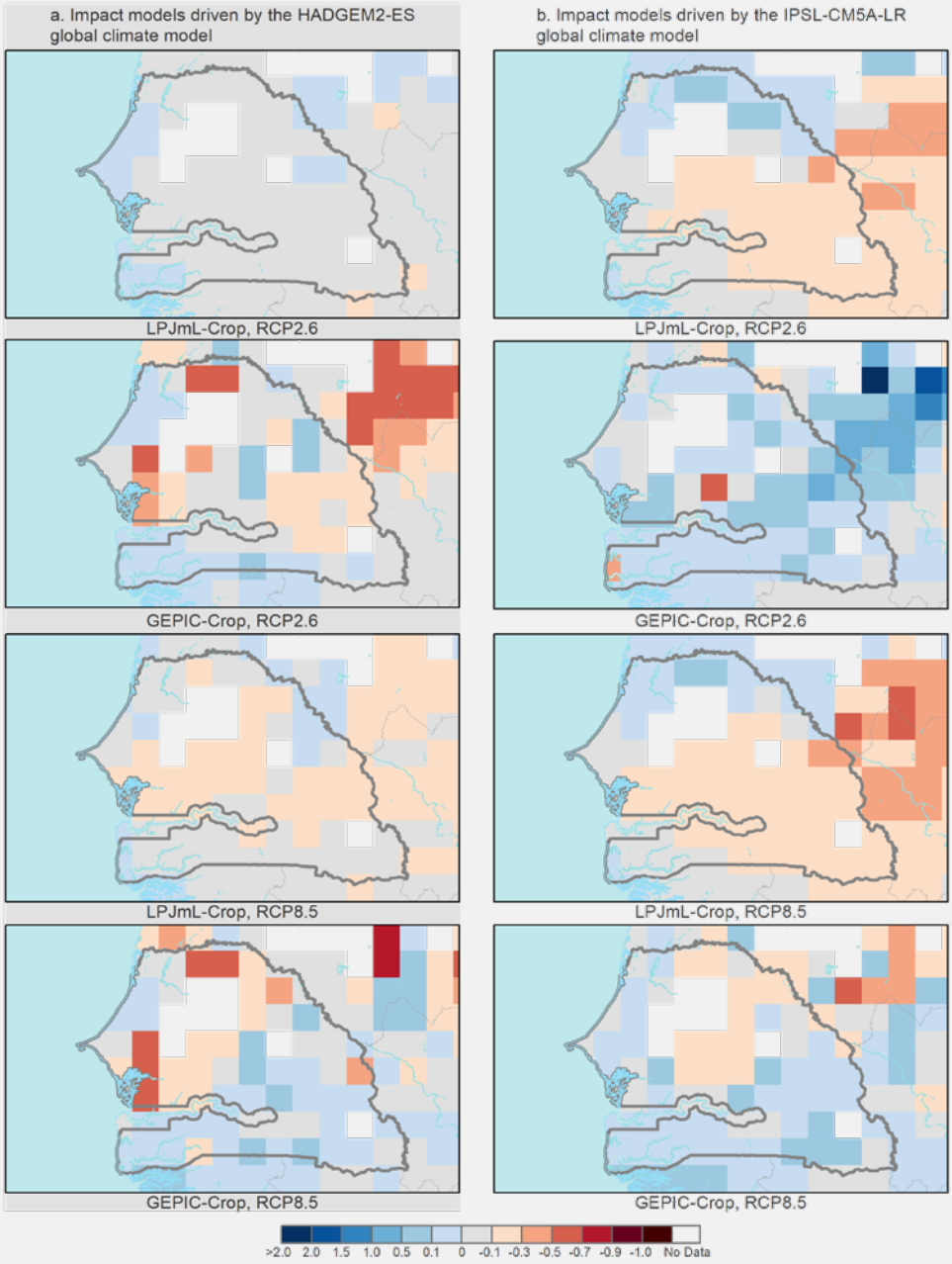
Figure 3.1 ISIMIP Average Index Values against 1970–2010 Baseline for Water Availability in Senegal, 2010–50



Notes: Data calculated against 1970–2010 baseline for water availability, from LPJmL/water and WaterGap, forced with the HadGEM2-ES climate model (panel a) and IPSL-CM5A (panel b) under RCP2.6 and RCP8.5. Blue areas indicate wetting relative to the historical baseline, and gray to tan to red areas indicate drying.

Figure 3.2 ISIMIP Average Index Values against 1970–2010 Baseline for Crop Production in Senegal, 2010–50



Note: Data calculated against 1970–2010 baseline for crop production. Blue areas indicate increased crop production relative to the historical baseline, and gray to tan to red areas indicate decreased crop production.

Figure 3.3 ISIMIP Average Index Values against 1970–2010 Baseline for NPP in Senegal, 2010–50

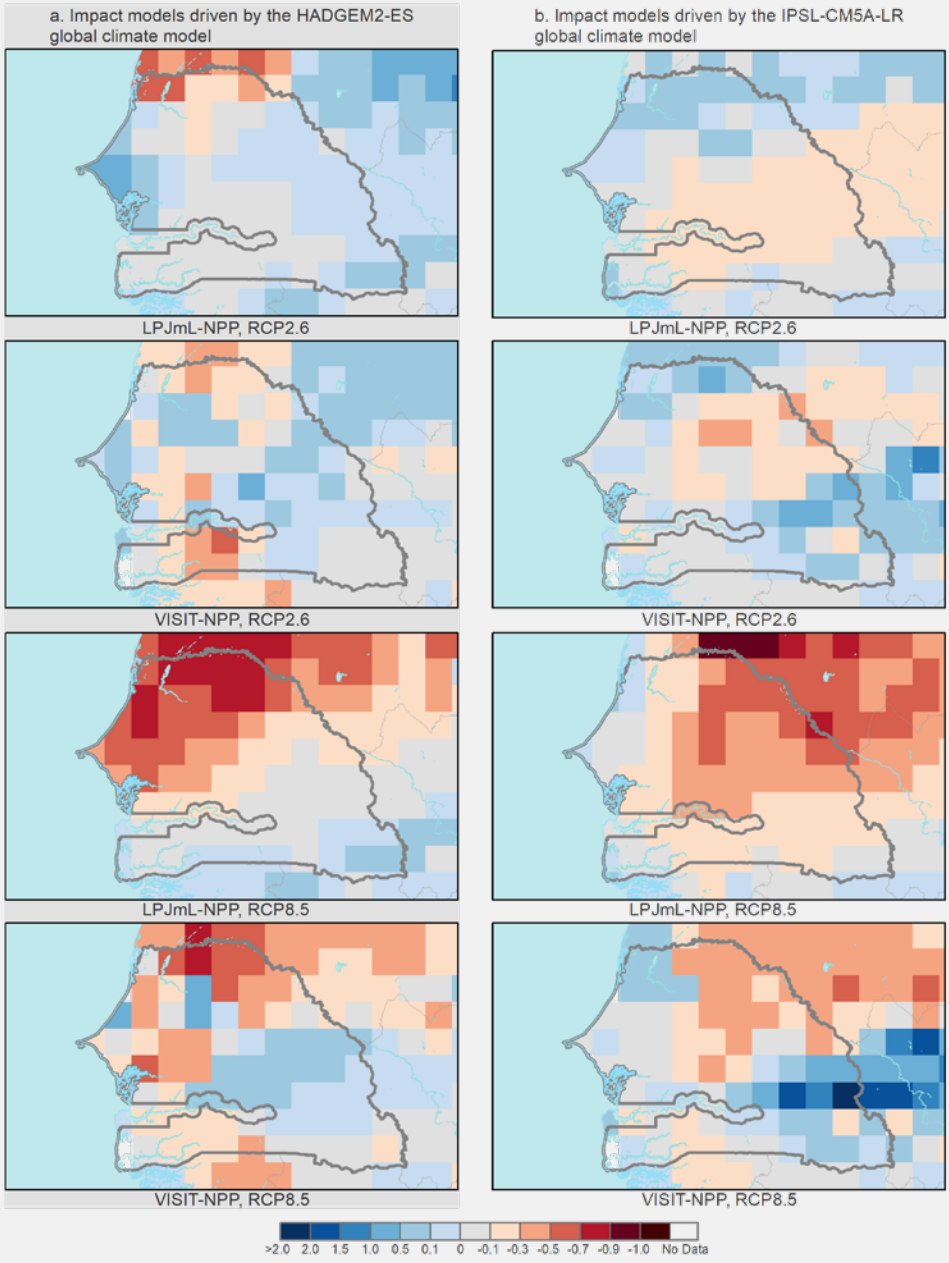
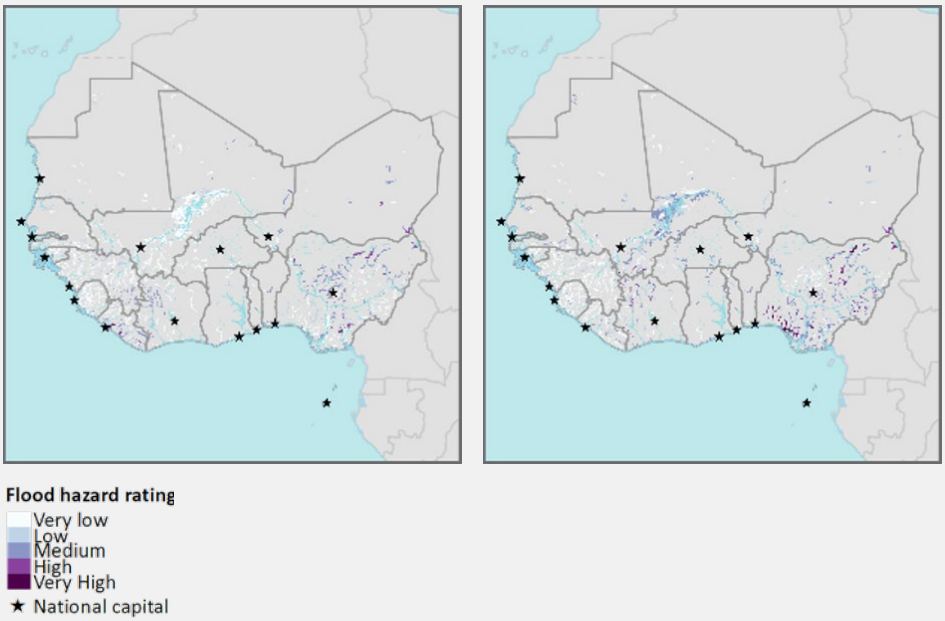


Figure 3.4 Flood Hazard Rating for 2040, under RCP2.6 (left) and RCP 6.0 (right)



3.2 POPULATION CHANGE PROJECTIONS

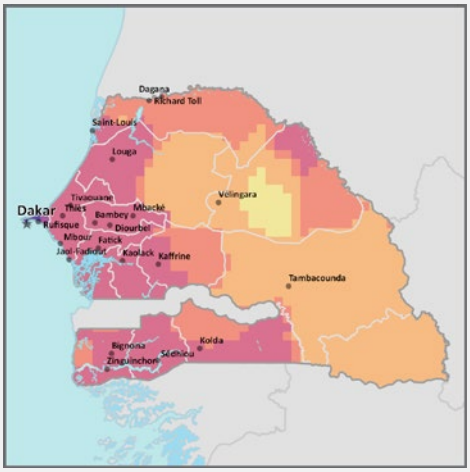
Senegal's average population density is estimated at 82.3 people per square km of land area (2018). However, this masks significant disparities between regions. Based on 2010 density patterns, the west and southwest of the country reveal high-density levels with significantly lower density inland south of Matam. Today, Dakar on the coast has the highest density rate in the country with more than 5000 people per square km, while Velingara situated in Matam, a region located in the center-west of the country, has a density of less than 5 people per square km.

Senegal could experience a doubling of its population from 2010 to 2050 and an intensification of the 2010 population density patterns in all four scenarios (figure 3.5). The population could increase from 12.6m in 2010 to 24.2m by 2050 (SSP2 scenario) and 30.5m by 2050 (SSP4 scenario). In Senegal, the changes in population density between 2010 and 2050 are greatest in areas close to the larger cities of Dakar, Diourbel, and Touba, which are all destinations for internal migration flows. In the context of the rapidly growing populations of West Africa, climate change impacts may slow population growth in some areas, but it will generally not cause population declines (figure 3.6 displays changes in population density between 2010 and 2050).

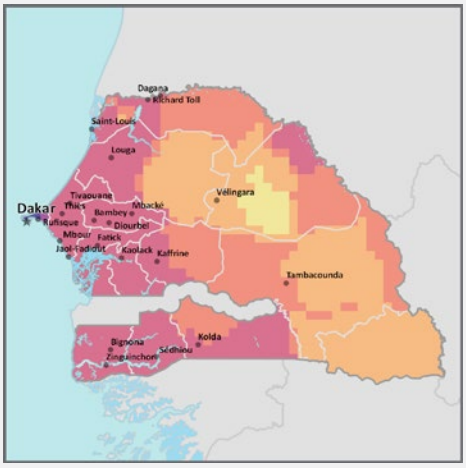
Cities which are already heavily populated in the western half of the country could continue to experience growth like Saint-Louis, Louga, Tivouane, Thies, Rufisque, Mbour, Jaol, Bambey, Mbacke, Fatick, Kaolack, Kaffrine, Bignone, Ziguinchor, Sedhiou, and Kolda. By contrast, cities in the eastern part of the country could remain with low density, including regions such as Matam, Tambacounda, and Kedougou. Both scenarios incorporating SSP4 (pessimistic and climate-friendly) show more intense density moving deeper in the center of the Senegal (west of Tambacounda and along the border with Mali to the east). However, this is due to a higher number of the projected population for the country in 2050.

Figure 3.5 Projected Population under the Four Scenarios in Senegal, 2050

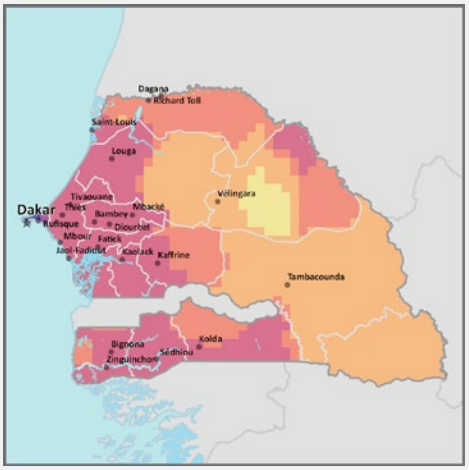
a. Inclusive development (SSP2 and RCP8.5)



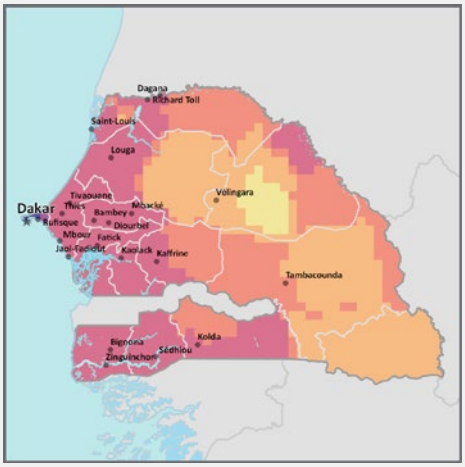
b. Pessimistic (reference) (SSP4 and RCP8.5)



c. Optimistic (SSP2 and RCP2.6)



d. Climate-friendly (SSP4 and RCP2.6)

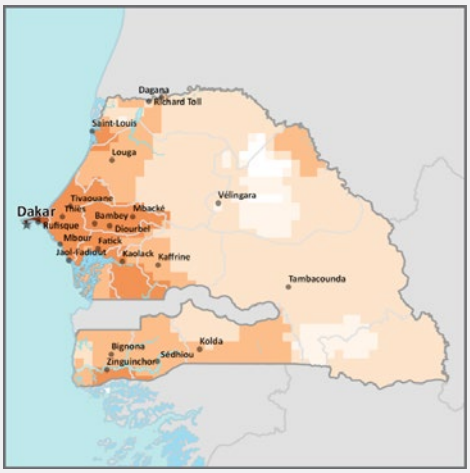


Population density
(number of people per square kilometer)

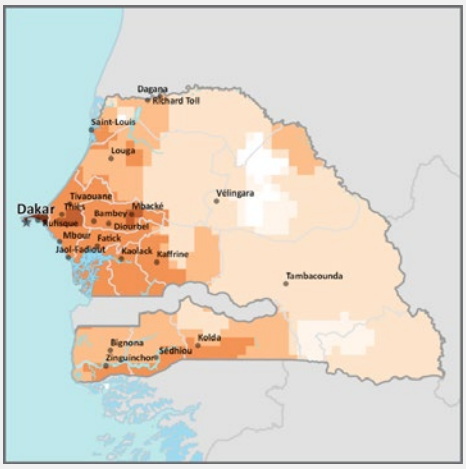
- < 1
- 1 to 5
- 5 to 25
- 25 to 250
- 250 to 1,000
- > 1,000
- ★ National capital

Figure 3.6 Projected Change in Population Density under the Four Scenarios in Senegal, 2010-50

