Landscapes of West Africa

A Window on a Changing World

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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

Preface

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.

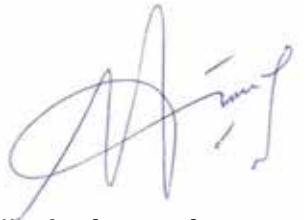
The West Africa Land Use Dynamics (LULC) Project is emblematic of this cooperation. Initiated in 1999, the LULC project has had several phases including training national experts to extract pertinent information from satellite images to characterize vegetation cover and producing tools and supporting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



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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.

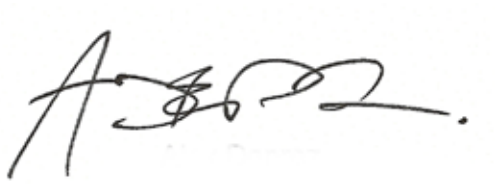
Rapid changes are occurring across West Africa's natural and human landscapes and balancing the need to preserve natural ecosystems with the need to grow more food, together with ensuring resilience in the same ecosystems, is a challenge. USAID West Africa's (USAID/WA) Environmental Threats and Opportunity 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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Acknowledgments

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:

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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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Richard Julia, friend and pilot based in Ouagadougou who made it possible for the project team to acquire thousands of aerial photographs in numerous countries of West Africa, and for his own photography of landscapes, wildlife and cultures of the Sahel.

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.

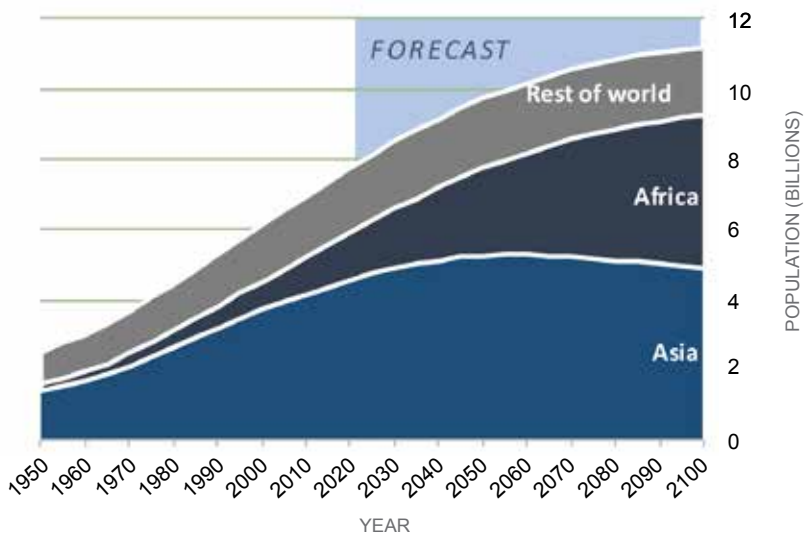
When humankind appeared on Earth around 200,000 years ago the influence of human activity on the environment must have been small and localized. The influence of scattered small groups of people on the global ecosystem would have been overwhelmed by the forces of natural systems (Steffen and others, 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

