Landscapes of West Africa

A Window on a Changing World





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On October 12, 2015, the Lunar Reconnaissance Orbiter took this striking view of the Earth as it circled 134 km above Compton Crater on the Moon, near the terminator between day and night. The sharp black outline of the lunar horizon is from mountains still on the night side of the terminator, silhouetted against the lower limb of the Earth. This image is reminiscent of the iconic Earthrise photograph taken by the crew of Apollo 8 as they orbited the Moon on December 24, 1968. Many people credit that unique view of our home planet as having sparked the environmental movement that so shaped our thinking about our planet during the 1970s and beyond.

Apart from its beauty, this image of the Earth from the Moon shows the African continent quite prominently. A great amount of cloud cover characterizes the blue planet. Several large areas are, however, clear: the deserts of North Africa and the Middle East, and in the Southern Hemisphere, the drylands of southern Africa. The tropical regions of Africa's mid-section are partially covered by belts of clouds that mark the intertropical convergence zone, where the northern and southern circulation patterns merge.

Source: NASA, Lunar Reconnaissance Orbiter

Dr. Djimé Adoum

Since the 1970s, West Africa has experienced many forms of climate stress — heavy rains, floods, and periods of drought. Drought has had a particularly devastating impact on agricultural production, pastoral livelihoods, and natural ecosystems. Economic losses alone are estimated in billions of dollars.

The concerns raised by these climate stressors have translated into initiatives to combat desertification and to adapt to climate change. The Comité Inter-états de Lutte contre la Sécheresse dans le Sahel (CILSS – The Permanent Interstate Committee for Drought Control in the Sahel) and the U.S. Agency for International Development (USAID) have put in place activities to benefit the population of the Sahel and all of West Africa.

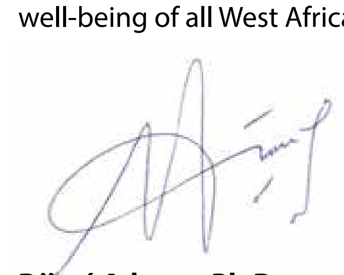
The West Africa Land Use Dynamics (LULC) Project is emblematic of this cooperation. Initiated in 1999, the LULC project has had several phases including training national experts to extract pertinent information from satellite images to characterize vegetation cover and producing tools and supporting information on land cover dynamics.

This atlas — Landscapes of West Africa: Window on a Changing World — is part of the current phase of the LULC project and provides insights into the changes occurring at national and regional levels through mapping time series data from 1975 to 2013. This work highlights landscapes that have undergone major transformations, and examines the drivers of change and their environmental and socioeconomic impacts.

The atlas showcases the accomplishments of the LULC project, and makes a case for further investment in natural resource management. Aimed at both decision-makers and the general public, the Atlas has a goal of making people aware of the changes taking place in the landscapes of the region.

Beyond raising awareness, the atlas also aims to incite action to protect the environment of West Africa and the Sahelian region. We therefore invite everyone — scientists, students, researchers, teachers, planners, managers of development or research projects, local, national and regional decision-makers, donors, members of civil society organizations, and visitors to the region — to make the most of this work.

Congratulations to the experts at CILSS, U.S. Geological Survey, USAID and the country-level teams of the LULC project for this fruitful partnership. We truly hope that this cooperation will continue and deepen, with the view of regaining the equilibrium of ecosystems. Doing so will constitute a decisive step towards realizing a green economy in West Africa, thereby enhancing the well-being of all West African people.



Djimé Adoum, Ph.D,
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USAID | WEST AFRICA
FROM THE AMERICAN PEOPLE

Alex Deprez

At the core of the U.S. Agency for International Development's (USAID's) mission is a deep commitment to work as partners in fostering sustainable development. Environments that are vulnerable to changing climate patterns are often the most reliant on agriculture for food and income, and the least able to financially protect themselves or respond to disasters. As effects of climate change are felt more severely, advanced mitigation and adaptation measures are key to resilience.

Rapid changes are occurring across West Africa's natural and human landscapes and balancing the need to preserve natural ecosystems with the need to grow more food, together with ensuring resilience in the same ecosystems, is a challenge. USAID West Africa's (USAID/WA) Environmental Threats and Opportunity Assessment and its Climate Change Vulnerability Assessment revealed that timely and accurate information, indispensable for good governance in the environmental sector, is scant and barely accessible. Mitigating climate change impacts and conserving biodiversity can support sustainable development, and prevent countries from sliding further into poverty.

USAID/WA worked in partnership with the U.S. Geological Survey (USGS) and the Comité Inter-états de Lutte contre la Sécheresse dans le Sahel (CILSS – The Permanent Interstate Committee for Drought Control in the Sahel), to analyze changes in land use and land cover in West Africa and to better understand trends over the past 40 years with the goal of improving decision-making in land management. Products derived from these analyses include maps that provide a clear record of changes and trends in three periods — 1975, 2000 and 2013 — in 17 West African countries and aggregated to the regional level.

These maps and analyses form the foundation for future landscape scenarios and contribute to a body of best practices for the re-greening of landscapes in West Africa. Application of the atlas and associated data goes beyond informing decision-making on land use planning. The time series maps provide credible information to help countries account for their carbon emissions to the United Nations Framework Convention on Climate Change and can also be used to quantify carbon emission trends in West Africa for the past 40 years.

This achievement would not have been possible without the U.S. Landsat Program. Landsat satellites have provided the longest-ever continuous global record of the Earth's surface. A partnership of the National Aeronautics and Space Administration and the USGS, the Landsat program provides image data that show the impact of human society on the planet — a crucial measure as the world's population has already surpassed seven billion people. The first Landsat satellite was launched in 1972 and now, 44 years later, Landsats 7 and 8 are continuing to provide an unbroken record of the Earth, providing critical information for monitoring, understanding and managing our resources of food, water, and forests. No other satellite program in the world comes close to providing such a long, unbroken record of geospatial information of the planet.

Knowing that these analyses will be put to use for decision making in natural resource management, I would like to thank all of the teams that worked tirelessly to produce this Landscapes of West Africa atlas. And my sincere gratitude goes to CILSS, the USGS, and the multitude of government institutions in West Africa for their commitment to completing this influential work.

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On behalf of the governments and the people of West Africa who have benefitted from the West Africa Land Use Dynamics Project, the Comité Permanent Inter-Etats de Lutte contre la Sécheresse dans le Sahel (CILSS – Permanent Interstate Committee for Drought Control in the Sahel) expresses its profound gratitude to all those who have contributed to the publication of this atlas. In particular, we would like to thank:

The U.S. Agency for International Development/West Africa (USAID/WA) which financed, encouraged and contributed actively to the review of this atlas;

The Resilience in the Sahel Enhanced (RISE) Program managed from USAID/Senegal's Sahel Regional Office, which supports the work of mapping best practices and re-greening, and promotes soil and water conservation in the Sahel;

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The national teams from across West Africa who provided valuable content for the maps and case studies.

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In Memory

Our thoughts are with three colleagues and friends who are no longer with us. All three contributed significantly to the success of the West Africa Land Use Dynamics Project, including major content contributions to this atlas:

Yendouhame John Kombaté, Responsable Suivi Evaluation et Communication, Agence Nationale de Gestion de l'Environnement, Ministère de l'Environnement, Togo;

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Introduction

Our global ecosystem is and has always been complex, dynamic, and in constant flux. Science tells us how natural forces of enormous power have shaped and reshaped Earth's surface, atmosphere, climate, and biota again and again since the planet's beginnings about 4.5 billion years ago. For most of the planet's history those environmental changes were the result of the interaction of natural processes such as geology and climate, and were described on the geological time scale in epochs spanning millions of years.