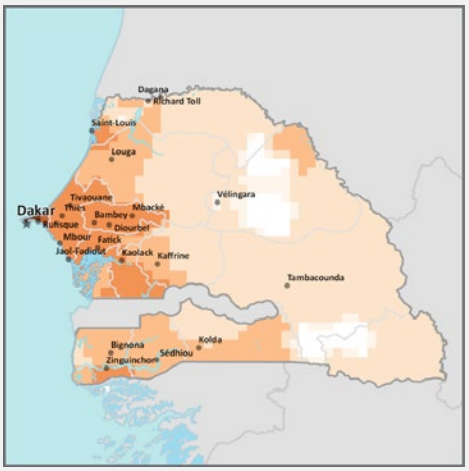
a. Inclusive development (SSP2 and RCP8.5)



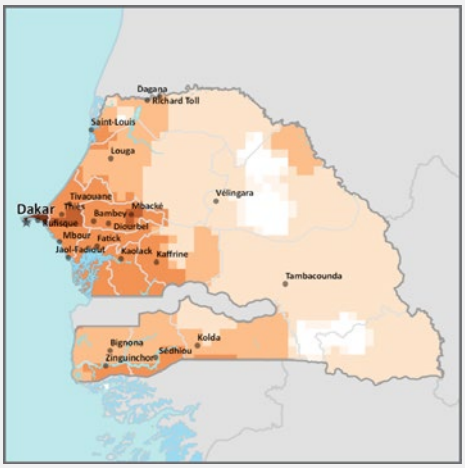
b. Pessimistic (reference) (SSP4 and RCP8.5)



c. Optimistic (SSP2 and RCP2.6)



d. Climate-friendly (SSP4 and RCP2.6)



Population change
(number of people per square kilometer)

- < 0
- 0 to 5
- 5 to 50
- 50 to 100
- 100 to 500
- 500 to 1,000
- > 1,000
- National capital

3.3 INTERNAL CLIMATE MIGRATION PROJECTIONS

The section presents the estimated number of internal climate migrants and their future locations, by comparing future population distributions under climate impacts with future population distributions under scenarios with no climate impacts.[21] Population distributions have been and will, in the future, be influenced by climate impacts on the water and agriculture sectors, ecosystem impacts, future flood risk, and increasing sea level rise, all of which influence the attractiveness of a locale by interacting with the

21. To produce these estimates, the total populations in each grid cell for the respective no climate impact (development only) population projections are subtracted from the three spatial population projection scenarios that include climate impacts—i.e., the pessimistic reference, more inclusive development, and more climate-friendly scenarios. Then, all those grid cells that have positive totals in the region are summed to estimate the number of climate migrants. Demographic variables of births and deaths are already captured within the natural population growth patterns, as part of the baseline. For details see methodology in Appendix A and B of Rigaud et al. 2021a.

local environment. Generally, areas that see positive deviations in water and productivity also see more in-migration. Differences in population levels between scenarios that include climate impacts (RCPs) and development trajectories (SSPs) and those that only include development trajectories are interpreted as being driven by the "fast" demographic variable—namely migration. The white areas around the central trend line represent the confidence intervals, which reflect the degree of agreement among the four model runs used to provide each estimate for each scenario. Narrower confidence intervals indicate greater agreement among the model runs comprising each scenario.

3.3.1 Scale and Trajectory of Internal Climate Migration

For Senegal, and notwithstanding variations in confidence intervals, all the scenarios display an upward trend in climate migration, but the increase is highest under the high emissions scenarios (RCP8.5) (figure 3.7). The number of internal migrants could see anywhere from a 2.7-fold increase (under the mean value of the optimistic scenario) to a 4.6-fold increase (under the mean value of the pessimistic scenario) between 2025 and 2050. The trajectory for the pessimistic scenario – which reflects high emissions and unequal development – depicts a sharp upward acceleration in 2045–2050 in accordance with the escalation of climate impacts

The pessimistic scenario projects a mean number of 603,000 internal climate migrants by 2050, the third highest number among the West African countries after Niger and Nigeria. This would represent 1.98 percent of the population by 2050 (figure 3.7; table 3.1). The range under the pessimistic scenario is significant, with the highest at 1 million and the lowest at 189,000 internal climate migrants, due to less agreement among the individual model runs as reflected in the wider confidence intervals. The projected mean number of climate migrants under the more inclusive development scenario is around 382,000 (1.58 percent of the population) climate migrants by 2050, with slightly less wide confidence intervals.

In contrast, the optimistic scenario projects the lowest average number of climate migrants with a mean of 92,000, representing close to 0.4 per cent of the total population by 2050. There is strong agreement among individual model runs, as reflected in the narrower confidence intervals. The climate-friendly scenario yields a slightly higher mean number of more than 134,000 (0.4 per cent) climate migrants by 2050 (figure 3.7; table 3.1).

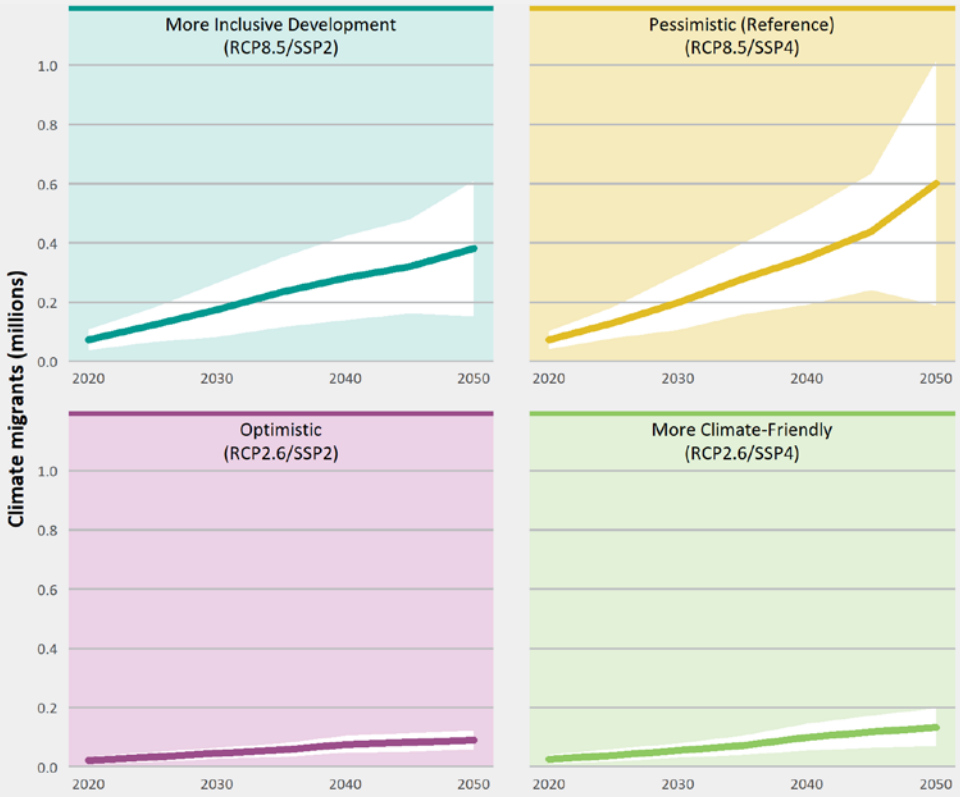
Wider confidence intervals in the more inclusive development scenario and the pessimistic scenario are related to diverging future trends in the water and crop models used as inputs in the population projections. This variation can be explained by the diverging future trends in the water and crop models used as inputs in the population projections under higher emission (RCP8.5). Some of the water models for RCP8.5 indicate no drying or a moderate drying trend, while others show severe drying. Similarly, some of the crop models project a widespread but moderate decline in crop productivity, while others show a patchwork of increase and declining productivity. As a consequence, the difference in projected population distributions going into each of the two scenarios is greater, which leads to wider confidence intervals.

While there is some level of uncertainty, policies based on equitable development and low emissions can reduce the number of climate migrants in Senegal by 85 percent (Figure 3.7; Table 3.1).[22] The mean value of the more inclusive development scenario is projected to reduce average internal climate migration by more than 200,000 by 2050 in comparison to mean value of the pessimistic scenario, while the mean value of the climate-friendly scenario reduces average internal climate migration by close to 470,000 (figure 3.8). Greatest gains are made when pursuing the optimistic scenario, which combines low emissions and inclusive development, with reductions of more than 500,000 internal climate migrants (figure 3.8). The uncertainty in the model provides an opportunity to forestall some of these impacts through concrete early action. Senegal would gain by rapidly pursuing highly resilient policies and economic transitions and shifting towards less climate-sensitive sectors at scale. Most importantly, these

22. Comparing the mean value of the pessimistic and optimistic scenario.

scenarios are not cast in stone. They provide a roadmap to chart out urgent and concerted action that is characterized by inclusive development and climate-friendly policies to reduce the adverse consequences of climate migration. At the same time, without collective global responsibility and action to meet the Paris target, some of these gains may become more difficult to realize.

Figure 3.7 Projected Total Internal Climate Migrants in Senegal 2020–2050



Climate migrants as a percentage of the total population

Year	2020	2030	2040	2050
%	0.47	0.93	1.3	1.58

2020	2030	2040	2050
0.45	0.96	1.37	1.98

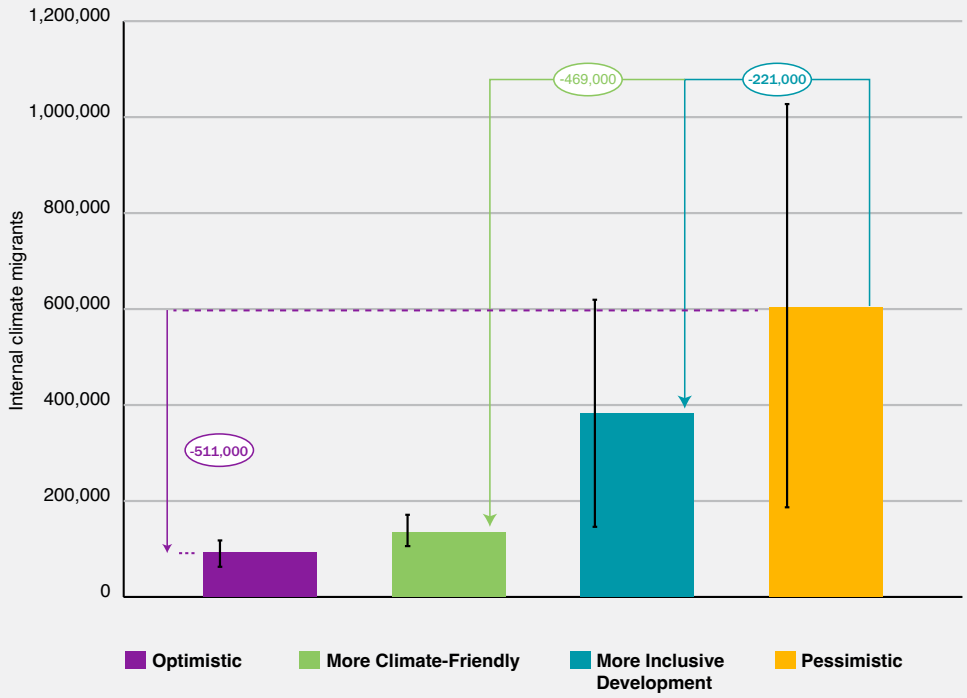
Year	2020	2030	2040	2050
%	0.15	0.24	0.35	0.38

2020	2030	2040	2050
0.16	0.27	0.39	0.44

Table 3.1 Projected Total Internal Climate Migrants in Senegal by 2050

	Scenario							
	Pessimistic/ Reference (RCP8.5; SSP4)		More Inclusive Development (RCP8.5; SSP2)		More Climate-friendly (RCP2.6; SSP4)		Optimistic (RCP2.6; SSP2)	
Average number of internal climate migrants by 2050	602,646		382,214		133,769		91,574	
Minimum (left) and Maximum (right)	189,283	1,016,008	153,886	610,540	70,279	197,259	60,069	123,078
Internal climate migrants as a percent of population (percent)	1.98		1.58		0.44		0.38	
Minimum (left) and Maximum (right) (percent)	0.62	3.33	0.63	2.52	0.23	0.65	0.25	0.51

Figure 3.8 Reductions in the Mean Number of Internal Climate Migrants in Senegal by 2050 using the Pessimistic Scenario as the Baseline



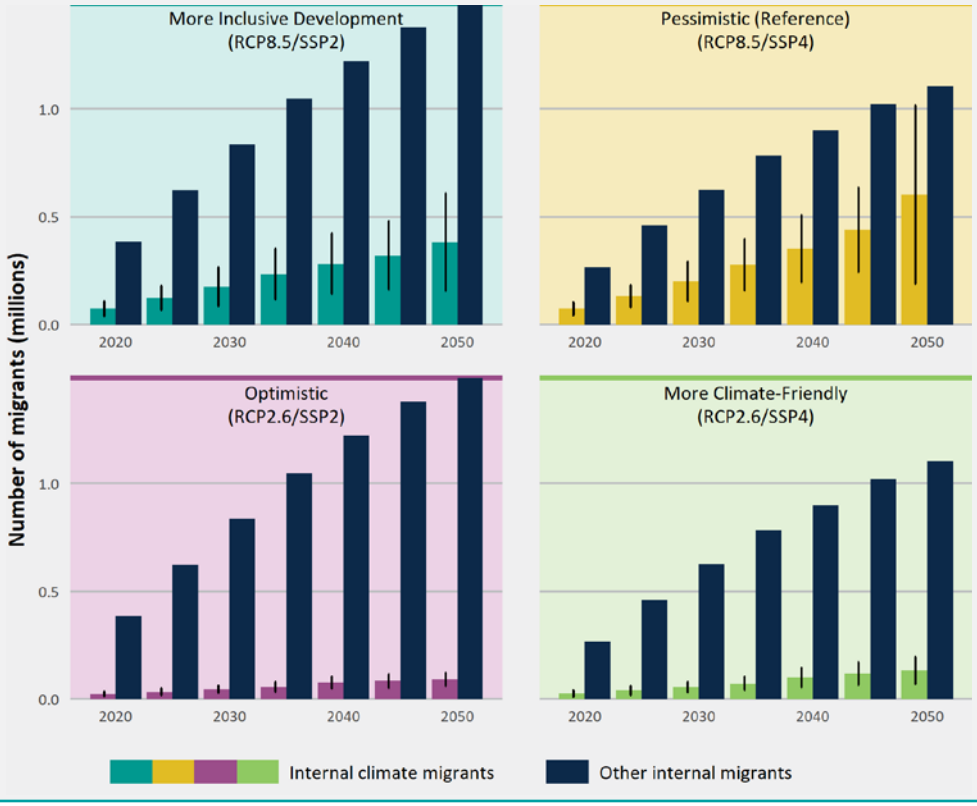
Note: The whiskers represent the lowest and the highest number of internal climate migrants in that scenario

3.3.2 Internal Climate Migrants vs Other Migrants

Other internal migrants include individuals who move internally due to changes in population growth, urbanization, income, and education (as set out in the SSP pathways). The projected number of other migrants was calculated by comparing projected population distribution under the SSP-only 2050 development scenarios (no-climate) to a counterfactual in which the population in each grid cell is scaled according to the 2010 population distribution. In other words, the counterfactual is a world in which the population changes, but people remain in place. The difference between these two scenarios is representative of development or "other" internal migrants.

Climate migration will not occur in isolation; other types of internal migration will occur simultaneously and will need to be managed in an integrated manner in a country with already high internal mobility. Internal climate migrants are projected to be a smaller share of other internal migrants—except for the pessimistic scenario (figure 3.9). By 2050 the share of internal climate migrants under mean number of the pessimistic scenario could make up more than 50 percent of the other internal migrants (and at the high end of the confidence interval they are nearly equal). However, climate migrants will increase steadily as a share of total internal migrants through 2050 across all scenarios, with the largest increase projected under the pessimistic scenario.

Figure 3.9 Projected Internal Climate Migrants Compared to Other Internal Migrants in Senegal, 2020-50



3.4 CLIMATE MIGRATION HOTSPOTS

Climate migration hotspots reflect areas of high certainty (with agreement across the scenarios at the top 5th percentile) where spatial populations will shift into (climate in-migration) or out (climate out-migration) of a grid cell over time.

Climate out-migration will occur in areas where livelihood systems are increasingly compromised by climate impacts.

Climate in-migration will occur in areas with better livelihood opportunities. These reflect movements from less viable areas with lower water availability and crop productivity and from areas affected by rising sea level and storm surges to areas with better opportunities.

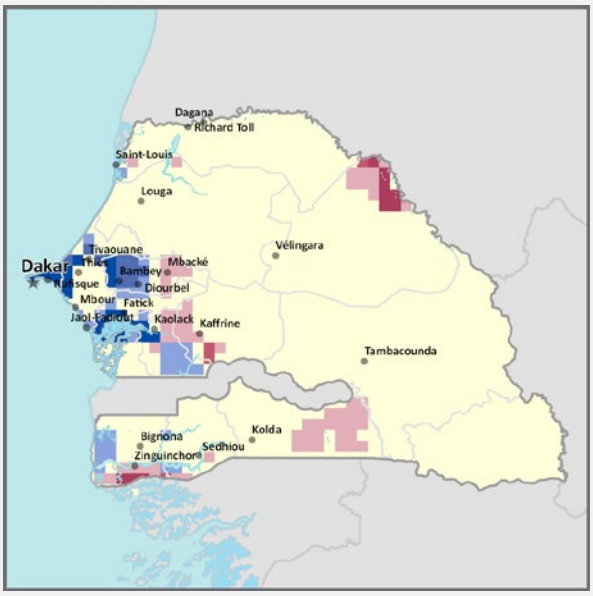
The emergence of climate out-migration hotspots as early as 2030 gains certainty and are accentuated by climate-in migration by 2050 (figure 3.10; figure 3.11). High levels of climate out-migration are visible in the Dakar-Diourbel-Touba corridor, in the coastal area north of Dakar (prone to flooding), and in the low-lying Saloum Delta region as early as 2030. These trends could run counter to the historical development induced migration trajectory, which is towards Dakar and away from inland areas.

Most of the projected out-migration climate hotspots are located in the center-west part of the country. Climate scenarios reflect the potential push impact not only of sea level rise in selected areas along the coast but also of declining water availability in the west-central area (Diourbel). For urban and rural areas, water availability appears indeed as the most critical driver. Regions like Ziguinchor, which were once abandoned by locals, are now becoming attractive again. This pattern would imply potentially shifting population distribution to currently less densely populated areas.

Projections for 2050 show high certainty climate in-migration emerging near the town of Matam on the Senegal River (border with Mauritania), and near Ziguinchor on the Guinea-Bissau border. There is also in-migration in eastern Diourbel and western Kaffrine, and south of the border near the Gambia. The climate in-migration areas coincide with regions characterized by the highest poverty levels in the country (Kolda, Ziguinchor). Positive climate impacts (pull factors) correspond to areas of increasing water availability and crop productivity/net primary production.

Andrea Borgarello / World Bank

Figure 3.10 Projected Hotspots of Climate In-migration and Out-migration in Senegal, 2050



IN-MIGRATION

- High certainty in high levels of climate in-migration
- Moderate certainty in high levels of climate in-migration
- Low certainty in high levels of climate in-migration

OUT-MIGRATION

- High certainty in high levels of climate out-migration
- Moderate certainty in high levels of climate out-migration
- Low certainty in high levels of climate out-migration

Figure 3.11 Projected Hotspots of Climate In-migration and Out-migration in Senegal, 2030 (Left) and 2040 (Right)

a. 2030

b. 2040)

IN-MIGRATION

- High certainty in high levels of climate in-migration
- Moderate certainty in high levels of climate in-migration
- Low certainty in high levels of climate in-migration

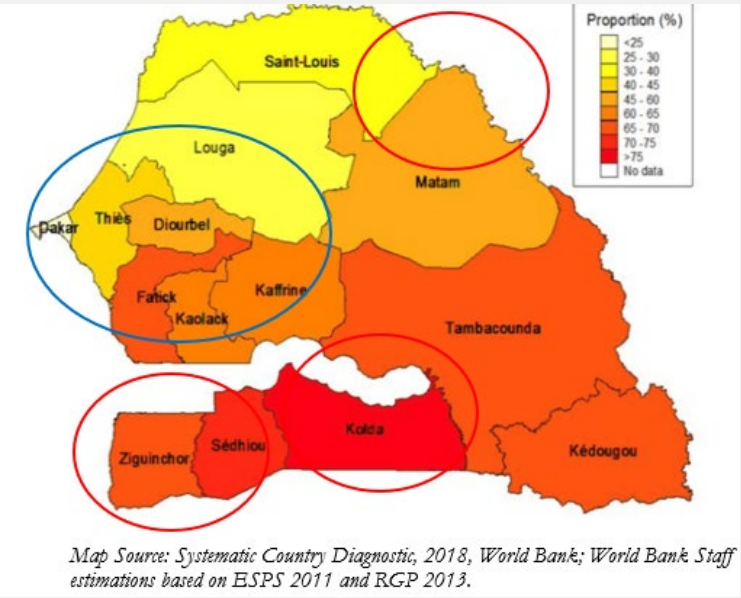
OUT-MIGRATION

- High certainty in high levels of climate out-migration
- Moderate certainty in high levels of climate out-migration
- Low certainty in high levels of climate out-migration

For Senegal, climate scenarios reflect the potential 'push' impact of sea level rise in selected areas along the coast, and of declining water availability in the west-central area (Diourbel) as per the ISIMIP results in figure 3.1. For urban and rural areas, water availability appears as the most important local characteristic—i.e., it is the driver with the largest coefficient (table 1.1). Positive climate impacts (pull factors) in the east and south correspond to areas of increasing water availability and crop productivity/ net primary production in the ISIMIP results. The high emissions RCP8.5 scenario shows much more dramatic potential population redistribution, which is the result of the significant water availability declines (in areas >90 percent) in the eastern portion of the country. As explained above, where differences are negative in these maps, particularly around Dakar, it means that while the regions are still likely to experience population growth, the growth will not be as high as it would have been in the absence of climate impacts—that is, it would have a dampening effect.

Climate in-migration hotspots coincide with regions with the highest poverty levels in the country (Kolda, Ziguinchor) while climate out-migration coincides with important economic centers in the country (Dakar) (figure 3.12). Table 3.2 provides a summary of selected high intensity climate-in and climate-out migration hotspots—and a status of their current development context—which will be critical in shaping policy and forward-looking approaches for early action on averting the adverse consequences of climate-induced migration.

Figure 3.12 Poverty Incidence by Province in Senegal



Source: World Bank 2018b

Box 3.1 Understanding Climate In- and Climate Out-migration hotspots

To map climate change-induced migration, population distributions are projected with and without climate impacts. The differences between the two are interpreted as changes in population due to migration. Hotspots represent the top 5th percentile of the distribution of total climate migrants per 15 km grid cell. Where two out of four scenarios overlap, it is considered a low certainty hotspot; where three out of four scenarios overlap, this is considered a moderate certainty hotspot; and where four out of four scenarios overlap, this is considered a high certainty hotspot. To be consistent across the time series, we apply the 2050 5th percentile population difference thresholds for 2030 and 2040. This gives a sense of the progression of hotspots over time.

More highly populated areas are more likely to have high in- or out-migration, since thinly settled areas typically do not see a lot of difference in absolute numbers of population between the climate and no climate impacts model runs. Even though an area may represent an out-migration hotspot (in blue, figures 3.10 and 3.11), that does not mean that population will decline in these areas. Given the rapid population growth in the region, very few areas will decline. Rather, the correct way to interpret this is that population growth will be dampened owing to climate impacts, particularly on water availability but also on the agricultural (crop and livestock) sector.

byakkaya / iStock

Table 3.2 Projected High-intensity Climate In and Out-Migration in Senegal

Region	Hotspot	Decade Emergence as High Intensity Hotspot*	Climate Context	Urban Development Context
Climate Out-migration Hotspots				
Dakar	Dakar, Rufisque	2030	Highly vulnerable to sea level rise, coastal erosion and tidal waves. Changes in ocean temperatures with impacts on upwelling, mangrove loss, and decrease in fish stock	Dakar is the main reception area in Senegal with 43 percent of all internal migrants. Floods have caused more than 300,000 people to move since 1989 in the Dakar region. Major hub concentration of the country's tourist infrastructure. Over $2 billion or 5 percent of assets are considered exposed to high natural hazard potentials in Dakar metropolitan area (World Bank 2009). Narrowing of the beach of Rufisque, particularly along the center of the city, resulting in overhanging buildings and stripped roads in the sectors of Merina and Thiawlene.
Fatick	Fatick	2030	Hot semi-arid climate; salt marshes are a main local resource	More than 43.6 percent of households work in the agricultural sector (ANSD 2014).
Kaolack	Kaolack	2030	Situated on the Saloum river about 100 kilometers (62 mi) from its mouth	Combination of heavy rains and insufficient drainage infrastructure in Kaolack (USAID 2015). There is a peanut oil processing plant with its own port facilities in the downstream suburb of Lyndiane, while salt pans across the Saloum river constitute the city's only other major industrial activity.
Thies	Thies	2040	Local steppe climate	Located just east of Dakar and the only region that borders the capital region. Overall, poverty rates in the region are low (World Bank and ANSD 2016). As the transportation hub of a productive agricultural hinterland (rice, peanuts, manioc, millet, and fruit) the city is a leading livestock-trading and meat-packing center.
Climate In-migration Hotspots				
Ziguinchor	South of Ziguinchor, near Guinea-Bissau border	2030	Lying at the mouth of the Casamance river	The region of Ziguinchor has great potential in fisheries and aquaculture with a coastline of 85 km and an important hydrographic network. Artisanal fisheries is an important activity, which includes salting, drying, smoking, cooking or fermentation, and employs a largely female labor force skilled in artisanal processing techniques. Ziguinchor is a region for tourism thanks to its scenic spots, rich historical and cultural heritage, and lush vegetation, the variety of landscapes along the Casamance River and rich avian fauna (World Bank 2012a).
Matam	Thilogne, Kanel	2040	Vulnerable to floods	Matam Region is one of the largest of the 14 regions and occupies one- seventh of the country's territory. Matam is one of the primary regions of origin of the Senegalese abroad (ANSD 2014). Fifty-eight of households in Matam suffer from food insecurity (CIAT/BFS/USAID 2016).
Tambacounda	East of Tambacounda	2050	Tropical savanna climate	Senegal's largest region in terms of geographic area. Despite its size, Tambacounda is sparsely populated and holds about 5.3 percent of Senegal's population. It is the region with the biggest differences in poverty headcount rates, ranging from 23.9 percent in Goudiry to 92.3 percent in Ndoga Babacar. Communes located along the border with Mauritania seem to flourish and have much lower poverty rates than the rest of the region (World Bank and ANSD 2016). Tambacounda is also a center for agricultural processing, with millet, sorghum, maize, and cotton grown in the dry plains of the region.

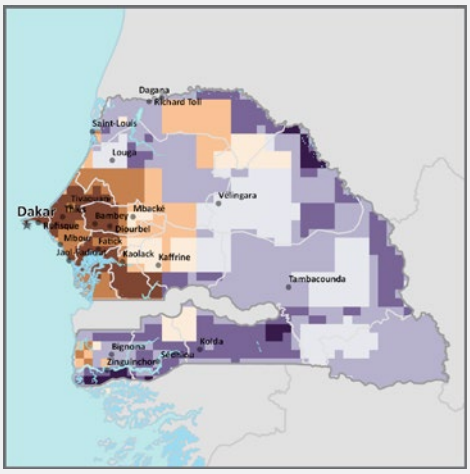
*Decade in which this locality becomes a high-intensity hotspot.

The population change per square kilometer owing to climate migration in Senegal could be positive in the east and south, across the four scenarios by 2050. Figure 3.13 displays the absolute projected population change per square kilometer due to climate migration by 2050—the difference between the climate and no climate impact scenarios—and additionally reinforces the hotspots results of Figure 3.9 while also reflecting the population shifts that will occur across the territory of Senegal. Areas of negative differences do not necessarily mean that the population will decline in these areas, but that owing to climate impacts their growth may be slower than it otherwise would have been.

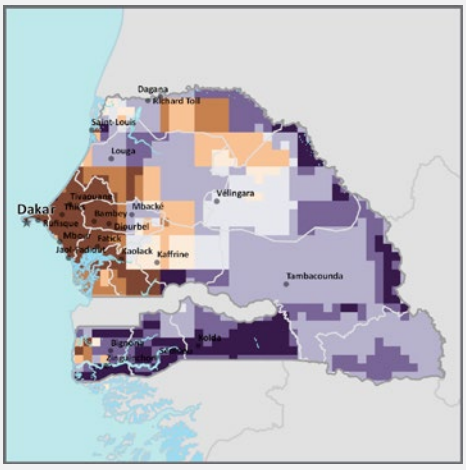
The pattern is starkly different across the low emissions (optimistic and climate-friendly) and high emissions scenarios (inclusive and pessimistic). This would also be a function of changes in water availability, which favors inland areas under RCP8.5, but also sea level rise impacts on the coast. This suggests that climate factors are a bigger driver of change than the demographic and development factors driven by the SSPs.

Figure 3.13 Projected Population Change due to Climate Migration in 2050

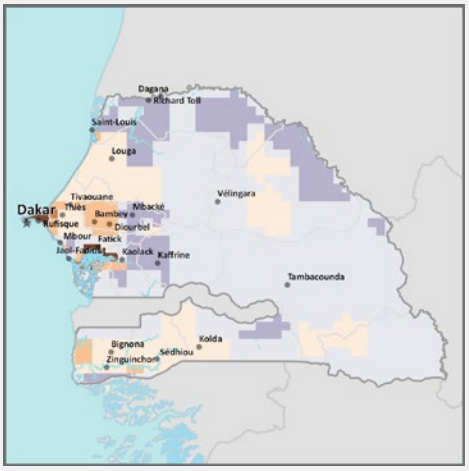
a. Inclusive development (SSP2 and RCP8.5)



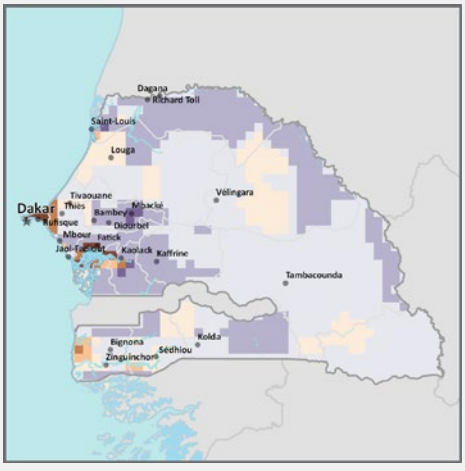
b. Pessimistic (reference) (SSP4 and RCP8.5)



c. Optimistic (SSP2 and RCP2.6)



d. Climate-friendly (SSP4 and RCP2.6)

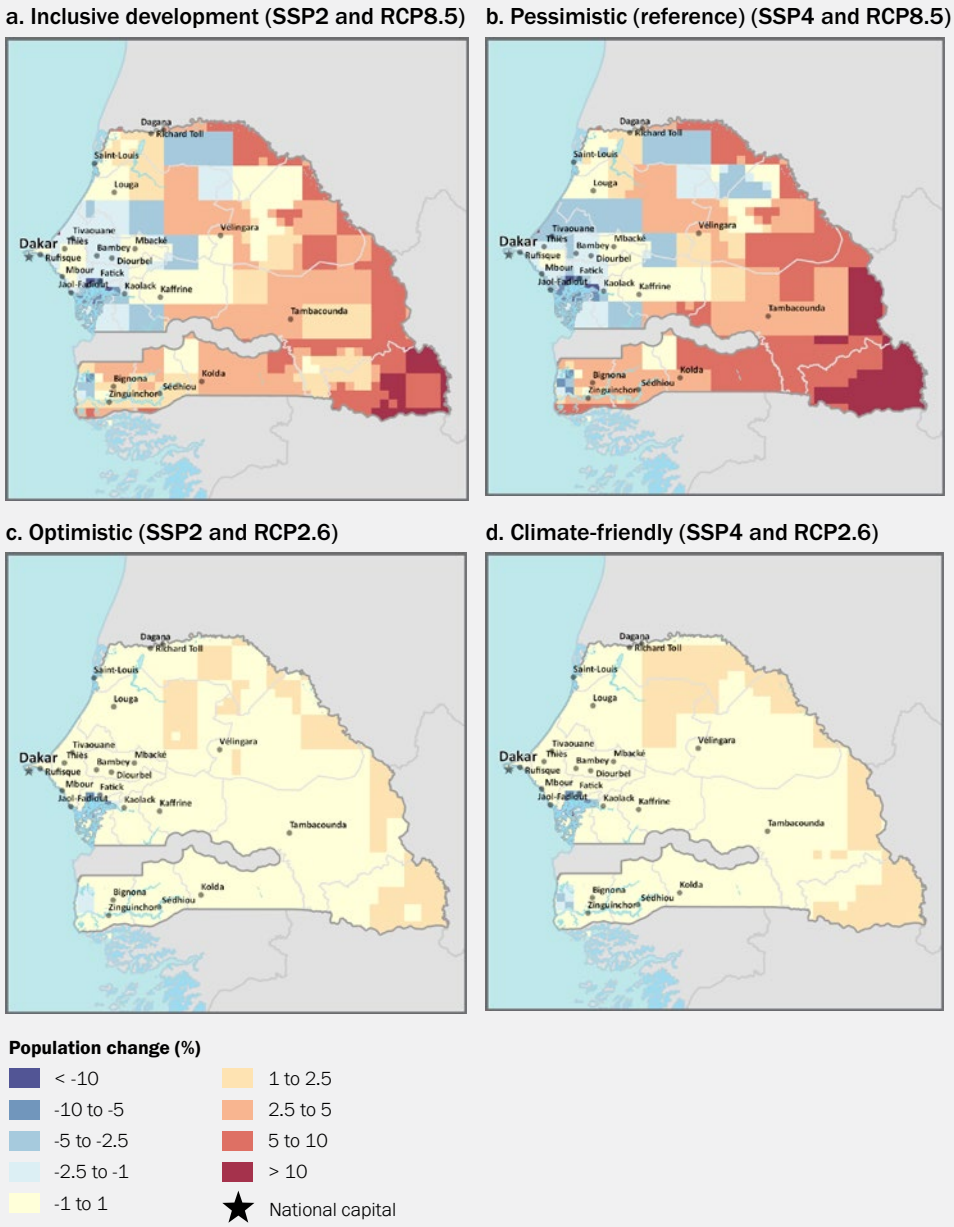


Population change (count)

- < -1,000
- -1,000 to -500
- -500 to -100
- -100 to 0
- 0 to 100
- 100 to 500
- > 1,000
- ★ National capital

Figure 3.14 displays the information in Figure 3.13—the difference between climate impact and no climate impact scenarios—as percentage of the population under the no climate impacts (SSP-only) scenario in each grid cell. This highlight changes in less densely settled areas, since even small changes in thinly settled areas will show up as high in percentage terms. Climate change impacts could make current internal migration destination areas in the west, for example large cities and coastal areas, less attractive to migrants, potentially shifting population distribution to currently less densely populated areas, especially under the higher emissions scenarios (top panels, figure 3.14). In contrast to figure 3.13, figure 3.14 shows that the percentage changes in population around Dakar are relatively small in comparison to the large population in that region. It indicates proportionally large differences in population size in the east, south, and south-east. This seem to suggest that this would also be a function of changes in water availability, which favors inland areas under RCP8.5, but also sea level rise impacts on the coast. Percentage changes are highest in the thinly settled interior, while absolute changes are highest in the coastal zone.