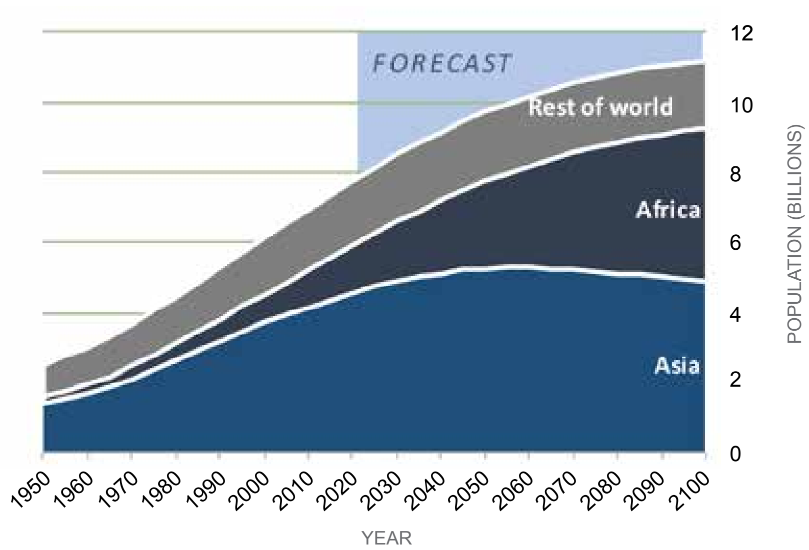
When humankind appeared on Earth around 200,000 years ago the influence of human activity on the environment must have been small and localized. The influence of scattered small groups of people on the global ecosystem would have been overwhelmed by the forces of natural systems (Steffen and others, 2007). Human population would not grow to 50 million (about 0.7 percent of the Earth's current population) for another 197,000 years. Population growth accelerated over the centuries that followed until the planet was adding more than that 50 million people every year. Our planet is now home to roughly 7.3 billion people and we are adding 1 million more people roughly every 4.8 days (US Census Bureau, 2011). Before 1950, no one on Earth had lived through a doubling of the human population, but now some people have experienced a tripling in their lifetime (Cohen, 2003).

With hunting and the use of fire, later agriculture and urbanization, and eventually the industrial revolution and modern technology, the ability of humans to shape their environment also grew exponentially. Earth scientists use the geologic time scale to describe time periods where different processes and forces shaped events in the Earth's history, such as ice ages and mass extinction events. They use periods of time they call epochs, which range from 11,700 years (the Holocene) to millions of years (the Pleistocene and Neogene). In about 2000, Earth scientists coined a new word — Anthropocene — to describe a new epoch where "the human imprint on the global environment has become so large and active that it rivals some of the great forces of nature in its impact on the functioning of the Earth system" (Steffen and others, 2011). Many in the Earth sciences believe that epoch has begun and that humankind with its vast numbers and its power to change the face of the Earth is at risk of putting the Earth system out of balance and causing the collapse of natural systems that are essential for humans to thrive, perhaps even threatening the future of all humankind.

"Mai lura da ice bashin jin yunwa" — He who takes care of trees will not suffer from hunger.

– Hausa proverb

Population growth in Africa and the rest of the world from 1950 to 2100



In 2015, the 17 countries included in this atlas are estimated to have a total population of over 369 million, representing a nearly 5-fold increase since 1950 — outstripping global population growth, which grew by 2.9 fold during the same time (UN, 2015). The young age structure of the West African population assures continued rapid population growth until 2050 and beyond. If United Nations estimates are correct the 17 countries in this atlas will grow to 835 million people by 2050; that would equate to 11.1 times as many people as lived on the same land in 1950 (UN, 2015)!

PHOTO (OPPOSITE PAGE): SUZANNE COTILLON / SGT

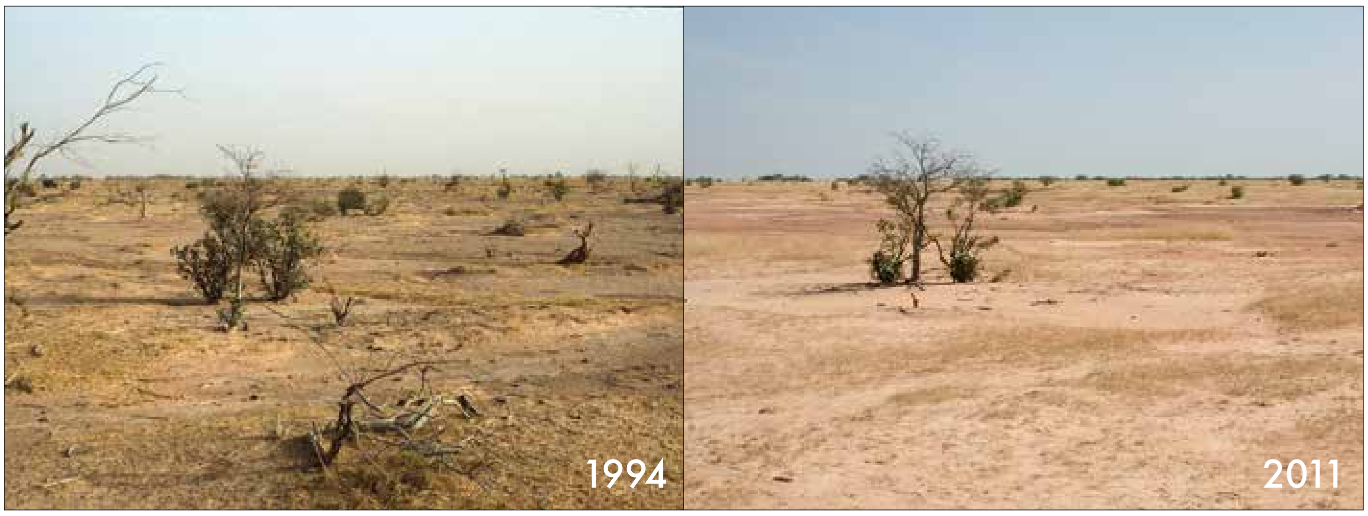
Wooded landscape fragmented by agriculture expansion in western Burkina Faso

JAMES ROWLAND / USGS

Parallel trends can be seen in the land cover changes of West Africa. With so many new families to feed, West Africa doubled the area covered by farms between 1975 and 2013. Vast areas of savanna, woodland, and forest landscape have been replaced or fragmented by cropland. At the same time villages, towns, and cities have grown in area — taking up 140 percent as much land as they had in 1975. In part to make way for those farms and settlements more than a third of the forest cover present in 1975 has been lost. In savanna and steppe landscapes of West Africa, drought, in some cases made worse by unsustainable land use practices, has degraded the vegetation cover contributing to a 47 percent increase in sandy areas (see top images pair, opposite page). The future is unpredictable, but the trends of the past four decades projected into the future would be unsustainable.

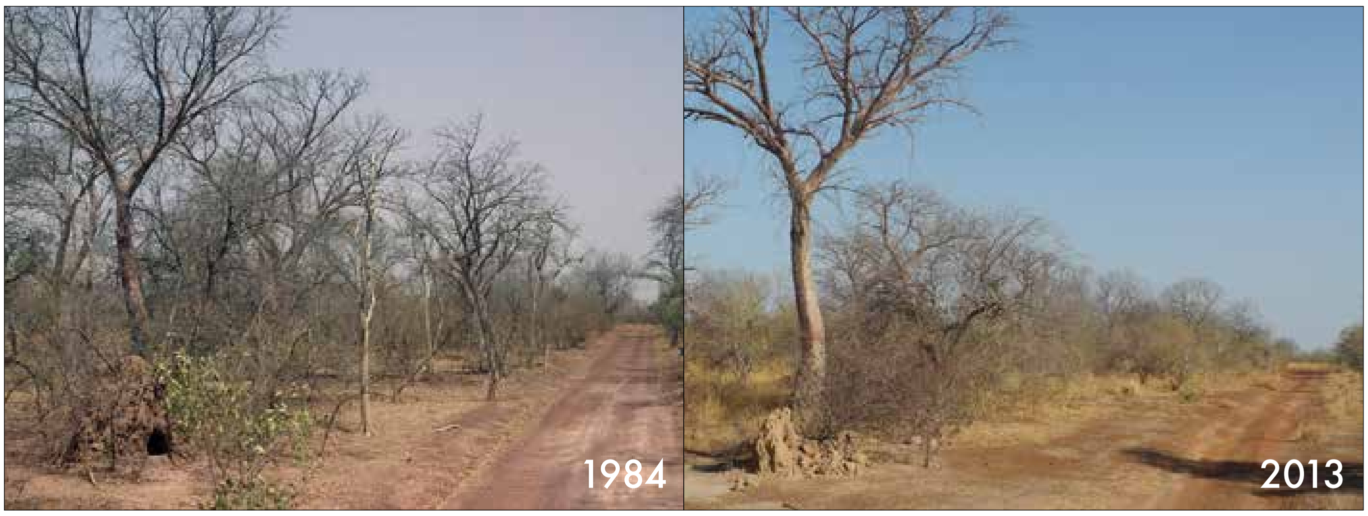
Conversion of the natural landscapes of West Africa to agriculture greatly reduces the natural biodiversity, and exposes the soil to wind and water erosion. The savanna, woodland, forest, and wetland ecosystems that are lost have some relatively tangible impacts such as the loss of natural ecosystem goods and services like wood for fuel and construction, honey, nuts, medicines, game animals, berries, and forage. There are also many important goods and services lost that are less visible such as biodiversity, carbon storage, water quality, water runoff versus infiltration, and regional climate functions.

Expansion of degraded land in the Ferlo region of Senegal



GRAY TAPPAN / USGS

Decline in vegetation cover and biodiversity in east-central Senegal

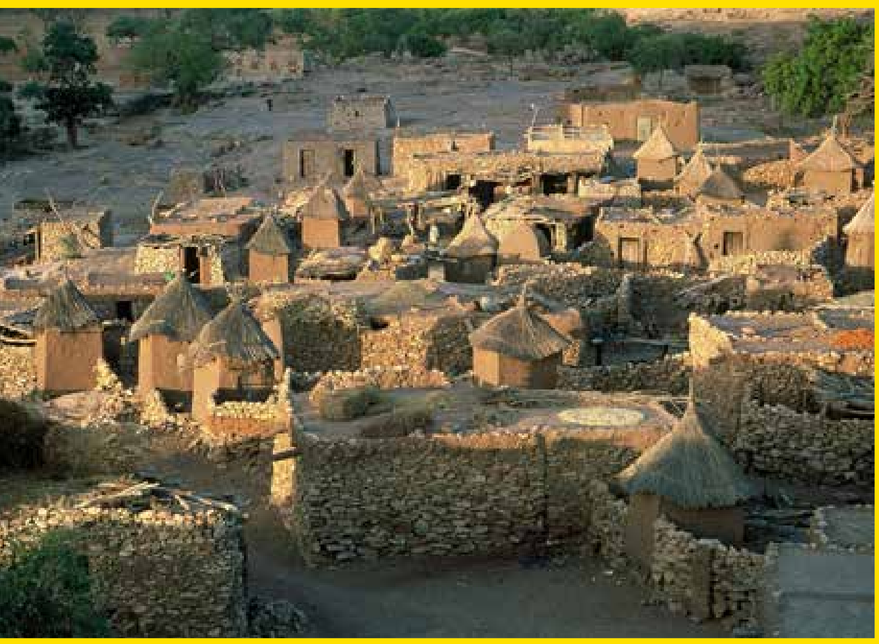


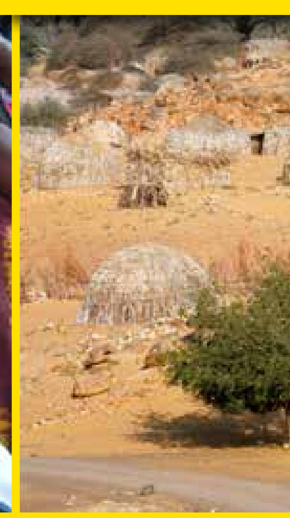
GRAY TAPPAN / USGS

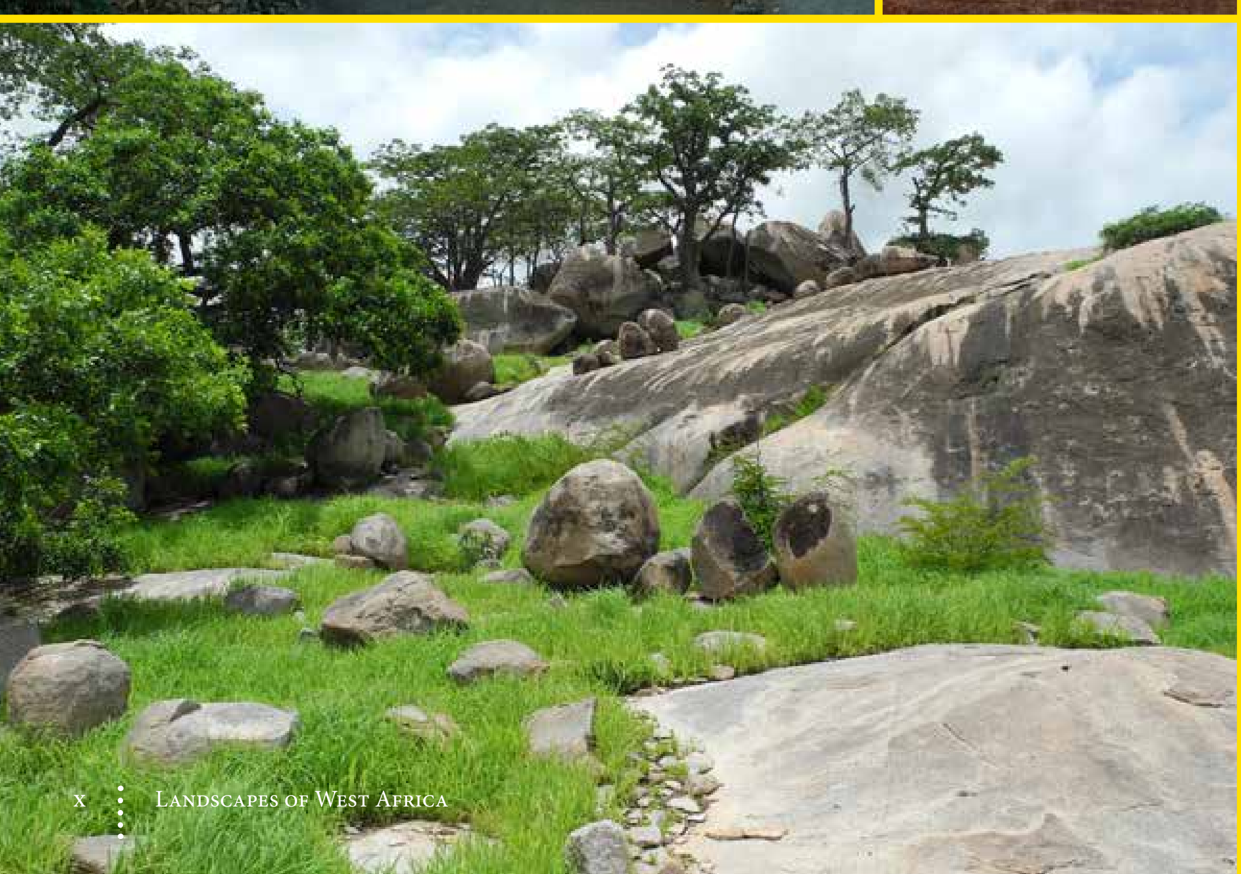
It is in the hands of today's decision makers to formulate wise, well informed choices about how to manage West Africa's land, to ensure that vital ecosystem services and agricultural productivity are able to support tomorrow's people. To make good choices the governments of West Africa need good information about the rapid changes now occurring, the causes of those changes, and the interactions occurring between climate, land use, other human activity, and the environment.