Figure 3.14 Projected Share of Difference in Population due to Climate Migration in 2050, according to the no climate scenario



3.5 INTERNAL CLIMATE MIGRATION BY ZONE: COASTAL AREAS, LIVELIHOOD ZONES, AND PROVINCES

3.5.1 Climate migration in coastal areas

By 2050, sea level rise is projected to reach 1m elevation under RCP2.6 and 2m elevation under RCP8.5, accounting for both the increase in surface height and changes in storm surge. Note that because retreat from the coast is likely to be incremental and over shorter distances, the processing of coastal migration is done using the 1-kilometer resolution modeling outputs, not the results aggregated to 15 kilometers. This means that numbers of coastal climate migrants are not directly comparable to the numbers of climate migrants reported at the country level (above), and only indirectly contribute to the migration numbers reported at the country level (where the 1-kilometer results add up to changes at the 15-kilometer level). Figure 3.15 presents the net migration out of the coastal zone, which is interpreted as the 5-kilometer strip along the coastline. As with Figure 3.6, the average for each scenario is represented by the solid line, and the white areas on the graphs represent the confidence intervals.

For Senegal, modeling results for the four scenarios indicates a negative impact of climate change in coastal zones, with some differences in the volume and uncertainty of coastal climate migration (figure 3.15). The pessimistic scenario projects that up to 206,000 people could be compelled to move from Senegal's 5-kilometer coastal belt by 2050 due to sea level rise compounded by storm surge. There is high degree of uncertainty in the high emission scenarios (pessimistic and more inclusive development), with confidence intervals that cross into positive numbers. The projections are the lowest in the low emission scenarios, with 41,000 and 77,000 coastal climate migrants in the optimistic and climate-friendly scenario, respectively, by 2050. Some out-migration from the coastal areas will be not only due to sea level rise but also due to changes in water availability, which as noted above vary considerably across model runs under the high emissions scenarios.

Figure 3.15 Projected Coastal Climate Net migration, 2020–2050

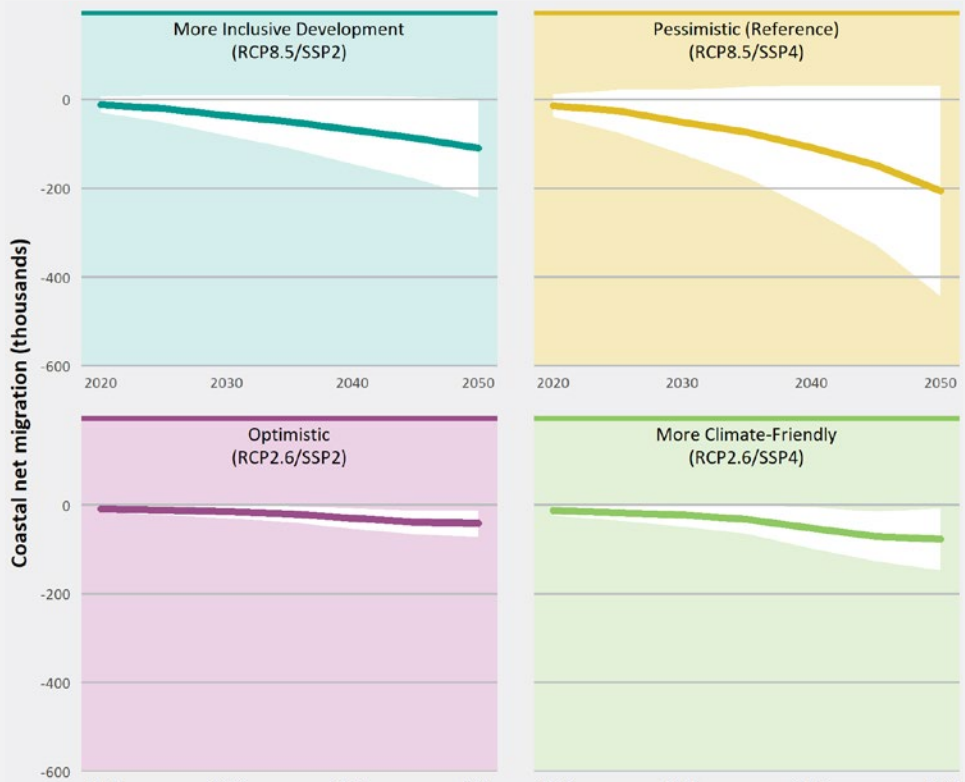
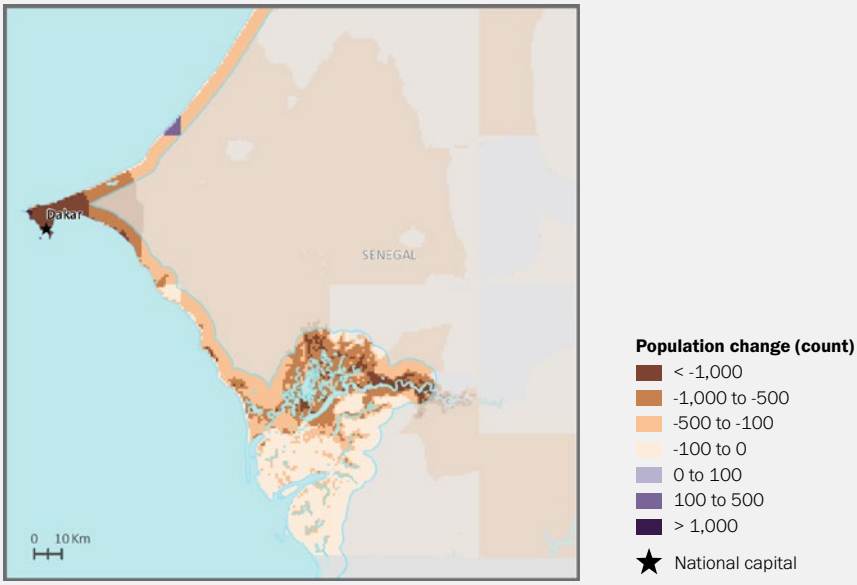


Figure 3.16 presents the 5-kilometer coastal strip overlaid on the population change per square kilometer in 2050 owing to climate migration for the pessimistic scenario only. This is defined as the difference in projected population per square km between the climate impact scenarios and the respective no climate impact scenarios. The map is intended to highlight climate migration in the coastal zone.

In Senegal, coastal zones are largely an area of climate out-migration except for a small area of in-migration northeast of Dakar. The primary drivers are sea level rise impacts and declining water availability.

Figure 3.16 Population Change due to Climate Migration for the Coastal Zone of the Cape Verde Peninsula, Pessimistic Scenario



3.5.2 Climate migration by livelihood zone

Livelihood zones used here are based on an aggregation of anthropogenic biomes produced by Ellis et al. (2013 and 2010). These livelihood zones are static, meaning they are not projected into the future based on likely climate influences on ecosystems (e.g., Williams et al. 2007), but reflect the historical climate period from 1970–2010. The distribution of zones in the future could obviously be altered by climate impacts on the water and agriculture sectors and natural ecosystems. Furthermore, livelihood zones are land-based, and therefore do not take into account livelihoods dependent on marine fisheries along the coast.

Rainfed croplands, pastoral lands and rangelands, and semi-natural lands and wildlands cover almost all of the area of Senegal (figure 3.17 below displays the distribution of livelihood zones in Senegal). There are a few spots of irrigated croplands and rice-growing areas, limited to the south-east of the country. Most of the dense settlements are located in the western part of Senegal along the coast.

Livelihoods in dense settlements and rainfed croplands consistently show an upward trend in negative values of net climate migration across all scenarios and for each decade. Table 3.3 below shows the potential hotspots for livelihoods, for each decade and under each scenario. This is consistent with the results reported in figure 3.15 (coastal climate net migration) and figure 3.10 (hotspots of climate in- and out-migration). For example, the optimistic scenario projects out-migration from dense settlements

between 16,000 and 76,000 people by 2050. Dense settlement hotspots include Saint-Louis in the north of Senegal and close to the Mauritanian border, major towns like Dakar and Thies, the coastal stretch between Mbour and Joal Fadiout and, closer to the Guinea-Bissau border, places like Mlomp, Bignona, and Ziguinchor.

Trends for rainfed croplands are projected to show negative net migration figures under all scenarios with the exception of the more climate-friendly scenario. For example, the pessimistic scenario projects increases in negative net migration in rainfed croplands from 65,000 to 180,000 people in 2030 and 2050 respectively. Under the climate-friendly scenario, there are projected decreases in negative net migration in rainfed croplands from 10,000 to 2,000 in 2030 and 2050 respectively. Rainfed cropland zones include the provinces of Dakar, Thies, Diourbel, Fatick, Kaffrine, Kaolack, some pockets in the center of Kolda, and Sedhiou, the eastern half of Louga, and isolated spots in Tambacounda close to the border of Mauritanian and along the Gambia.

Figure 3.17 Livelihood Zones

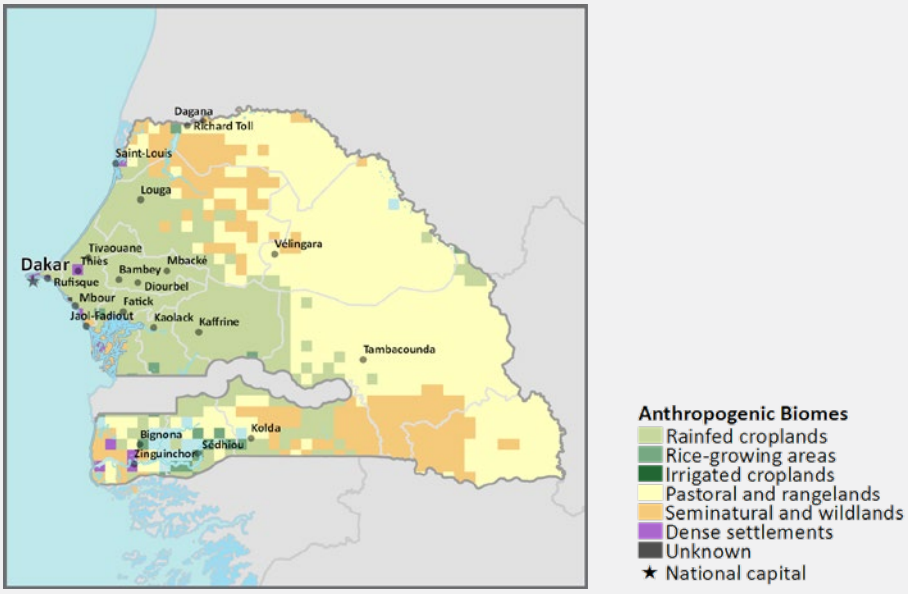


Table 3.3 Projected Net Climate Migration by Scenario and Livelihood Zone and Decade

Year and scenario	Scenario			
	More Climate-friendly (RCP2.6/SSP4)	More Inclusive Development (RCP8.5/SSP2)	Optimistic (RCP2.6/ SSP2)	Pessimistic (Reference) (RCP8.5/SSP4)
2030				
Dense settlements	-11,086	-12,348	-6,547	-21,226
Irrigated croplands	448	3,831	207	4,292
Pastoral and rangelands	15,531	59,447	13,895	62,865
Rainfed croplands	-10,459	-68,329	-11,993	-65,195
Rice-growing areas	627	1,626	279	2,241
Seminatural and wildlands	4,874	15,971	4,157	17,277
Undefined	64	-199	2	-255
2040				
Dense settlements	-24,299	-23,107	-12,684	-44,599
Irrigated croplands	606	6,342	78	7,303
Pastoral and rangelands	25,629	92,470	21,514	106,040
Rainfed croplands	-9,090	-101,351	-13,865	-98,918
Rice-growing areas	947	3,293	200	4,453
Seminatural and wildlands	6,536	22,651	4,976	26,022
Undefined	-328	-298	-219	-301
2050				
Dense settlements	-32,478	-35,441	-15,705	-76,357
Irrigated croplands	357	8,338	-122	15,669
Pastoral and rangelands	29,714	127,600	23,466	180,664
Rainfed croplands	-2,273	-133,494	-10,771	-180,489
Rice-growing areas	1,035	4,423	182	10,415
Seminatural and wildlands	3,964	29,385	3,209	51,431
Undefined	-319	-812	-258	-1,334

3.5.3 Climate migration by province

Figure 3.18 and Table 3.4 display net climate migration for 2050, by subnational first-level administrative area (equivalent to a province or region depending on the country).

For Senegal, while some regions are net winners (Tambacounda, Matam), others are net losers (Fatick, Kaolack). For many of the provinces, results show large confidence intervals expanding from negative (out-migration) to positive (in-migration) values, especially for the high emissions scenarios. The largest negative numbers are for Dakar, Diourbel, Fatick, Kaolack, and Thies. With the exception of Diourbel and Kaolack, these are coastal provinces. The primary climate driver of out-migration is the projected desiccation of the western portions of Senegal. Tambacounda and Matam are large regions in the eastern portion of Senegal that will see increases in water availability under at least the Hadley (HadGEM2-ES) climate model runs (particularly under RCP2.6), leading to climate in-migration. Finally, owing to the lack of subnational data on the median age distribution in Senegal, that demographic variable does not play a role in the migration modeling. The sex ratio does vary, but it has a small overall impact on population change, and flood risk will tend to increase migration to regions such as Ziguinchor.