Experts from institutions in 17 countries in West Africa have partnered with the Comité Inter-états de Lutte contre la Sécheresse dans le Sahel (CILSS – The Permanent Interstate Committee for Drought Control in the Sahel), the U.S. Agency for International Development (USAID) West Africa and the U.S Geological Survey (USGS) to map changing land use and land cover and associated factors across much of West Africa through the West Africa Land Use Dynamics Project. This publication presents the results of that work. The following chapters present maps, graphs, tables, and images detailing the natural environment of these 17 countries and changes that have taken place over the past four decades.

This atlas tells a story of rapid environmental change with both hopeful and worrisome chapters. The story is told with maps and numbers detailing the rate, magnitude, and location of land cover change but also with words and images that seek to make the story more real for the people living in West Africa and around the globe. The hope is that this information helps to build a clearer picture of past and current land use and land cover in order to guide us all in making informed choices that will support the livelihoods and well-being of ours and future generations.

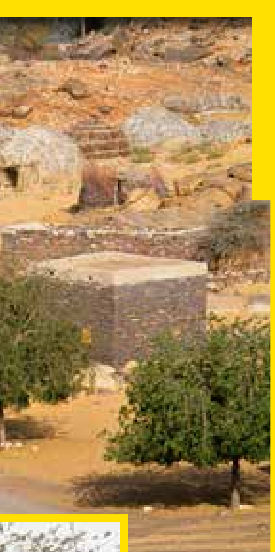






Chapter I

West Africa's Changing Environment






1.3
Drivers of Land Changes

Changes in land use and land cover result from a myriad of factors acting on the land surface. These factors fall into two large groups, those originating from human activity and those originating from natural forces. Among the human factors, the size and growth of the human population plays a large role, but it is not the only underlying human cause of land cover change. The impacts of population growth are amplified or attenuated by institutional factors and national and regional policies, as well as processes of globalization, all of which shape economic opportunities that the populations of West Africa respond to in complex and interrelated ways that ultimately affect land use and land cover patterns (Lambin and others, 2001). For example, the progressive integration of West Africa into a global market economy has led to expansion of foreign investment in the mining and timber industries of the Guinean forest countries, which increases the rate of forest loss. Structural adjustment programs have encouraged agricultural specialization toward a small number of cash crops, such as cotton and peanuts in the Sahelian countries, which replace a more diverse mix of local grains and tubers. Finally, increasing affluence of the growing population affects consumption patterns, such as the increased demand for processed food, meat, and dairy by the wealthy urban populations, with repercussions on natural resources and land use (Godfray and others, 2010).

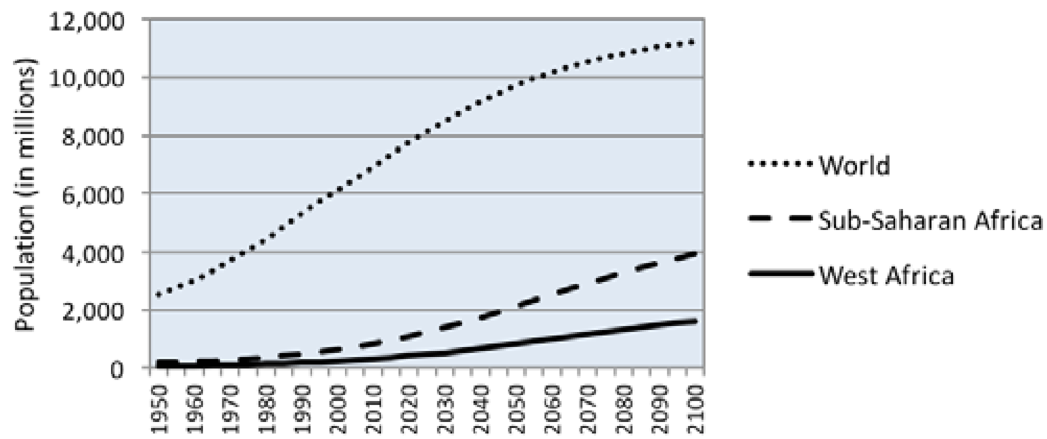
In addition to human factors, natural factors have also contributed to changes on the land. With geology and landforms stable over long periods of time, climate is the most dynamic natural factor to affect land cover at annual to decadal time scales. Most importantly, the recurrence and persistence of drought conditions in the semiarid swaths of West Africa have directly changed the land cover by desiccating soils, shrinking water bodies, stressing the vegetation, and exposing bare soil and sandy substrate to erosion. Indirectly, it has affected people's ability to use the land for crop cultivation and for foraging by livestock, forcing them to find other ways of securing their livelihoods, which in turn have altered the land use and land cover. For example, the threat of drought to agriculture in the Sahel pushed farmers and pastoralists to migrate from the arid frontier toward more humid stretches of land, or into the urban areas in search of jobs. In other instances, the combined pressures of drought and population increase have spurred investments in soil and water conservation, and in agricultural intensification in southern Niger and central Burkina Faso (Reij, Tappan, and Smale, 2009).

With the understanding that driving forces of land use and land cover change interact in complex ways, two key underlying drivers of change will be given particular attention: (1) population, which determines the demand and pressure on land resources, and (2) climate, which affects the supply or constraints of land resources.

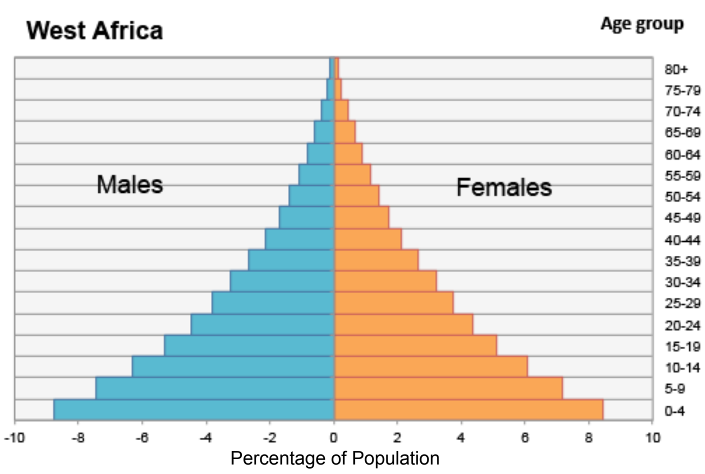
Drought in the Sahel Region, Senegal

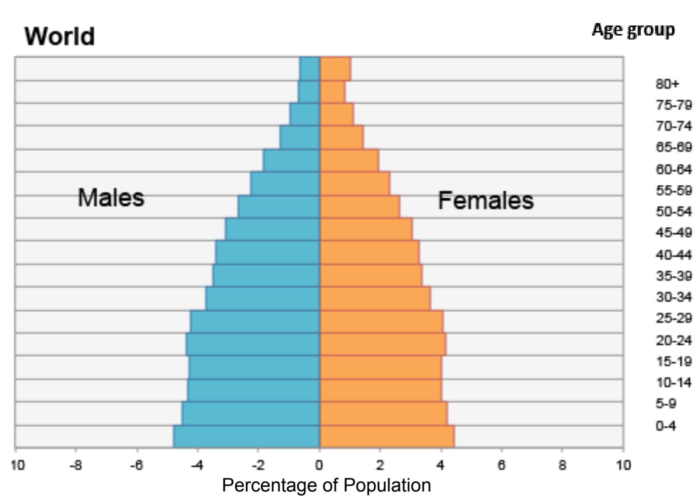
With a 2015 population of 367 million (UN, 2015), West Africa is home to 5 percent of the world's population. This is a five-fold increase in population since 1950, when 73 million people lived in the region, which makes West Africa the fastest growing of any of the world's regions. For comparison, the world population has increased less than three-fold during the same time period. The young age structure of the West African population — almost half of West Africans are 15 years old and younger — assures continued population growth into the near and medium future. Assuming a medium fertility model, the population of the region is projected to exceed one billion by 2059, when almost one in 10 of the world's people will be West African (UN, 2015).