Figure 3.18 Projected Net Climate Migration by Province and by Scenario for all of Senegal, 2050

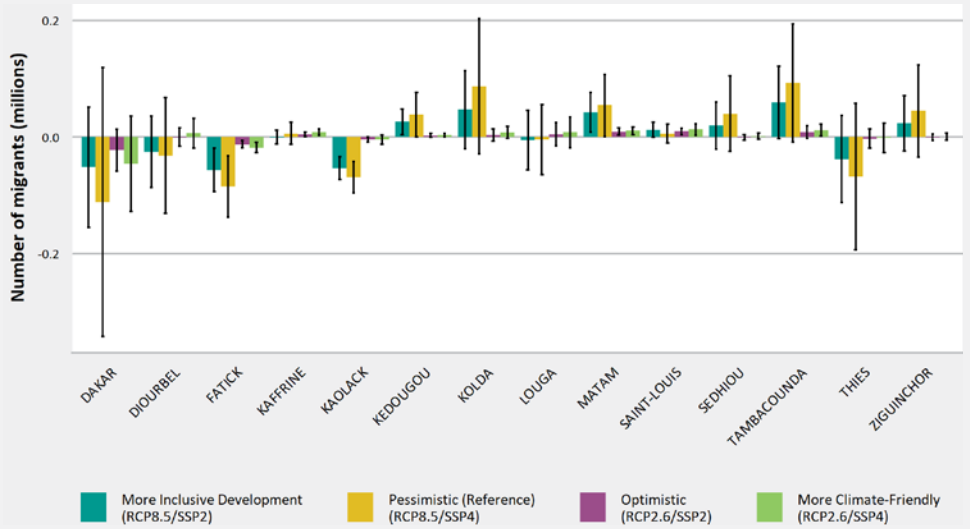


Table 3.4 Projected Net Climate Migration by Scenario and by Province of Senegal, 2050

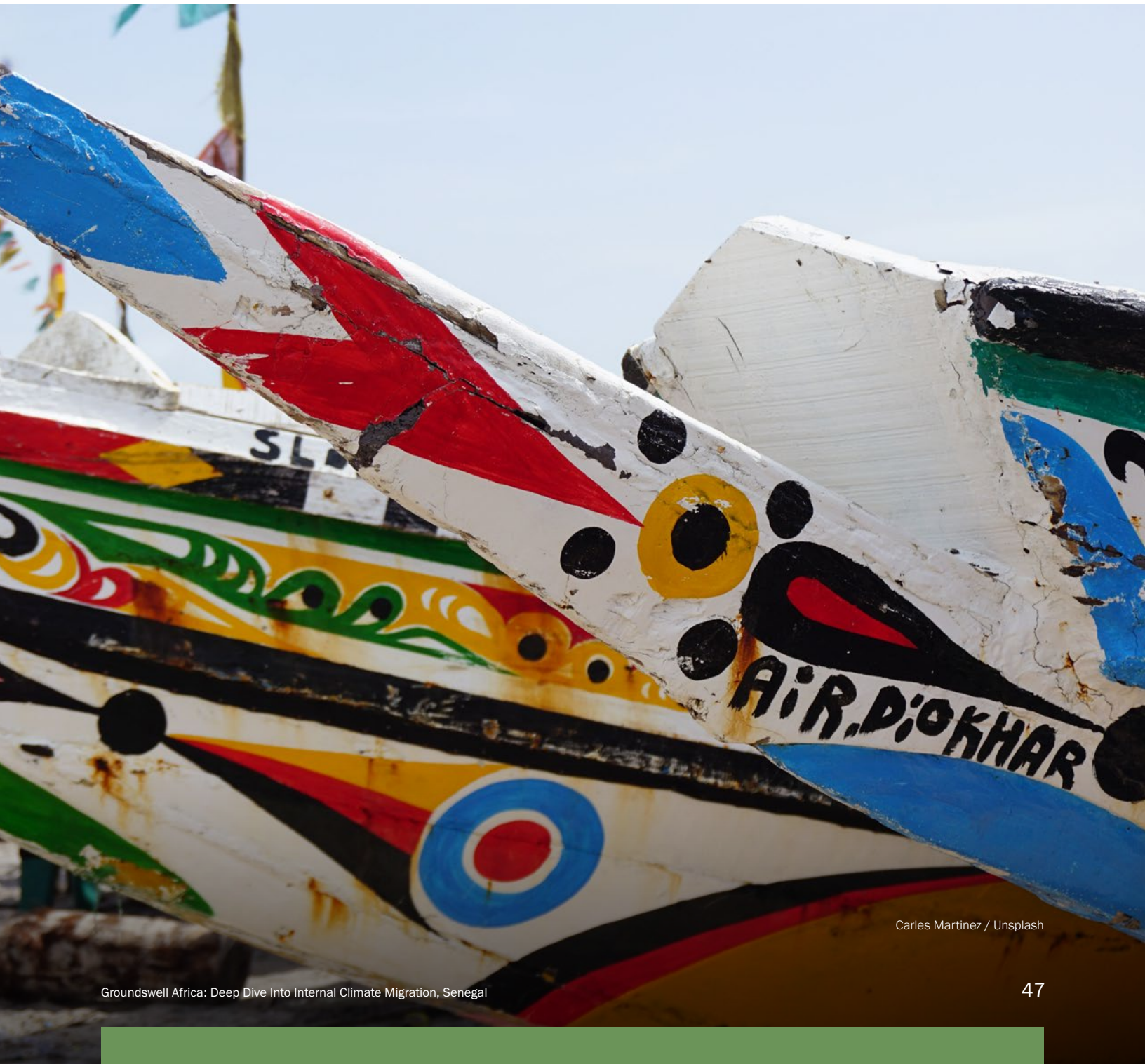
Administrative provinces	More Climate Friendly (RCP2.6/ SSP4)	More Inclusive Development (RCP8.5/SSP2)	Optimistic (RCP2.6/ SSP2)	Pessimistic (Reference) (RCP8.5/SSP4)
Dakar	-46,283	-51,473	-22,504	-111,612
Diourbel	6,347	-25,397	-218	-31,948
Fatick	-18,272	-56,555	-12,496	-85,106
Kaffrine	8,169	-200	4,557	6,125
Kaolack	-4,457	-53,275	-4,289	-68,808
Kedougou	3,381	26,027	2,655	38,436
Kolda	7,672	47,019	3,727	87,142
Louga	8,016	-5,557	4,665	-4,418
Matam	10,731	42,413	9,494	54,479
Saint-Louis	12,979	12,620	9,817	5,959
Sedhiou	1,186	19,984	-418	40,114
Tambacounda	11,693	59,114	8,492	92,957
Thies	-1,635	-38,113	-2,932	-68,032
Ziguinchor	471	23,392	-550	44,713

3.6 SENEGAL AND WEST AFRICAN COUNTRIES

West Africa is a highly mobile region, and it is therefore important to contextualize Senegal's modeling results against mobility in the regional context. The ECOWAS Protocol on the Free Movement of Persons, Residence and Establishment was signed in 1979 and Senegal is a signatory to the Protocol. The Protocol allows ECOWAS citizens: (a) to enter any ECOWAS state without a visa; (b) to reside in any ECOWAS member state for up to 90 days without a visa; and (c) to apply, after 90 days, for a permanent residence permit which allows them to start businesses, seek employment, and invest. An ECOWAS passport was

established in 2000. However, the implementation of the ECOWAS Protocol remains incomplete. Given the free movement and connectivity among the West African countries, which has contributed to regional integration and economic development, considering the potency of climate-induced migration in the region has become an urgent task to inform planning, policy, and actions.

The adoption of the ECOWAS Protocol on Transhumance (1998) and Regulation (2003) is a major achievement for countries in West Africa to facilitate regional livestock mobility. Since the adoption of the Protocol, several West African countries have passed legislation on pastoralism, including Senegal, and through the use of the International Transhumance Certificate (ITC). However, the implementation of the ECOWAS protocol remains uneven today. Support for the domestication of the protocol into national legislation should be encouraged given that pastoralist transhumance represents an adaptation strategy to adverse climatic conditions in the region and a source of food security.



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Senegal is projected to have the third highest number of internal climate migrants in West Africa (Figure 3.19). By 2050, Senegal could have a mean number of 603,000 internal climate migrants, preceded by Niger and Nigeria with 8.5 and 8.4 million, respectively. Projections for 2050 indicate that areas around Matam on the Senegal River bordering with Mauritania, and areas near Ziguinchor and Kolda close to the Guinea-Bissau border, are likely in-migration hotspots. There are also areas of projected in-migration in eastern Diourbel, western Kaffrine, and south of the border near the Gambia. Coordination of future population mobility among neighboring countries along with proactive management of the natural resources (water, pasture, land) in these hotspots will be key, in particular as the areas coincide with high poverty incidence and population density and are in need of infrastructure and basic social services.

Internal climate migrants as a percentage of total population remain relatively low most West African countries, except for Niger with a mean percentage of 13.45 by 2050 (Figure 3.20). Cape Verde and Senegal are projected to have the second and third highest percentages, with a mean of 3.1 and 1.98, respectively, by 2050. Internal climate migration could make up a significant proportion of all migration by 2050, particularly under the high emissions scenarios, and significantly so for countries like Benin, Nigeria, Senegal. Indeed, climate migrants will make up between 25 and 35 percent of total migrants under the pessimistic and inclusive development scenarios both of which have high emission scenarios.

Figure 3.19 West African Countries with the Highest Mean Number of Internal Climate Migrants under the Pessimistic Scenario by 2050

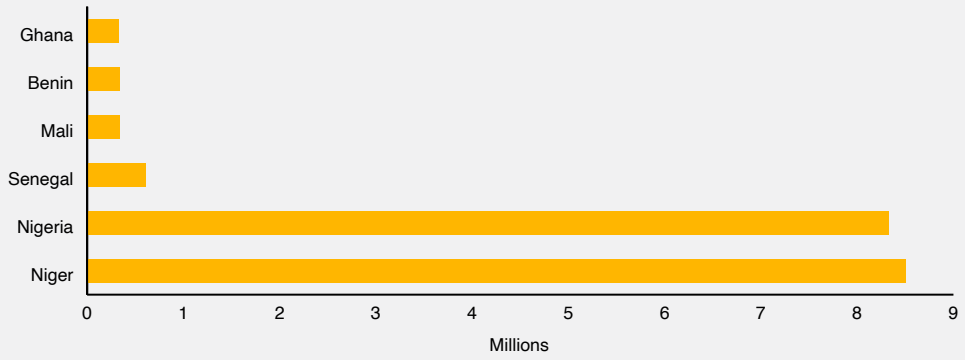
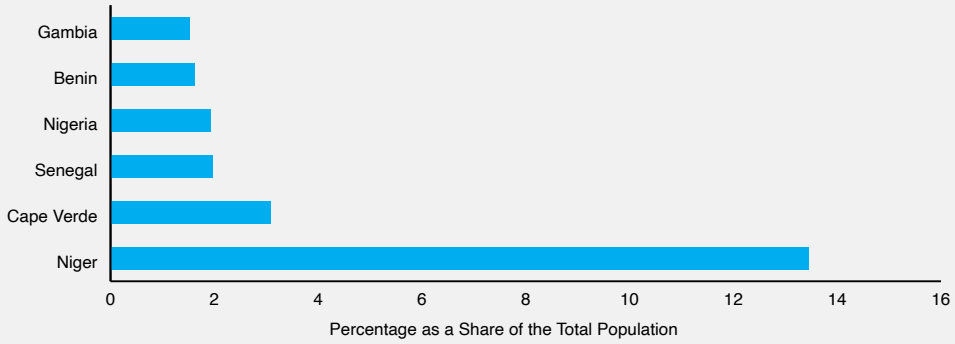


Figure 3.20 West African Countries with the Highest Mean Percentage of Internal Climate Migrants as a Percentage of the Total Population under the Pessimistic Scenario by 2050



Consultations

A regional consultation was conducted in Accra, Ghana, in September 2019, with representatives from government, academia, donors, and civil society organizations from selected West African countries, including Senegal, to solicit feedback on the modeling results.

A second, virtual, consultation was conducted in March 2021, at a regional level, with a focus on the results of the deep dive analysis for Nigeria and the overall strategic response framework, including implications for policy and action (World Bank, unpublished). During the virtual consultation, participants underlined that migration is not new in the sub-region and that several drivers, in addition to climate change and environmental degradation, motivate people to move from one place to another. Increasingly, seasonal "rural to urban" migration is turning into permanent migration as individuals grapple with worsened environmental conditions and diminished resilience capacity. In West Africa, there are strong interlinkages between the loss of livelihoods (as a result of diminished livestock, crop productivity, and drought), unemployment, conflicts, political radicalism, and migration.

An integrated approach to tackling migration in the region by mainstreaming climate change factors in future migration policies was underscored. Fragility and conflict are key features to consider, as these elements could also impact projections related to climate migration. Future population growth remains paramount to address into any development planning process including migration policy design. Participants provided some examples of sound solutions adopted to manage migratory movements including ensuring adequate water points along transhumance corridors for livestock, which helped reduce conflicts between herders and local communities, or providing training to farmers on soil fertility to slow agricultural productivity decline, a factor which has contributed to out-migration (World Bank, unpublished).

Vincent Tremeau / World Bank

Chapter 4

A Strategic Response Framework to Address Climate Migration in Development

4.1 CONTEXT

Climate induced migration is no longer part of the distant future, but a debilitating and undignified everyday reality of vulnerable individuals and communities (Podesta 2019; Wodon et al. 2014). In Senegal, climate-induced migrants are projected to reach a high of 1 million by 2050 under the high end of the pessimistic scenario (3.33 percent of the population), but hotspots of migration are located in vulnerable areas prone to climate impacts, and also at the heart of economic centers.

Climate-induced migration is both a symptom and a signal of underlying failures and crises and must be addressed more pointedly if countries are to achieve their Sustainable Development Goals (SDGs) (IDMC 2012; ODI 2018). The results presented for Senegal reveal that the reality of intensifying climate impacts, the escalation in the scale of climate-induced migration, and the emergence and spread of climate migration hotspots as early as 2030 will act across the territory. The deepening nature of this crisis, alongside the entrapment of the most impoverished, means that inaction is not an option. Current policies and strategies must understand and address the climate–migration–development nexus in a more focused manner.

International frameworks and national policy responses have increasingly recognized climate-induced migration as an underlying cause and threat to sustainable development, but current responses to address the issue continue to lag (de Jong 2019; Thomas and Benjamin 2018; Wilkinson et al. 2016a). Greenhouse gas (GHG) emissions continue to increase and compliance with the Paris Agreement is at risk (UNEP 2020; Watson et al. 2019). More generally, inequitable and uneven growth and development

has left behind an increasing number of individuals, communities, and regions (IDA 2020), with climate impacts amplifying the challenge (FAO et al. 2020; World Bank 2020d). Without transformative and at scale action on climate and development, communities vulnerable to climate change are projected to have increasing numbers of internal climate migrants by 2050 (Rigaud et al. 2018).

Senegal is a signatory to several key legal agreements related to mobility. Senegal has signed or ratified international conventions on migration policy and since 2000 has facilitated, with ECOWAS support, the use of the International Transhumance Certificate (ITC), a sort of passport to facilitate cross-border transhumance for nomadic herders (Alex and Gemenne 2016; Rigaud et al. 2018). Finally, Senegal has signed (but not yet ratified) the African Union's Convention (also known as the Kampala Convention) for the protection and assistance of internally displaced persons in Africa. Senegal's National Action Plan for Adaptation to Climate Change (NAPA), prepared in 2006, makes reference to the impact of sudden disasters like floods on the local population (such as the displacement of villagers in Palmarin as a result of severe floods) (Senegal Ministère de l'Environnement et de la Protection de la Nature 2006). Senegal's NAPA also lists coastal zones as vulnerable areas to climate change and presents several adaptation options including drafting climate-adapted land use plans.

Migration as an adaptation strategy can be a pathway out of poverty (Adger et al. 2003; Barnett and O'Neill 2012; Ellis 2003). Under certain circumstances, voluntary migration can be a desirable form of adaptation, not a reflection of failure to adapt (Black et al. 2011; McLeman and Smit 2006). However, migration must be addressed holistically and embedded in development policies and planning through inclusive and participatory approaches. Strengthening adaptive capacities and increasing readiness in the face of climate change, can create an enabling environment for the positive effects of migration to manifest (Rigaud et al. 2018; Warner et al. 2009). Senegal's 2018 National Policy on Migration establishes a clear link between climate events and migration (including internal migration) as one of the key strategic pillars for action (IOM 2018). More recently, Senegal's 2020 Nationally Determined Contribution (NDC) provides priority actions to adapt key sectors such as agriculture, livestock, fisheries, water resources, health, biodiversity, and coastal zones to a changing climate (Senegal 2020).

The urgency for transformative and far-sighted planning and action on climate migration cannot be postponed—with 2030 being a critical year. The latest IPCC report finds that the global average temperature increase will likely exceed 1.5°C within the next two decades, and could potentially surpass 2°C by the end of the century if carbon-intensive human activities continue at the current rate (IPCC 2021). Climate impacts will continue to deepen existing vulnerabilities and lower capacities, leading to poverty, fragility, conflict, and violence. Already, the number of additional displacements attributed to disasters is on the rise—30.7 million new displacements across 149 countries and territories occurred in 2020, with 4,300,000 of internal displacements occurring within Sub-Saharan Africa as a result of disasters (IDMC 2021). In Senegal, climate-related shocks are projected to have the biggest impact on welfare decrease, according to the 2018 World Bank Systematic Country Diagnostic (SCD) for Senegal (World Bank 2018b). Ex post responses to crises will not suffice. It's imperative to have a step change—transformation at scale— to counter distress-driven climate migration, as part of broader development action.

Agenda 2063 is Africa's blueprint and master plan for transforming Africa into the global powerhouse of the future. Senegal can seize this framework to advocate and advance future reforms geared towards a climate resilient economy. Agenda 2063 was developed in 2013 under the auspices of the African Union, provides a 50-year vision and is one of the most looking forward framework the continent can offer. Several goals proclaimed by the Agenda are aligned with the UN Sustainable Development Goals (SDGs) in particular on transformed, sustainable and inclusive economies and climate resilient sectors. Goal 4 of the Agenda on transformed economies supports SDG 8 and 9 on resilient infrastructure, innovation, and productive employment. Similarly, Goal 7 of the Agenda on environmentally sustainable and climate resilient economies and communities reinforces SDG 6,7, 13 and 15.

There is a real opportunity to harness climate migration as a factor of growth, jobs, and economic transition within countries, which to date has remained untapped (Scheffran, Marmer, and Sow 2012; Rigaud et al. 2018). A unified approach to addressing climate migration must deliver on the core development needs—food, water, environment—and priorities to deliver on the SDGs of individual countries and the World Bank's poverty alleviation goals (World Bank 2020d). Climate migration will play out against a backdrop of other mega-trends of population growth, urbanization, and biodiversity loss as well as technological innovation, digital revolution, and broader economic transitions to low-carbon pathways (World Bank 2020d). The plausible climate migration scenarios presented in this report are not cast in stone but provide an opportunity—through proactive global and local/national action—to not just reduce the scale of climate migration, but to harness opportunities for growth and jobs as part of the transition to resilient and low-carbon economies in the pivotal 2020s decade. This chapter proposes a strategic response framework for mainstreaming climate migration into development policy and planning in Senegal.