Projected population growth from 1950 to 2100



Age structures of the populations of West Africa and the world in 2013





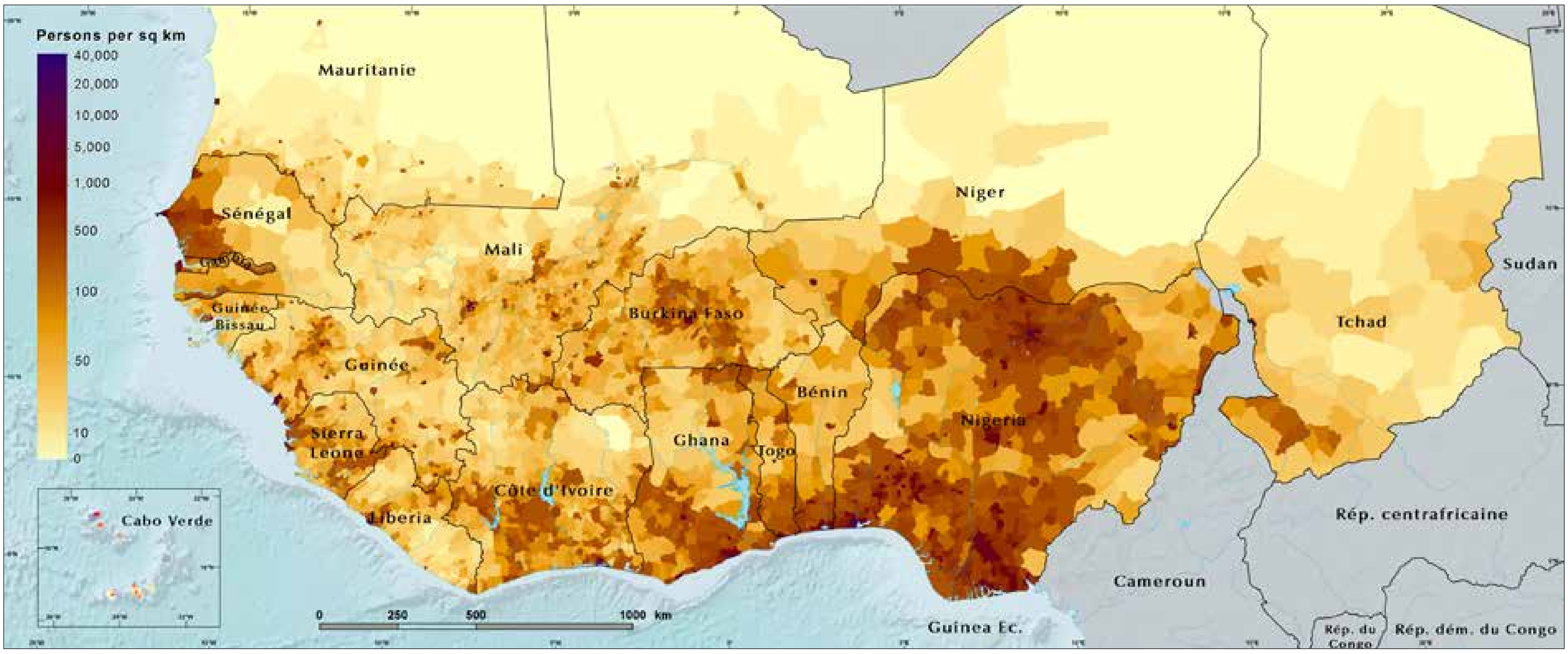
The age structure of West Africa's current population forms the shape of a pyramid with a wide base and concave sides, indicating a high birth rate and a relatively high death rate, resulting in rapid growth. By comparison, the age structure of the global population has moved toward a more rectangular shape, describing a population that is only slowly expanding, with lower birth and death rates and more people living to old age.

Niger, Filingué department

STEFANIE HERRMANN / U. OF ARIZONA

PHOTO (OPPOSITE PAGE) : GRAY TAPPAN / USGS

Population densities by administrative units in West Africa in 2015



(DATA SOURCE: CIESIN, 2005)

West Africa's population is unevenly distributed throughout the region, reflecting differences in the physical environment as well as the history of human settlement (see map above). In the arid northern part of the region, only a small, sparse population can be sustained. In the arable regions, where soils are fertile and the climate is favorable for crop cultivation, higher population densities are found. Thus, the Peanut Basin of western Senegal, the Niger-Nigeria border region, central Burkina Faso, and southwestern Chad stand out by their relatively high rural population densities. Settlements are also concentrated in the riverine plains of the Senegal and Niger rivers, where perennial water availability supports irrigated agriculture of rice and high value garden crops. In the densely forested southern part of the region, which has historically been more difficult to develop, rural population densities are generally lower than in the open savanna. However, along the coast, population densities are driven up by a large number of coastal settlements, including some major urban agglomerations.

RICHARD JULIA

Aerial view of Niamey, Niger in 2006, showing the irrigated fields along the Niger River.

The map of population densities (opposite page) shows higher population densities in Nigeria than in any other West African country. Indeed, almost half of West Africans are Nigerian, and with over 172 million inhabitants, Nigeria is the most populous country in the entire African continent. The remaining 16 countries account for the other half of the West African population, with Ghana coming in at a distant second (7.5 percent of West Africa's population). What might explain this noticeable difference between Nigeria and the rest of West Africa? People tend to settle where the climate is clement, the soils are fertile, and economic opportunities are present. Nigeria encompasses an extensive savanna region, without the extreme aridity found in the northern countries, and a large delta and coastal plains. Two important perennial rivers, the Niger and the Benue, as well as their tributaries, assure sufficient water provision. While civilizations flourished across the region in the 15th through 19th centuries, the high concentration of kingdoms, empires and particularly city states — such as Kano, Katsina, Oyo, Ife, Benin, Nri, Igbo and others — is unique to the territory that became modern Nigeria. Two out of the three ancient trans-Saharan trade routes originating from North Africa and Arabia ended in Nigeria, which brought an influx of people to settle and trade. As an already very densely populated country today, Nigeria provides a preview of the pressures on the land resources that other parts of West Africa will likely have to face in the future.