4.2 CORE POLICY DIRECTIONS AND DOMAINS OF ACTION

Climate migration is a reality and a cross-cutting issue which has to be addressed through policy-informed actions that are farsighted in their approach and execution. Unless concerted climate and development action is taken now, the scale of climate migration will ramp up by 2050, and hotspots of climate in- and out-migration will spread and intensify. These trends will likely accelerate beyond 2050 with worsening climate change.

The World Bank's *Groundswell* report underscored the need for bold and transformational action to address climate-induced migration through four lines of policy action (Rigaud et al. 2018):

- Cut greenhouse gases now.
- Pursue inclusive, climate-resilient, and green development.
- Embed climate migration in development planning.
- Invest in an improved understanding of migration.

These policy directions must be buttressed with a core set of action domains to ensure durable and sustainable development outcomes with respect to distress-driven climate migration (Figure 4.1).

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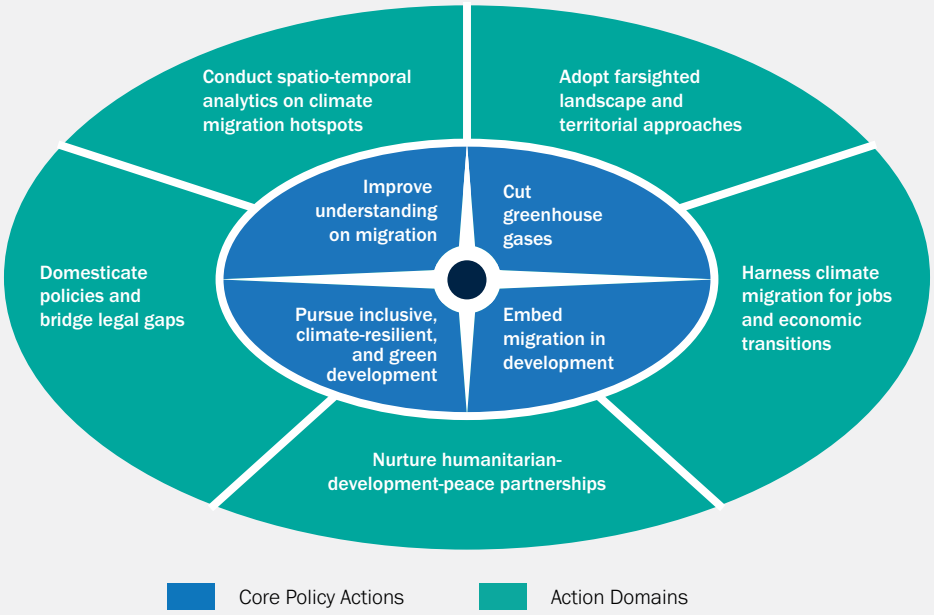
Figure 4.1 Core Policy Directions and Action Domains to Mainstream Climate Migration into Development



Source: Rigaud et al. 2021a.

a. MACS was derived as part of the two Groundswell Africa regional reports: *Groundswell Africa: Internal Climate Migration in West African Countries* (Rigaud et al. 2021a) and *Groundswell Africa: A Deeper Dive into Internal Climate Migration in the Lake Victoria Basin Countries* (Rigaud et al. 2021b).

The Migration and Climate-informed Solutions (MACS) framework (figure 4.1) allows us to make connections across time and space that have hitherto been missing and cope with future uncertainties and disruptions. It seeks to ensure that vulnerable communities are prepared to confront current and future climate risks, and that economy of the country is braced not just for the challenges but also the opportunities of climate migration.

MACS stems from the growing interest within the World Bank and the wider community to better understand the implications of climate induced migration and mainstream this phenomenon into development plans, programs, and policies. The Groundswell report (Rigaud et al. 2018) introduced slow-onset climate impacts (water stress, crop failure, sea level rise) into a model of future population distribution — and established four core policy actions central to MACS framework: (i) cut greenhouse gases now; (ii) pursue inclusive and climate-resilient development policies; (iii) embed climate migration in development planning; and (iv) invest in an improved understanding (Figure 4.1).

The findings from the Groundswell Africa paved the way for domains of action to bolster the delivery of core policy directions set within MACS to reduce, avert, and minimize distress-driven internal climate migration. It identifies five domains of action (i) conduct spatio-temporal analytics to understand the emergence of climate migration hotspots; (ii) enable/embrace landscape and territorial approaches; (iii) address and harness climate induced migration as an opportunity; (iv) nurture development-humanitarian-peace partnerships; and (v) bridge the gap in legal mandates and frameworks. The results contextualized and localized the Groundswell findings on the basis of literature review of the current and historic mobility patterns and stakeholder consultations. This analysis was further supplemented by the examination from the design features of 165 World Bank projects operating at the climate-migration-development nexus with commitments amounting to US$197.5 billion between 2006-2019 (Rigaud et. a. 2021c).

The MACS framework underscores the need for anticipatory approaches. While the core policies offer high-level forward looking strategic directions, the domains of action are grounded in reality, linked to sectoral interventions, and speak to different group of actors in an inclusive way and along the entire development-climate-humanitarian spectrum.

MACS is designed to be flexible, based on the premise that climate migration is linked to broader development challenges across spatial scales. Paramount to this premise is the need for country leadership and bottom-up engagement to set out policy and embed action in concrete investment projects backed with the right operational instrument. MACS is not restricted to any single country or region nor is there one formula or pre-determined sequence of actions to operationalize it. It provides a holistic yet flexible set of domains of action that can be applied and sequenced, at different stage of planning, in response to the local, country or regional context and migration patterns. It was developed with vital contributions from World Bank staff and a group of internal and external peer reviewers. Stakeholders inputs from civil society, government institutions, and academia, as well as regional and international organizations and donors were also integrated during the course of consultations.

The MACS framework speaks to both policymakers and practitioners as it offers critical information and insights with regards to trends, timelines and development and policy implications of climate-induced internal migration. It is intended to inform the preparation of strategic and sectoral development plans and is targeted to national and local level planners, who are in the frontline of future climate migration trends. From the World Bank's perspective, MACS offers inputs to the core diagnostic tools – including the new the Country Climate and Development Report (CCDR)—that inform country engagement and helps to pinpoint areas that may become hotspots of climate in- or out-migration in both rural and urban areas, and across vital landscapes, and key coastal and livelihood zones. In addition, the framework is geared to inform international actors along the humanitarian-development-security continuum. Donors and development partners can use MACS to leverage concrete instruments to finance investments and design new projects, which tackle climate migration as a cross-sectoral issue and address challenges faced by climate-driven migrants and host communities, in particular, in fragile environments.

4.2.1 Overarching Core Policy Directions

Action across four major policy areas (Figure 4.1) of the MACS framework could help reduce the number of people forced to move in distress due to climate change.

1. Cut greenhouse gases now to reduce climate pressure on people's livelihoods and the associated scale of climate migration

Rapid reductions in global emissions can reduce the scale of distress-driven climate migration. Lower global emissions reduce climate pressure on ecosystems and livelihoods and broaden the opportunities for people to stay in place or move under better circumstances. In Senegal internal climate migrants as a percentage of population could drop from a high of 3.33 percent under the high end of the pessimistic scenario to approximately 0.25 percent under the low end of the optimistic scenario by 2050 (Table 3.1). Stringent global climate action would be needed to adhere to the UN's Paris Agreement and limit future temperature increases to less than 2°C by the end of this century, close to the more climate-friendly scenario in this report. According to UNEP (2020), the world is moving towards a temperature rise more than 3°C this century and this could increasingly foreclose some of the options for reducing climate-induced migration. Increased ambition in the next round of NDC submissions must have bolder and more comprehensive mitigation policies and include carbon pricing, urban and land-use planning, and innovations in performance standards. Mitigation policies must be inclusive and pro-poor, guarding against potential blowback of mitigation measures. In Senegal, our analysis indicates that low-carbon emissions growth and equitable development can lower the scale of future climate-induced human mobility by half a million by 2050, comparing the mean number of the pessimistic and the optimistic scenario.

2. Pursue inclusive and climate-resilient development policies together with targeted investments to manage the reality of climate migration

Climate migration demands anticipatory development policies that respond to the scale of the issue over the medium to long term. If action is undertaken sooner rather than later, Senegal will be in a more manageable position to address the projected increase in the number of climate migrants by 2050. In some cases, an economic transition toward sectors which are less sensitive to climate change needs to be part of the longer-term solution. These shifts can provide alternative job opportunities for climate migrants and growing populations and help strengthen the resilience of economies. Good management of demographic transitions and investment in human capital can also reduce climate vulnerability. Targeted interventions—such as facilitating informed migration decisions, making social protection portable and scalable, and tapping the potential of financial and social remittances—must be deployed in the short and medium term to support positive and sustainable outcomes.

3. Embed climate migration in development planning

There is an urgent need for countries to integrate climate migration for all phases of migration across timescales into national development plans and policy. Most regions have poorly prepared laws, policies, and strategies to deal with people moving from areas of increasing climate risk into areas that may already be heavily populated. Policy focus on the full migration life cycle—i.e., *adapt in place*, *enable mobility* and *after migration*—will ensure the presence of the adequate ecosystem to avert, minimize, and address climate-induced migration in response to current and future climate risks and impacts. Given the slow pace of lowering emissions globally, transformative and at-scale inclusive development becomes an even greater imperative to counter distress-driven climate migration.

***Adapt in place* ensures help to communities to stay in place where local adaptation options are viable and sensible.** Components of successful local adaptation include investing in climate-smart infrastructure, diversifying income-generating activities, and building responsive financial protection systems for vulnerable groups, including women. Under the WACA regional investment project, both green and grey interventions are planned in Senegal to include coastal stabilization work for the Corniche in Dakar, protection of the island of Gorée (a UNESCO World Heritage Site), and regeneration of shared or transboundary ecosystems. Income-generating activities are also planned to sustain local livelihoods of the most vulnerable communities affected by coastal erosion in Saint-Louis, over and above a citizen engagement plan (World Bank 2020b). Thus, coastal hotspots are good entry points to engage the local communities on adaptation options in the face of worsening climate conditions and push for mobility.

***Enable mobility* facilitates movement of people away from unavoidable climate risks when the limits of local adaptation and viability of ecosystems are reached.** Governments should facilitate safe, orderly, and dignified migration (or, as a last resort, planned relocation) toward areas of lower risk and higher opportunity by providing skills training, information, and legal support. The Regional Sahel Pastoralism Support Project, with Senegal as a beneficiary, supports trans-boundary migration as an adaptation strategy for pastoralists and livestock threatened by droughts and conflict. The project was designed to improve the subregional infrastructure network for migrating pastoralists, including migration corridors, markets for regional trade in livestock products, and shared water points. The Saint-Louis Emergency Recovery and Resilience Project for Senegal, approved in 2018, gave direct temporary relocation support to close to 1,000 households (nearly 10,000 people) in the city of Saint-Louis who have already been displaced by coastal erosion or are amongst the most vulnerable people living within the 20-meter zone considered at very high risk of flooding (World Bank 2018a). The five-year project also adopted an inclusive, participatory approach to plan for the relocation of the affected communities by ensuring the active involvement of local communities throughout the project cycle.

In *after migration*, sending and receiving areas, and their people, are well connected and adequately prepared for the medium and longer term. Policy makers should develop and implement migration preparedness plans for the immediate and longer-term population growth from migration. In particular, secondary cities have an increasing role to play as growth poles that can support large, active domestic

markets and focus areas for tertiary manufacturing, while also strengthening rural to urban linkages by providing access to markets. Increasingly plans should include viable livelihood opportunities, skills training, critical infrastructure and services, registration systems for migrants (to access services and labor markets), and the inclusion of migrants in planning and decision-making.

4. Invest now to improve understanding of internal climate migration

More investment is needed to better contextualize and understand climate migration, particularly at scales ranging from regional to local, where climate impacts may deviate from the broader trends identified in a global-scale analysis. There are inherent uncertainties in the way climate impacts will play out in a given locale and this will affect the magnitude and pattern of climate change-induced movements. Studies such as those conducted for this report are necessary to provide insights on the scale of the issue. Over time, as more data become available on climate change and its likely impacts on water availability, crop productivity, and sea level rise, the scenarios and models would need to be updated. Increasing the modeling resolution and improving data inputs to produce more spatially detailed projections are among the possible future applications of the approach used in this report.

Building country-level capacity to collect and monitor relevant data can increase understanding of the interactions among climate impacts, ecosystems, livelihoods, and mobility and help countries tailor policy, planning, and investment decisions. Pastoralism surveillance tools (bulletins, maps, and alerts) have been generated for several countries in Africa, including Senegal (ACF 2016). These tools use a combination of satellite and field/digital data to measure biomass and surface water production and accessibility together with livestock conditions. Including climate-related and migration questions in national census and existing surveys are a cost-effective way to advance understanding. Decision-making techniques under deep uncertainty need to be further developed and applied for policymaking and development planning. Evidence-based research, complemented by country-level modeling, is vital. In support of this, new data sources—including from satellite imagery and mobile phones—combined with advances in climate information can be beneficial to improving the quality of information about internal migration. Under the WACA regional investment operation, Senegal seeks for example to strengthen its coastal observation and early warning systems. In all of these efforts, the privacy of personal data needs to be protected, and human rights need to be respected.

4.2.2 Domains of Action to Drive Planning and Action at Scale

Climate migration is a reality and as a cross-cutting issue has to be addressed through policy-informed action that is farsighted in its approach and execution. The MACS framework through its five domains of action can bolster the delivery of the core policy direction to reduce, avert, and minimize distress-driven internal climate migration as presented and summarized in Table 4.1.

Table 4.1 Domains of Action to Drive Planning and Action: Rationale and Illustrations

DOMAIN OF ACTION	RATIONALE	ILLUSTRATION
1. Conduct spatio-temporal analytics to understand the emergence of climate migration hotspots	Climate induced migration leads to emergence of climate in- and out-migration hotspots and poses distinct spatio-temporal challenges. Coinvesting in iterative scenario modeling, grounded in new data and development progress, will be crucial for decision support based on countries' own progress against which climate-induced migration will unfold. Such investments will be best placed to facilitate long-term planning and investments in adaptive capacity to secure climate resilience.	In Senegal, climate-induced migration is expected to increase as early as 2030 as a result of more severe and variable droughts and floods. In-migration hotspots will occur in areas where poverty levels are high.
2. Adopt landscape and territorial approaches for farsighted planning to avert, minimize, and address climate-induced migration	Addressing underlying causes of distress-driven migration—both slow- and rapid-onset climate factors—through enhanced land management, natural resource management, livelihoods, and ecosystem integrity must be a priority. Placement within larger territorial approaches to enable planning across spatial and time scales through a focus on the full migration cycle is an imperative for readiness and sustainable and durable outcomes.	In Senegal, the coastal areas will witness both rapid-onset climate events such as storm surges and floods, as well as slow-onset climate factors such as coastal erosion. Floods have affected 400,000 to 600,000 people a year from 1980 to 2008 in Senegal and cost more than $42 million in estimated flood damages over the same period. Urban planners need to consider the full migration cycle as part of their coastal resilient land use mapping process.
3. Address and harness climate-induced migration as an opportunity for jobs and economic transitions	Effective management of climate-induced migration can drive growth, jobs, and economic transition. Driving economic transition to help countries leap-frog into climate resilience at scale, by harnessing climate migration to nurture jobs, skills, and economic growth through well-conceived economic, demographic, and urban transitions.	Climate migrants as a percentage of population could average 2 percent in Senegal. However, in-migration hotspots could occur in areas where poverty levels are high and with low adaptive capacity. Growth poles can be an important determinant for driving internal migrants and will require human capital investment alongside structural transformation. Coastal fisheries in the Gulf of Guinea need to be an important area of focus in the face of growing fisheries-driven mobility.
4. Nurturing development-humanitarian-peace partnerships for end-to-end action at the national and local levels	Climate-induced migration can exacerbate the current social fault lines and contribute to or exacerbate conflict and potentially derail humanitarian and development agendas of poverty reduction. For an end-to-end approach that provides for human dignity in mobility we need to work collectively and in partnership—building on mandates and responsibilities—with country governments and local actors.	In Senegal, with water becoming increasingly scarce, farmers are expanding their fields into pastoral regions and transhumance corridors. In turn, pastoralists leave their villages with their herds earlier in the year to deal with excessive drought, thus leading to increased tensions between migrant herders and sedentary farmers compounded by underlying ethnic/political tensions. The scale and complexity of climate-induced migration challenges could require integration of humanitarian-development-peace efforts.
5. Bridge the gap in legal mandates and frameworks on climate-induced migration to support well-conceived responses	Legal architecture brings clarity, protects affected individuals and communities, and reconciles international funding and local decision-making. There is an opportunity to build on the legal architecture to address climate-induced mobility to drive operations and response at scale.	Harmonizing migration actions, methodologies, and data collection and sharing between Senegal and neighboring countries (such as pastoralism surveillance) with the support of the ECOWAS is a key step. Tackling this regional coordination challenge requires sound legal mandates and frameworks.