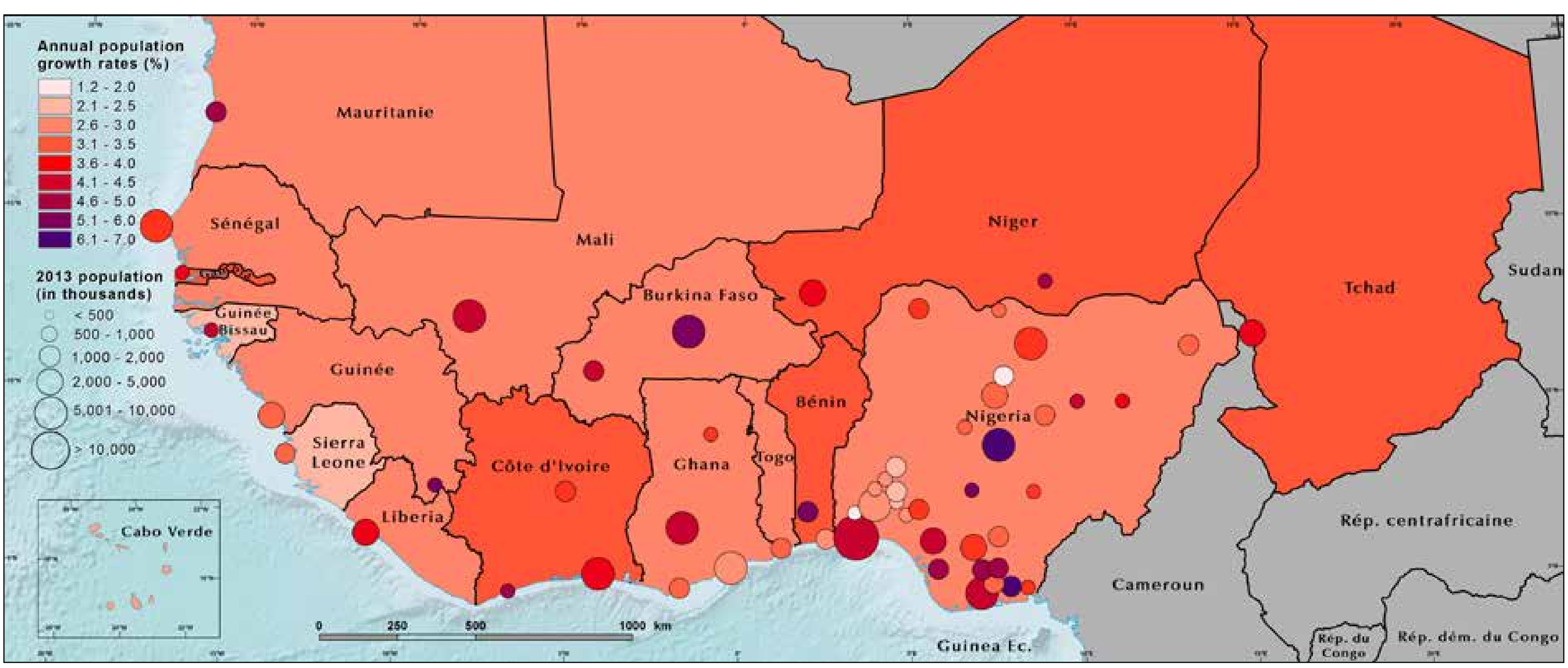
Not only has West Africa's population been growing rapidly at an average annual rate of 2.75 percent, it has also become more urban, with some major cities recording mean annual growth rates of up to 9 percent.


Kejetia Central Market, Kumasi, Ghana

STEFANIE HERMANN / U. OF ARIZONA

A majority of West Africans still live in rural areas, yet the urban population has increased from only 8.3 percent in 1950 to almost 44 percent in 2015. The changes in lifestyle and consumption patterns associated with a progressive urbanization of the population affect land use and land cover patterns beyond the obvious increase of built-up area (Rindfuss and others, 2004). Dietary demands of the urban population translate into land demands in the urban periphery, in particular for the cultivation of high-value, perishable crops, such as fruits and vegetables. Part of the wages earned in the city reach the rural areas in the form of remittances to the homelands of the new urbanites, where they spur investments in economic activities that potentially affect the land cover, such as through abandonment or intensification of agriculture. These are just a few of the linkages between population and land use/land cover (Lambin and others, 2001).

Annual population growth rates 1975–2013 by country and by urban agglomeration of over 100,000 inhabitants



(DATA SOURCE: UN, 2015)

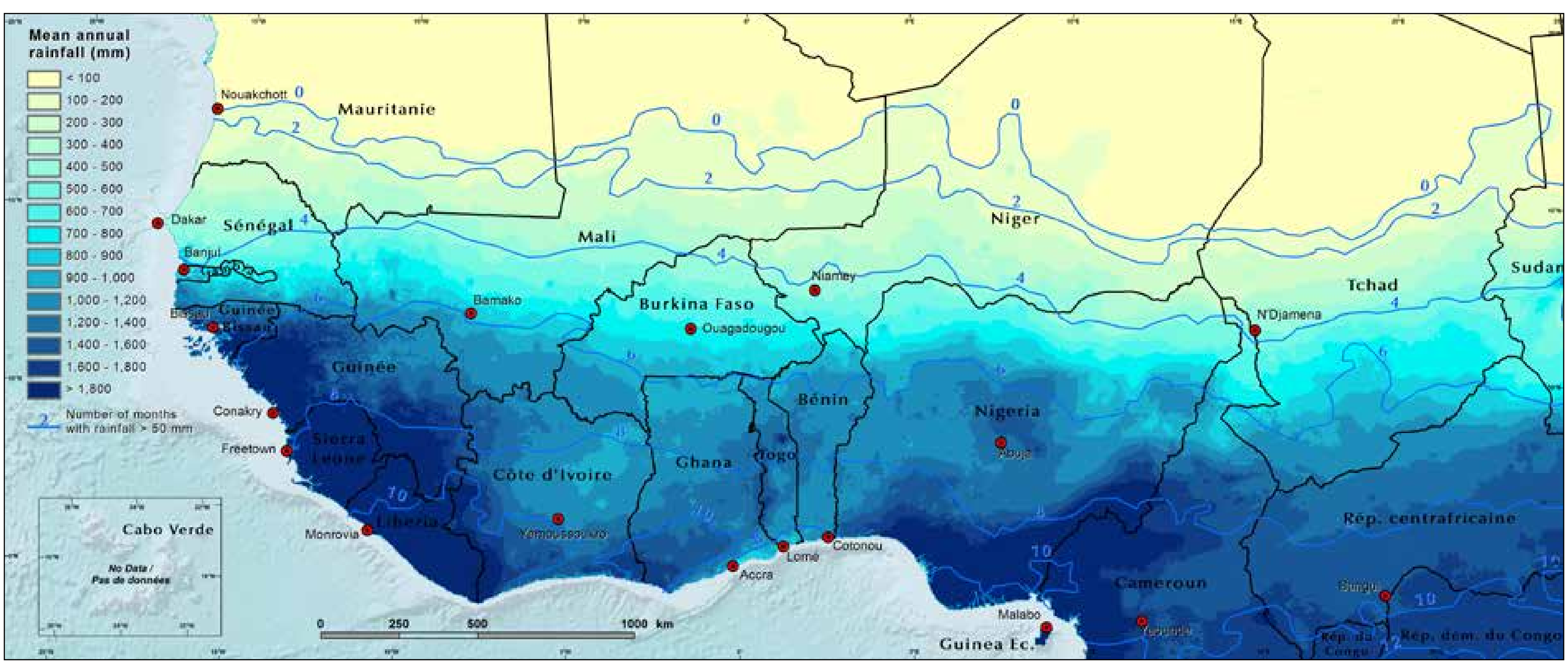
Climate

West Africa's climate is controlled by the interaction of two air masses, the influence of which varies throughout the year with the north-south movement of the Intertropical Convergence Zone (ITCZ). Hot, dry continental air masses originating from the high pressure system above the Sahara Desert give rise to dusty Harmattan winds over most of West Africa from November to February. In summer, moist equatorial air masses originating over the Atlantic Ocean bring annual monsoon rains (Nicholson, 2013).

As a result of these interacting air masses, West Africa's precipitation regime is characterized by latitudinal belts of decreasing rainfall and wet season length. At the Gulf of Guinea, precipitation is abundant year-round without a marked dry season. At higher latitudes, precipitation decreases and is limited to a wet season of decreasing duration. This latitudinal pattern is somewhat modified by altitude, with higher mountain elevations, e.g. the Guinean Highlands and the Jos Plateau in central Nigeria, receiving more precipitation than lowlands of the same latitude. Along the south–north gradient of decreasing rainfall, Abidjan, Côte d'Ivoire (5° north latitude) records a mean annual rainfall of 1,600 mm; Ouagadougou, Burkina Faso (12° northern latitude) 700 mm within a 5-month rainy season; and Agadez, Niger (18° northern latitude) 165 mm annually in a short 2.5-month rainy season. Temperatures in the lowlands of West Africa are high throughout the year, with annual means usually above 18°C. In the Sahel, maximum temperatures can reach above 40°C.

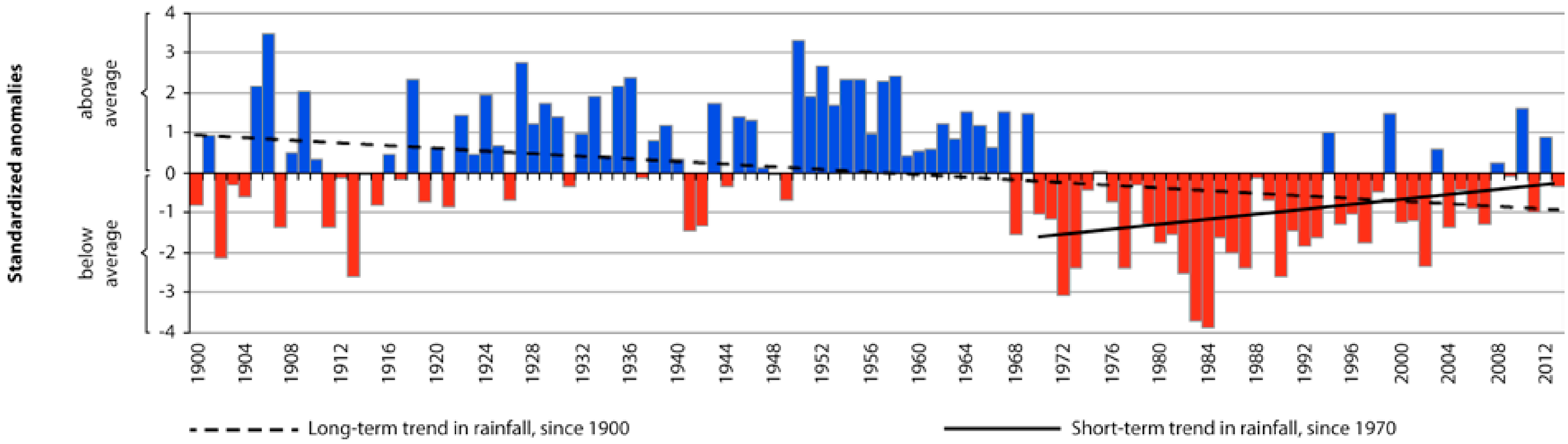
Not only scarcity of rainfall, but also its variability and unpredictability become more significant with latitude. Thus, year-to-year rainfall variability ranges from 10 to 20 percent in the coastal areas to over 40 percent in the northern Sahel (FAO, 1983). Drought is a recurring phenomenon in semiarid West Africa, where average rainfall conditions seldom prevail, and rainfall is skewed to dryness, i.e., a few heavy rainfall years are balanced out by a larger number of below-average rainfall years. From the late 1960s through the 1980s, the Sahel zone experienced droughts of unprecedented spatial extent and duration (Hulme, 2001). These droughts followed a period of more favorable rainfall in the 1950s and early 1960s, which had encouraged government planners and farmers to expand agriculture northward (Glantz, 1994). The great Sahelian droughts forced the abandonment of agriculture at the arid margin, triggered a famine crisis that killed thousands of people and their livestock, and has been blamed for widespread environmental degradation in the region.

Mean annual rainfall 1981–2014, with number of months of 50 mm or more of rainfall



(DATA SOURCE: FUNK AND OTHERS, 2015)

Standardized rainfall anomalies in the Sahel region (10–20°N, 20°W–10°E) derived from station data



(DATA SOURCE: MITCHELL, 2013)

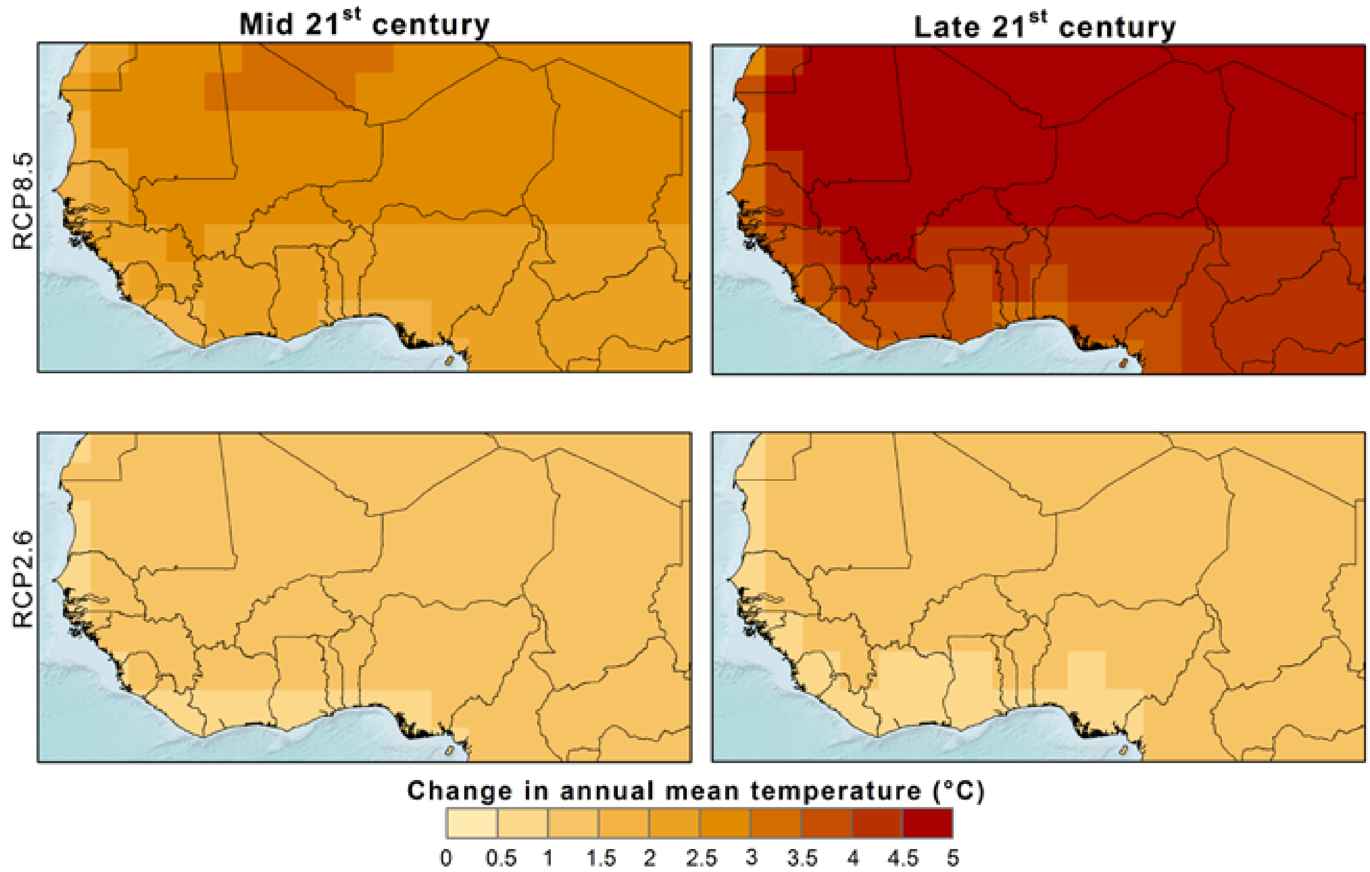
Average annual rainfall has recovered some from the low point of the early 1970s, however it has not been enough to erase the long-term drying trend since 1900 — the earliest available rainfall records (Nicholson, 2005). Moreover, for agro-pastoralists not only annual rainfall totals are important, but also the frequency and distribution of rainfall events throughout the wet season. Too much rain at once can damage crops or change pasture composition in unfavorable ways. Heavy rainstorms also cause severe soil erosion, particularly on cleared cultivated land.