1. Conduct spatio-temporal analytics to understand the emergence of climate migration hotspots

Climate induced migration is not uniform within Senegal—its impacts vary across space and time. As a result, it poses distinct spatial challenges that necessitates spatially aware long-term planning that can avert, minimize, and reduce the negative impacts of climate migration. While the increase in climate migration is projected as a gradual trend over the next 30 years across all scenarios, the reality for Senegal is that significant climate-driven mobility is expected to occur as early as 2030. This trend contrasts with some other African countries where climate-driven mobility is expected in 2040 or 2050. Furthermore, the scale of the climate migration in Senegal will take place in pockets with already high levels of poverty, thus prompting the need for immediate action. Expanded and more granular modeling and analysis undertaken in this study, including a focus on water stress, crop productivity, net primary productivity, sea-level rise compounded by storm surge, floods and conflict would benefit from local data, tailored assessments, and on-site interviews. These findings have important policy implications and require greater scrutiny and analysis. It is imperative to develop climate migration hotspot maps for the country and identify spatial climate risks and impacts to secure resilience.

Early action, aided by state-of-the-art models on the current and future trends of mobility, is crucial for policymakers to drive proactive and informed action in this regard. Investing in evidence-based research at the national level and mobilization of new data sources—including from satellite imagery and mobile phones— can help better contextualize and understand climate migration (particularly at local scales) where climate impacts may deviate from the broader regional or global trends. The results from this study demonstrate that climate migrants will move from less viable areas with lower water availability and crop productivity, and from areas affected by rising sea level and storm surges. These trends and the emergence of "hotspots" of climate-migration will have major implications on conceiving effective responses. In Senegal, climate in-migration hotspots will be concentrated near the town of Matam on the Senegal River (border with Mauritania), and near Ziguinchor on the Guinea-Bissau border, in eastern Diourbel and western Kaffrine, and south of the border near the Gambia—areas which have high incidence of poverty. On the other hand, the climate out-migration hotspots will be concentrated in the center-west of the country including Dakar, Thies, Fatick, and Kaolack. These trends imply the need for greater development efforts, investments, and focus to adequately prepare Senegal's regions for the influx of climate migrants. The suite of policy actions to embed resilience in hotspots should include investments and economic opportunities in green industry, environmental safeguards, institutional strengthening and coordination, health, sanitation, and energy infrastructure.

2. Embrace landscape and territorial approaches for farsighted planning to avert, minimize, and address climate-induced migration

Climate change impacts along with other socioeconomic trends could change the desirability of land and natural resources, alter the ways in which they are used, and shift the comparative advantage of locations across the landscape (Childress, Siegel, and Törhönen 2014). Ultimately, these changes have implications on migration patterns and necessitate deeper engagement with land uses and their interactions with broader forces. Senegal's coast is particularly vulnerable to climate change and extreme events. Yet Dakar is the main reception area in the country for all internal migrants. The capital also attracts a huge portion of the country's tourism flow and infrastructure whereby over $2billion or 5 percent of assets are considered exposed to high natural hazard potentials in the Dakar metropolitan area (World Bank 2009). Analysis of climate change impacts on landscape, terrestrial and marine ecosystems, and natural habitats in conjunction with community-focused planning is a step forward. Local Integrated Coastal Zone Management (ICZM) plans and analysis of adaptation options are good entry points for communities, such as in the Casamance estuary, to address the delicate balance between the coastline and riverine estuaries and potentially avoid the loss of land and livelihoods due to severe marine erosion.

The placement of a landscape approach within larger territorial approaches enables planning across spatial and time scales through a focus on the full migration life cycle (before, during, and after). It takes into account the underlying causes of distress-driven migration, and addresses both slow-onset and rapid-onset migration and their interlinkages. It offers a pathway to site-specific planning for climate-induced migration with an expanded and integrated view of land that can support local priorities and natural resource uses. Unlike sector-oriented planning, it allows a deeper understanding of human-natural ecosystems and how they impact migration through land management, natural resource management, livelihoods, and ecosystem integrity. Local, national, and regional level planning is essential to avert conflicts and crises, which will be amplified by population increase. Site-based and locally driven practices to undertake forest management, conserve wildlife, and develop water management plans and integrated community programs and land use plans will help avert, minimize, and address climate-induced migration. The Sahel Irrigation Initiative Support Project and the Senegal River Basin Climate Change Resilience Development Project, both ongoing operations supported by the World Bank, are two concrete examples which illustrate climate-smart approaches to natural resource management.

3. Address and harness climate-induced migration as an opportunity for jobs and economic transitions

Migration affects the well-being of the migrant, the household, and the sending and receiving community (World Bank 2019b). Incremental, low-regrets measures alone will not be sufficient to counter the magnitude of climate impacts (Kates, Travis, and Wilbanks 2012). Sequences of flexible incremental adaptation should be explored alongside more transformational adaptation, to secure resilience over longer timescales (Kates, Travis, and Wilbanks 2012; Pal et al. 2019). Sound management of demographic transitions and investment in human capital can reduce adverse impacts of climate migration. With more erratic rainfall patterns and a projected decrease in agricultural productivity, Senegal will need to boost less climate-sensitive sectors of its economy to support a large influx of young job seekers. The World Bank Casamance Development Pole Project for Senegal specifically targets youth employment, agricultural productivity, and better connectivity. Its objectives are to: (i) enhance the agricultural productivity of youth and female farmers for selected crops; and (ii) improve transport linkages in isolated rural communities in targeted areas of the Casamance region (World Bank 2013b). Demographic transitions need to be accompanied by policies to absorb larger working-age populations into productive and climate-resilient labor markets—and to ensure that they have good access to health care, employment, and education.

Good management of migration, driven by climate change over longer time scales, can produce positive momentum for such shifts (World Bank 2019a). Climate-smart urban transitions also provide win-win opportunities to invest in the next generation of skills to foster green and resilient jobs, and secure cities as engines of growth. For instance, vibrant cities in Senegal like Dakar or St-Louis will be impacted by sea level rise, compounded by storm surges. Dakar, which hosts 23.2 percent of the total population concentrated in 1 percent of the country's territory, will see a population dampening due to climate out-migration. In such cases, early action to fortify coastal assets through green and grey infrastructure must be optimized through adapt-in-place options, while considering participatory planned relocation as part of longer-term solutions. Anticipatory planning through a focus on climate in-migration to secondary cities or peri-urban areas could lay their foundation as growth poles in place of sprawling slums steeped in poverty. Combining these opportunities with climate-smart urban transitions that also nurture and build skills, talent, and workforce to harness the youth bulge through a focus on energy-efficient, green, and resilient urban infrastructure and services would present a win-win scenario. Remittance services facilitation, access to livelihood and education, skills training, registration services to improve access to public goods, accessible transport systems, social protection, mitigating conflict, cash for work programs, and land tenure offer ways to make migration work for all (Merotto 2019).

4. Nurturing development-humanitarian-peace partnerships for end-to-end action at the national and local levels

Migration can be seen as a triple nexus of humanitarian-development-peace efforts, working with national and local stakeholders. While this report does not focus specifically on cross-border migration, the modeling identifies numerous migration hotspots in areas close to national borders. Climate change can be an inhibitor or a driver of cross-border migration, depending on a range of factors that propel individuals to decide to move. Countries must deploy holistic strategies to deal with the different facets and actors of mobility in the face of climate change. Cooperation and stepped-up action by development, humanitarian, security, and disaster communities across the mobility continuum could greatly assist countries in pursuing more holistic and durable solutions to climate-induced migration and displacement in support of peace, stability, and security in the region (World Bank 2019b). In the past, humanitarian efforts were followed by development efforts and these operated with different objectives, counterparts, instruments, and logic (Guinote 2019). However, climate change is posing novel challenges and causing hitherto unknown dilemmas to undermine the humanitarian, development, and peace agenda. Unplanned migration and the absence of policies and strategies to integrate different communities can exacerbate the existing social tensions and fault lines into a downward spiral leading to conflicts (Thoha 2020). In Senegal, with water becoming increasingly scarce, farmers are expanding their fields into pastoral regions and transhumance corridors and pastoralists leave their villages with their herds earlier in the year to deal with drought, thus leading to increased tensions between herders and farmers.

Treating migration as a nexus of the humanitarian-development-peace frameworks implies overcoming structural barriers and internal divisions around sources of funding, coordination mechanisms, and project timelines (OCHA 2017). This approach can benefit from the comparative advantage of different actors to strengthen the local capacity (OCHA 2017). Ultimately, this approach is geared to reduce humanitarian need, risk, and vulnerability through a range of well-aligned short-, medium- and longer-term contributions by humanitarian and development actors (OCHA 2017). The linkages need to happen in a contiguum (simultaneously) to secure peace, address the humanitarian objectives to save lives and alleviate human suffering, and as achieve the development priority to alleviate poverty. Modalities to increase the impact of climate-linked humanitarian development and peace actions include strengthening local platforms for solving cross-border natural resource management conflicts, mobilizing community leaders and traditional institutions; and facilitating bilateral and multilateral partnerships.

5. Bridge the gap in legal mandates and frameworks on climate-induced migration to support well-conceived responses

There is an absence of comprehensive and coherent legal architecture to address climate-induced mobility (Leighton 2010; Kuusipalo 2020). Adequate protections under international law are generally not afforded to those moving primarily due to environmental factors (Kuusipalo 2020). As the impacts of climate change intensify, there will be more migrants and displaced people not covered by law.

A well-defined and implemented legal architecture brings clarity, protects affected individuals and communities, and reconciles international funding and local decision-making (Mayer 2011). It can pave the way for migrants to demand and seek assistance; ensure meaningful consultation about relocation; secure tenure at the new location; restore, if not improve their livelihoods; and ensure that disadvantaged and vulnerable individuals and communities receive special attention (Kuusipalo 2020).

Policy makers must guarantee that existing legal frameworks are in line with the Kampala Convention and international frameworks. This will bolster the legal architecture to address climate-induced migration. Key components of any legal framework should include and promote a cross cutting view of housing, land and property issues, access to schools, work, and health care policies; monitoring and evaluation of the extent to which governments' actions are aligned with their legal obligations, legal clinics, and the collection of accurate information.

4.3 CALL TO ACTION

The Plan Senegal Emergent (PSE), Senegal's National Development Plan, was adopted in 2014 and aims to achieve middle-income status for Senegal by 2035. The PSE has three strategic axes or pillars: (a) transforming the structure of the economy to support strong and sustainable growth; (b) expanding access to social services and social protection and preserving the conditions for sustainable development; and (c) responding to the requirements of good governance, through institutional strengthening, and promoting peace, security, and African integration.

Building on the first Priority Action Plan for 2014–2018 (PAP 1), the PSE's next PAP for 2019–2023 (PAP2) provides several entry points and strategic objectives for addressing climate-induced migration challenges in Senegal (Senegal, Ministère de l'Économie, des Finances et Du Plan 2018). Tackling the negative impacts of climate change is recognized as a key objective. According to the PAP2, this objective translates into the strengthening of communities' capacity for adaptation and resilience and the preservation and sound management of natural resources (reducing biodiversity loss, coastal erosion, land degradation, and deforestation). NDC implementation, building a green economy, and private sector engagement are critical crosscutting actions.

Further, the PAP2 recognizes the need to strengthen the national migration governance framework of Senegal and its implementation, based on an improved data and monitoring system of migratory movements throughout the entire territory and across borders. Other significant sectoral interventions include: (i) employment opportunities, research and innovation, and skills training in particular for women and young people, to make the most of the demographic dividend; (ii) incentives to investors and firms to develop competitive industrial hubs and special economic zones (SEZ) in support of decentralization and export diversification; (iii) a high-value agriculture using smart technologies and inputs and efficient irrigation techniques; (iv) encouraging IT connectivity throughout the country together with improved road and multi-modal transport systems; and (v) social protection systems buffered with education opportunities and access to health services.

The Country Partnership Framework (CPF) for Senegal, together with the World Bank upstream Systematic Country Diagnostic (SCD), aims to support Senegal's ambition to promote sustainable, resilient, and inclusive growth. The SCD prepared in 2018 clearly puts forward climate change, in particular climate-related shocks and stresses, as one of the key constraints to the country's sustainability and a major obstacle to poverty reduction. The document states unambiguously that environmental changes are likely to intensify migration across the region, noting that young adults often leave rural and urban households. According to the analysis, competition between migrants and locals over access to arable land and pasture will likely increase with tougher weather conditions.

The CPF for Senegal covering the period FY20–FY24 (5 years in total) focuses on 3 critical areas for sustained growth: (i) building human capital to enhance productivity and ignite the demographic dividend, (ii) boosting competitiveness and job creation for private-sector led growth and (iii) increasing resilience and sustainability in the context of growing risks. The strategy also incorporates three cross-cutting themes: (a) pushing the boundaries of digital use to accelerate Senegal's transition into a modern and inclusive economy; (b) fostering improved female agency and reducing the gender gap in key indicators across objectives; and (c) mitigating the effects of climate change. The CPF stresses how climate-related risk (unpredictable rains, rising sea levels, and saltwater intrusion) will cause dramatic changes across the economy, including displacement of rural and coastal populations to cities and tourism areas.

The World Bank Group's efforts to address the adverse impacts of climate change on communities in Senegal consist of a diversified package of operations. Emergency-type interventions include the Saint-Louis Emergency Recovery and Resilience Project, which supports planning for relocation of populations and for strengthened urban and coastal resilience in greater Saint-Louis. The Storm Water Management and Climate Change Project builds drainage infrastructure in peri-urban areas of Dakar and other coastal zones prone to flooding. Long-term investments focused on increasing resilience of communities to a changing climate such as the Regional West Africa Coastal Areas Resilience Investment Project (WACA)

and the Regional Sahel Pastoralism Support Project, with Senegal as a beneficiary in both projects, are also critical interventions. Other relevant operations in the country include the Social Safety Net Project and the technical assistance on adaptive social protection, which support the development of an early warning system and provide adaptive recovery services to those who have experienced climate shocks.

Our study shows that climate-induced migration is ramping up in Senegal and is becoming evident as early as 2030, and is projected to rise to 2 percent of the total population (approximately 600,000 people) under a pessimistic scenario. Hotspots of in and out-migration are also emerging and do not fit traditional spatial patterns of migration. In-migration hotspots will occur in regions with high poverty levels and therefore with low preparedness and absorptive capacity. Therefore, supporting additional analytics and state of the art models and observation systems should improve the country's understanding with regard to the emergence of climate migration hotspots.

Adopting a proactive and anticipatory stance on climate-induced migration will contribute to improving the living conditions of people in climate-vulnerable urban areas. This stance will directly support one of the Senegal CPF's objectives (objective 3.1: Promote and protect resilient livelihoods, ecosystems, and infrastructures in the face of climate change). The call to embed climate migration in national and local planning processes through a landscape/territorial approach will support pillar 2 of Senegal's national development plan which aims to ensure a more balanced territorial development of the country, improve natural resource management, protect the most vulnerable segments of the population, and improve access to basic social services.

Considering the full migration cycle will assist urban planners in the preparation of a resilient land-use mapping process and strengthen the role of regional/local authorities as part of a transition towards decentralization. To do so, supporting the use of IT innovations such as maps, mobile phones, and satellite data can help identify gaps in investments and services, in particular for pastoral mobility in times of crisis. Integrated coastal zone management plans and citizen engagement plans are a good entry point at a local level to discuss adaptation options with communities, including proactive and forward-looking measures such as planned relocation. Management information systems and databases can also assist in tracking beneficiaries and potential social services.

Embracing a regional approach to address migration challenges is conducive to reducing potential conflicts. Promoting peace and social stability and cohesion is key for Senegal, as expressed in the country's national development plan. Sharing information across neighboring countries, facilitating movement along migration corridors, supporting market linkages, conducting livestock disease surveillance, and vaccination campaigns for pastoralists' livestock are sound potential actions. The role of regional intergovernmental institutions such as ECOWAS can be instrumental in providing capacity building and promoting better regulation to ease movement across countries. Training local institutions about conflict resolution related to land rights and land access could also be transformative.

Tackling the youth bulge in Senegal and anticipating the mobility of young adults in search of new horizons will ensure that climate-induced migration is addressed and harnessed as an opportunity for jobs and economic transitions. Migration should be considered as an opportunity, in particular for the youth moving to urban areas in line with the domain of action on harnessing climate migration for jobs and smart economic transitions.

Growth poles can be an important determinant for driving internal migrants, and will require human capital investment alongside structural transformation. Migration can be a positive driver of change, pressing cities to transition more quickly to technological innovations and to develop employment strategies. This approach would support Senegal's overall strategy to develop site-specific growth poles ("zones économiques spéciales") and industrial or multi-services hubs with high potential for employment, including green economy jobs and furthering regional integration. Boosting secondary cities in Senegal and enhancing greater linkages between rural and urban spaces through better physical and virtual connectivity will provide opportunities for migrants and contribute to reducing spatial/territorial inequalities.

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Appendix A

ISIMIP Projections to 2050–2100

This appendix presents the projections for the water, crop, and ecosystem models out to 2050–2100 for the West Africa region.[23] Positive index values are capped at 2, which represents a tripling of the baseline value (whether it be water availability, crop production, or ecosystem productivity).