The great Sahelian droughts provide the most dramatic worldwide example of multi-decadal climate variability that has been directly measured. However, for lack of an observational rainfall record before the 20th century, or sufficient proxy indicators, it remains unclear how unique these droughts have been at time scales of centuries and millennia (Hulme, 2001). Are they part of the normal variability of this semiarid climate, or harbingers of human-induced climate change? Understanding the climatological processes behind the droughts is a prerequisite for attributing them to natural or human causes and to eventually predicting the impacts of future climate change on rainfall in the region. The current understanding is that variations in sea surface temperatures in the global oceans play the largest role in Sahelian rainfall variability, amplified by land cover (Giannini, 2016). Thus, climate is not only driving land use and land cover change, but to some extent is also driven by it. Particularly at local scales, the effects of vegetated versus bare soil on temperatures and humidity are quite noticeable, as illustrated in the examples of farmer-managed natural regeneration (see pages 70–71) (Reij Tappan, and Smale, 2009).

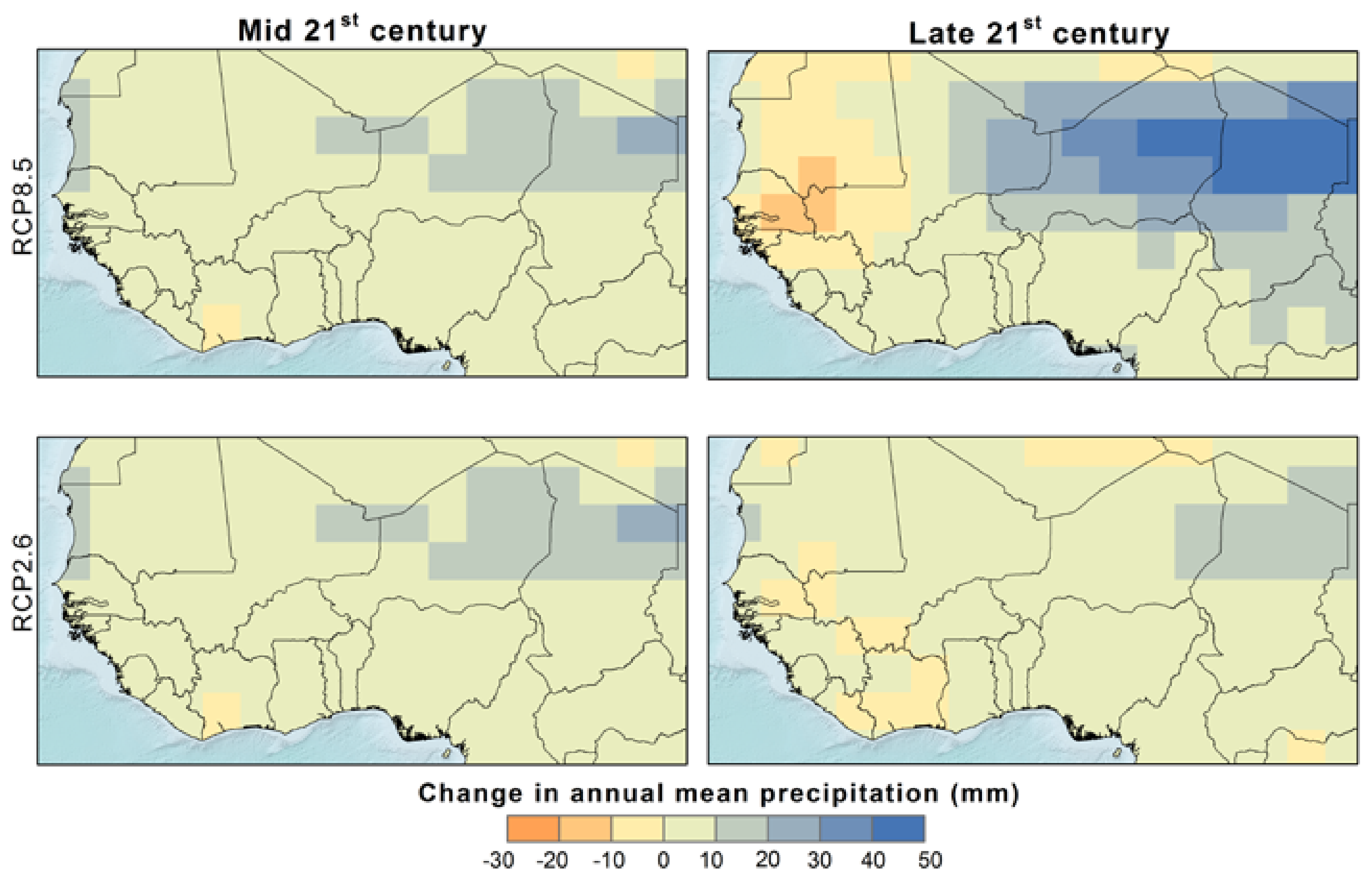
Dust storm, Winde Mborni, Mauritania, July 2008

STEFANIE HERRMANN / U. OF ARIZONA

Predicted temperature change for the mid- and late 21st centuries



Predicted rainfall change for the mid- and late 21st centuries



Models of projected changes in temperature and annual mean precipitation of West Africa were commissioned by the Intergovernmental Panel on Climate Change (IPCC). The scenarios predict temperature and precipitation for both the mid-21st century (2046-2065) and the late 21st century (2081-2100) relative to the late 20th century (1986-2005), based on two alternative greenhouse gas emission scenarios, RCP2.6 and RCP8.5 (RCP stands for Relative Concentration Pathways). Model projections based on these two extreme pathways are contrasted here, with RCP2.6 assuming that global greenhouse gas emissions peak between 2010 and 2020 and decline substantially thereafter, and RCP8.5 assuming that emissions continue to increase throughout the 21st century. The projections shown are multi-model averages. The averages tend to level out the considerable variability and disagreement between the individual models.

As the maps show, both scenarios predict a warming trend and predominantly positive changes in annual rainfall for most of West Africa. While most changes are small and insignificant, a wetter future is predicted for Niger and Chad, whereas the RCP8.5 scenario indicates a possible drying trend for the western part of West Africa.

These maps were reproduced for West Africa from data from the IPCC 5th Assessment Report (Niang and others, 2014).


Flooded village along the Niger River south of Niamey in 2012.

GRAY TAPPAN / USGS

Temperatures over West Africa have increased over the last 50 years, in line with an increase in global temperatures (Niang and others, 2014). The impact of global warming on rainfall in West Africa, however, remains notoriously difficult to assess in a climate that is susceptible to significant variation at multiple time scales. Different climate models, which differ in their representation of atmospheric processes, show significant variation, and disagreement, in their projections of future rainfall in West Africa. While there is a high level of confidence that temperatures will continue to increase in West Africa (between 3°C and 6°C above the late 20th century baseline by 2100), some models project a drier future, others a wetter future, and yet others no significant change in rainfall totals (see bottom adjacent figure). An increase in the frequency of extreme rainfall events has been observed over the past 50 years and is likely to continue into the future. Future soil suitability for major crops is expected to be affected by climate change; in particular beans, maize and banana production might face declines and require cropping system transformations (Rippke and others, 2016). The coastal countries of West Africa are also vulnerable to sea level rise resulting from global warming, leading to flooding and coastal erosion.

Climate variability and change have impacted, and are continuing to impact, land cover in West Africa by changing the amount and timing of water availability to vegetation cover. Land use decision making responds to these changes in ways that further alter the land cover, from slight modifications of the quality of the land cover to outright transformations of the land cover type.