Figure A.1 shows that the 2050-2100 water availability projections are consistent with its early trajectory. Water availability will continue to decrease in the Western Sahel (Senegal into western Mali) and increase in the eastern Sahel (Burkina Faso and Niger). These trends will accelerate between 2050-2100, particularly in western Sahel and in the south under the IPSL-CM5A-LR global climate model and uthe Representative Concentration Pathway 8.5 (RCP8.5).

Figure A.2 shows that crop production will follow its early patterns with decreases across much of the region (except Sierra Leone, Liberia, and the northern Sahel) and some patchwork of mostly increases with some decreasing crop production under the GEPIC model. The 2050-2100 projections follow the same patterns with accentuated impacts, especially under RCP8.5.

NPP models out to the end of the century show similar patterns of increases in plant biomass in the northern Sahel and into the Sahara (Figure A.3). These projections are against a very low baseline productivity, and should be interpreted in this light.

23. The projections used an index in which the historical baseline value is subtracted from the projected value and then divided by the historical baseline value. For more details on this index the overall methodology, please refer to the World Bank's report *Groundswell Africa: Internal Climate Migration in West African Countrie*s (Rigaud et al. 2021a)

Figure A.1 ISIMIP Average Index Values against 1970–2010 Baseline for Water Availability, West Africa, 2050–2100

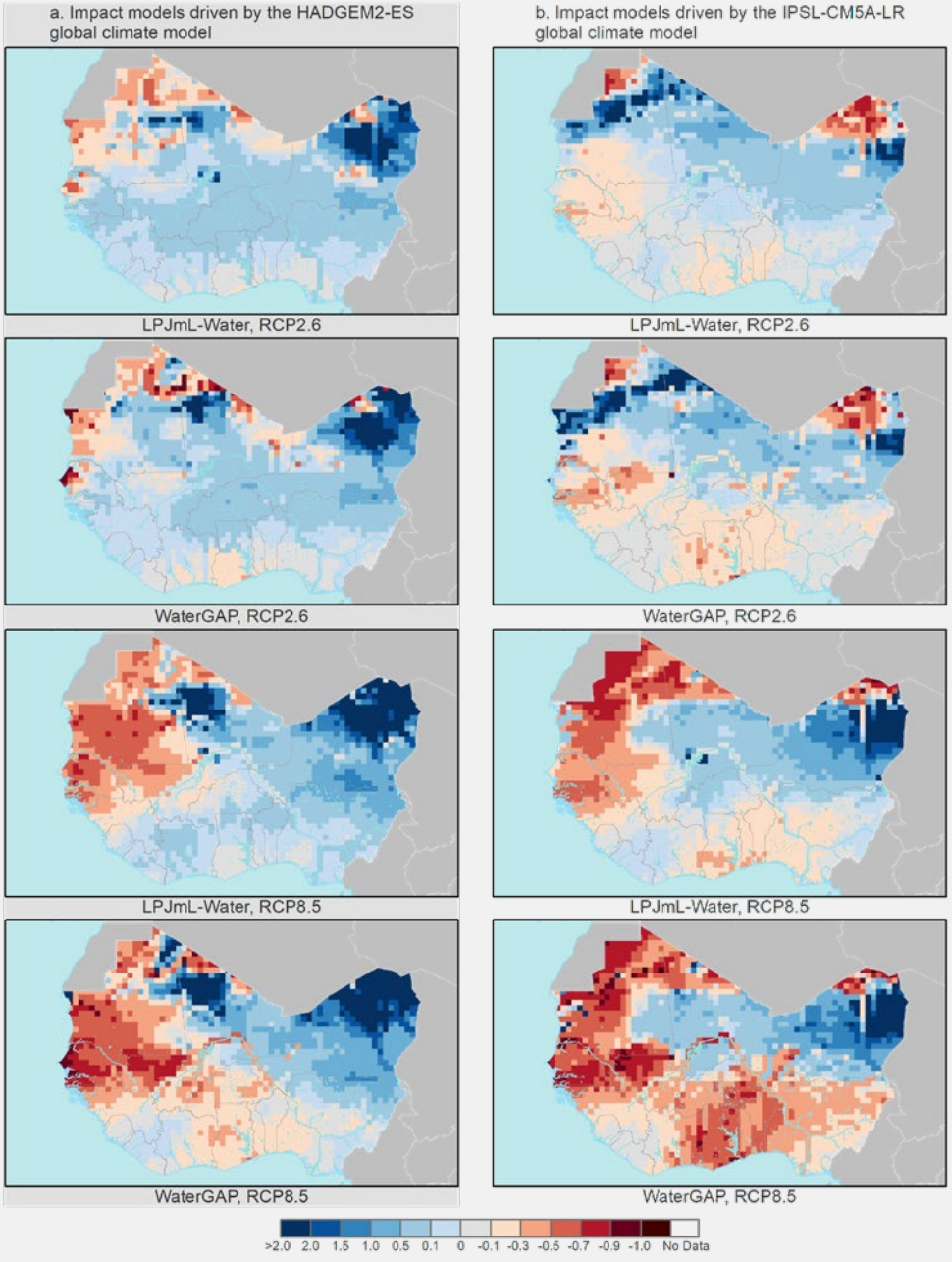
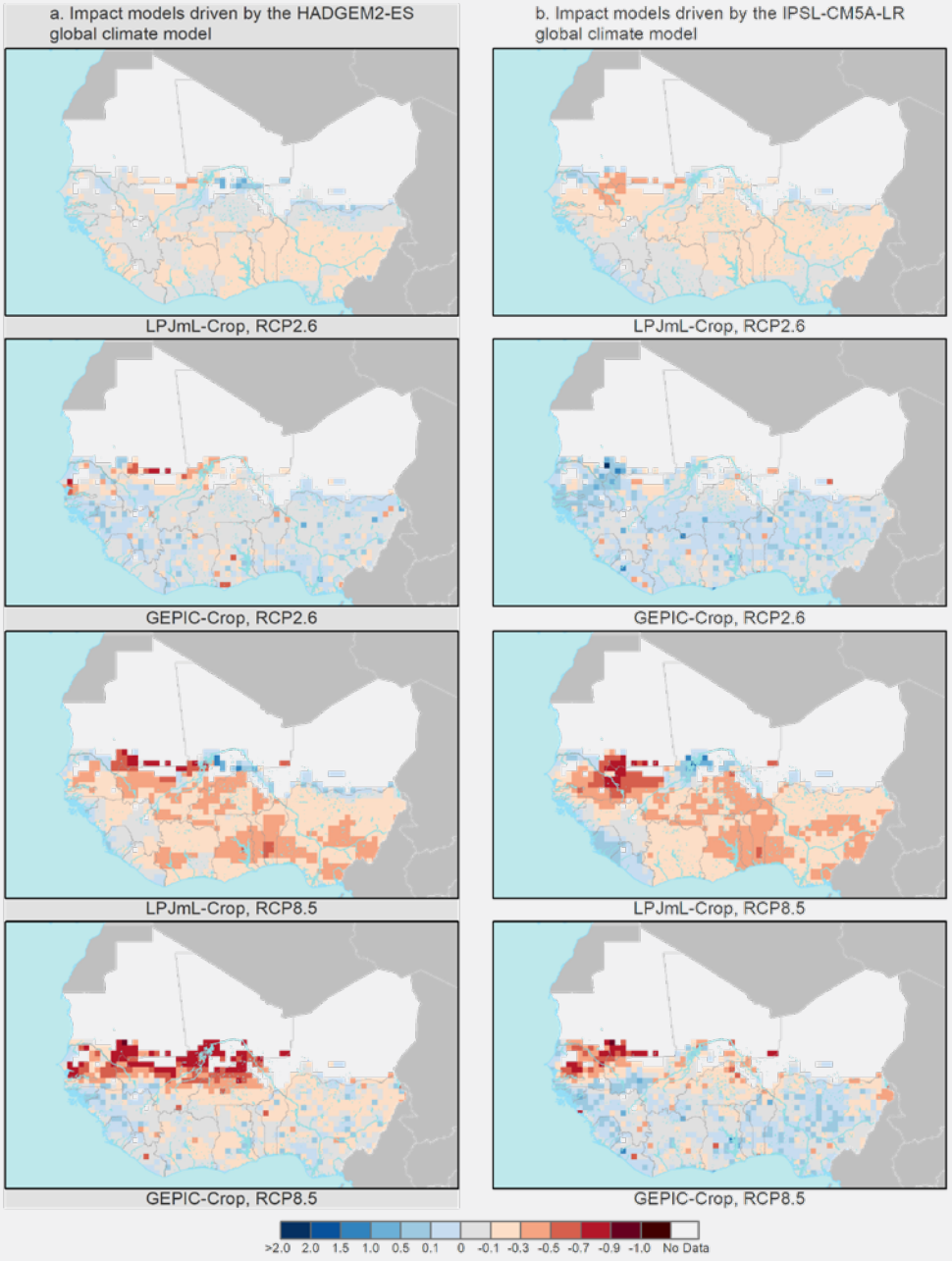
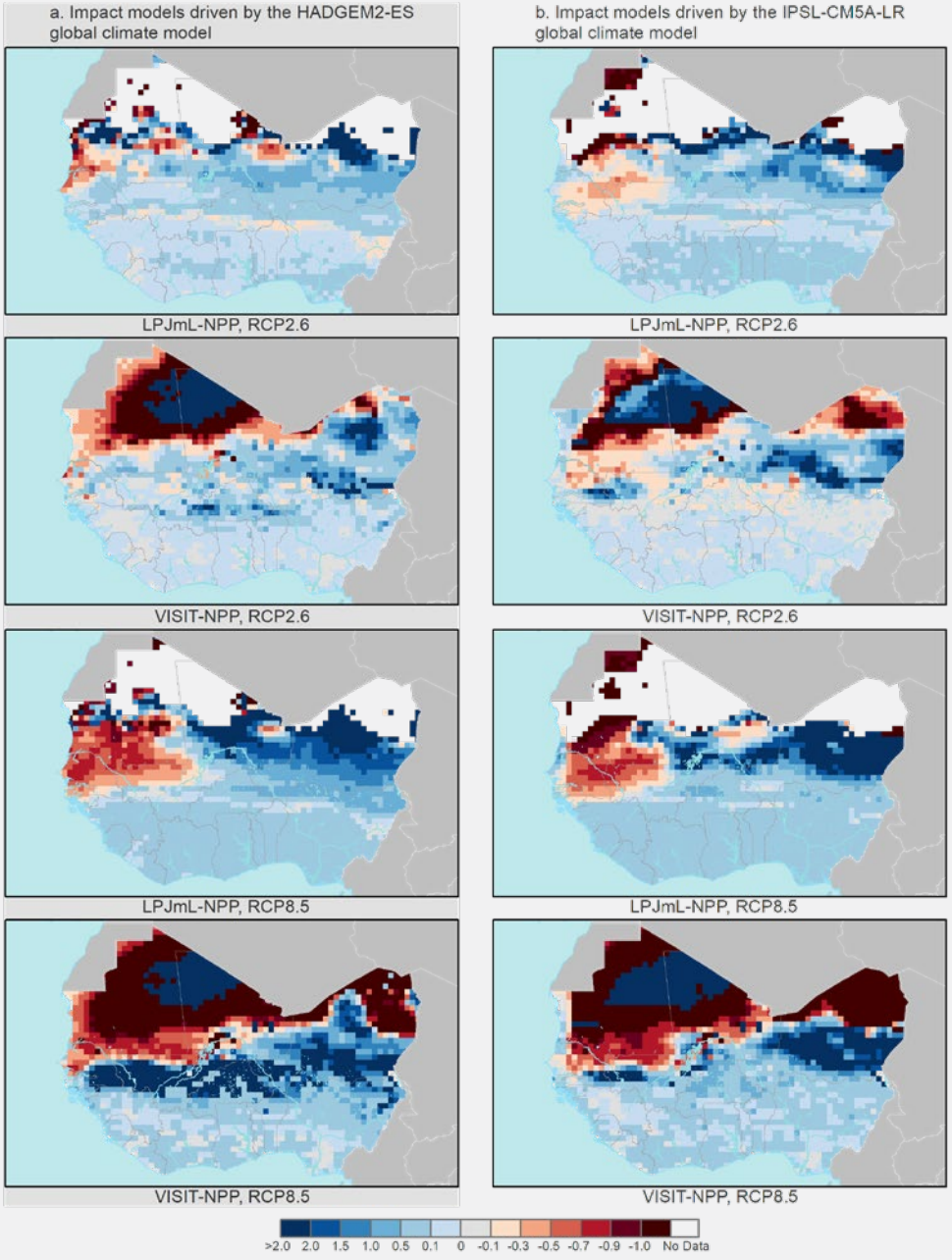


Figure A.2 ISIMIP Average Index Values against 1970–2010 Baseline for Crop Production, West Africa, 2050–2100

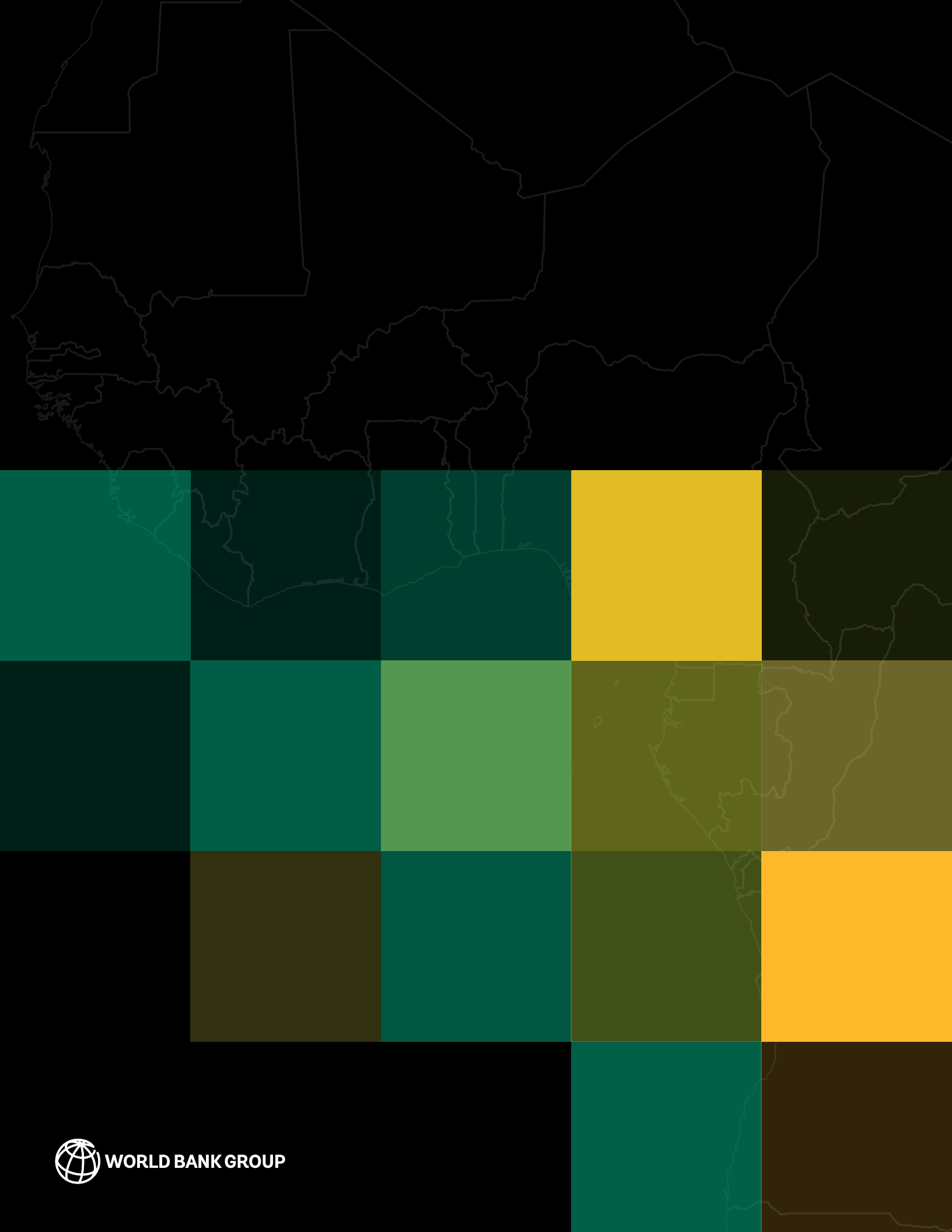


Note: Data compiled from LPJmL/crop (panel a) and GEPIC (panel b), forced with the HadGEM2-ES climate model (top four maps) and IPSL-CM5A (bottom four maps) under RCP2.6 and RCP8.5. Blue areas indicate wetting relative to the historical baseline, and tan to red areas indicate drying. White areas do not grow the four major crops.

Figure A.3 ISIMIP Average Index Values against 1970–2010 Baseline for Ecosystem NPP, West Africa, 2050–2100



Note: Data compiled from LPJmL (panel a) and VISIT (panel b), forced with the HadGEM2-ES climate model (top four maps) and IPSL-CM5A (bottom four maps) under RCP2.6 and RCP8.5. Blue areas indicate higher NPP relative to the historical baseline, and tan to red areas indicate lower NPP. NPP = net primary productivity.



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