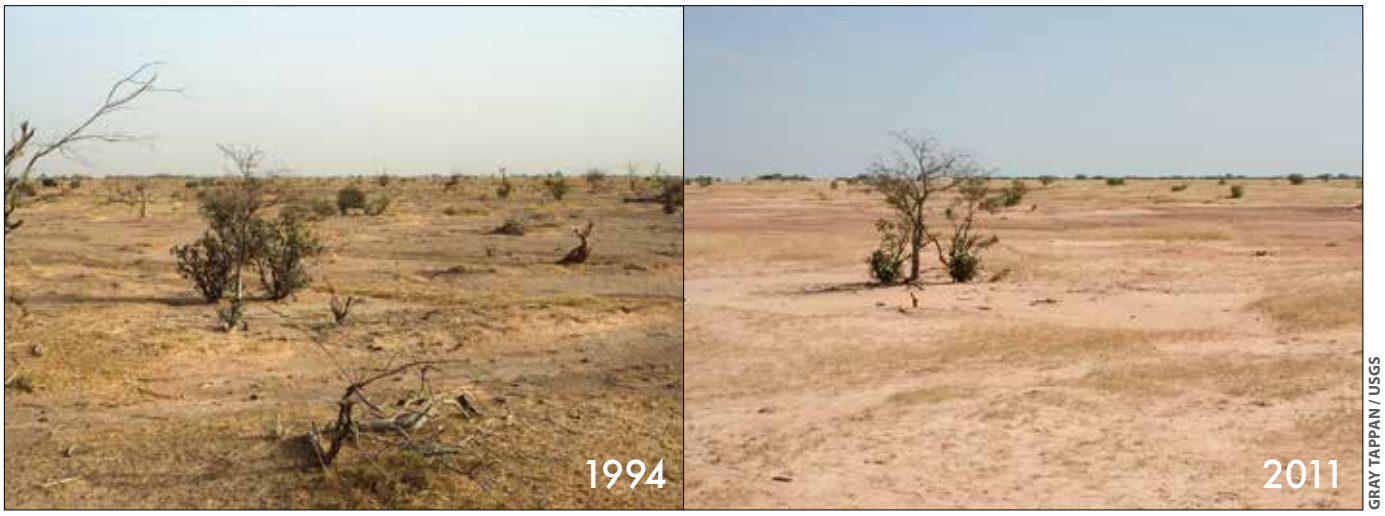
Wooded landscape fragmented by agriculture expansion in western Burkina Faso

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.

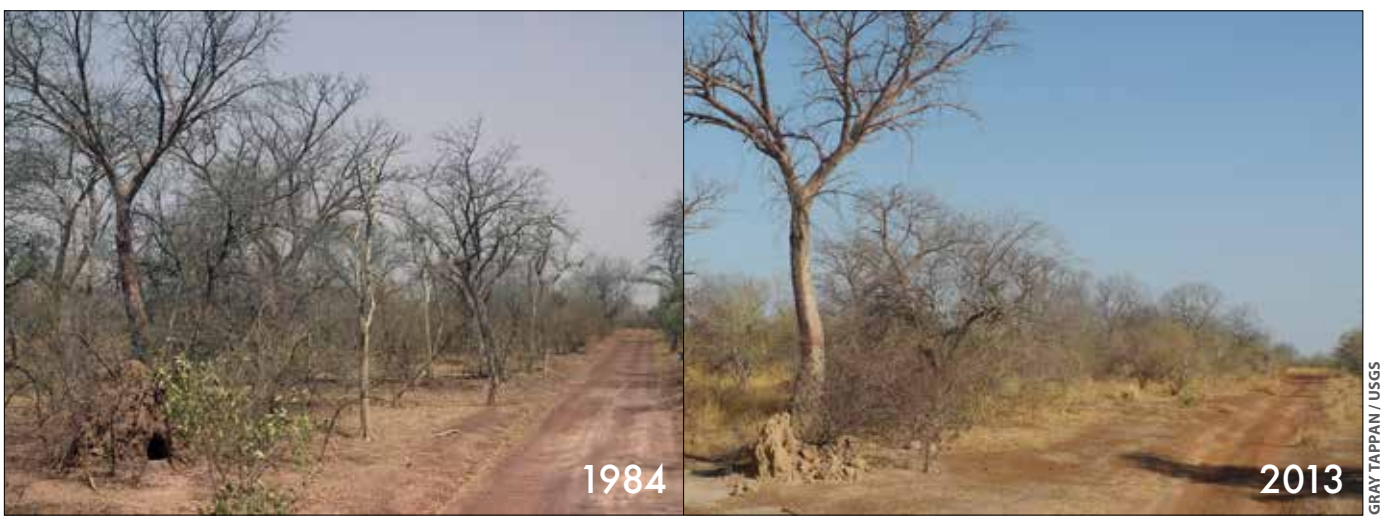
Conversion of the natural landscapes of West Africa to agriculture greatly reduces the natural biodiversity, and exposes the soil to wind and water erosion. The savanna, woodland, forest, and wetland ecosystems that are lost have some relatively tangible impacts such as the loss of natural ecosystem 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.

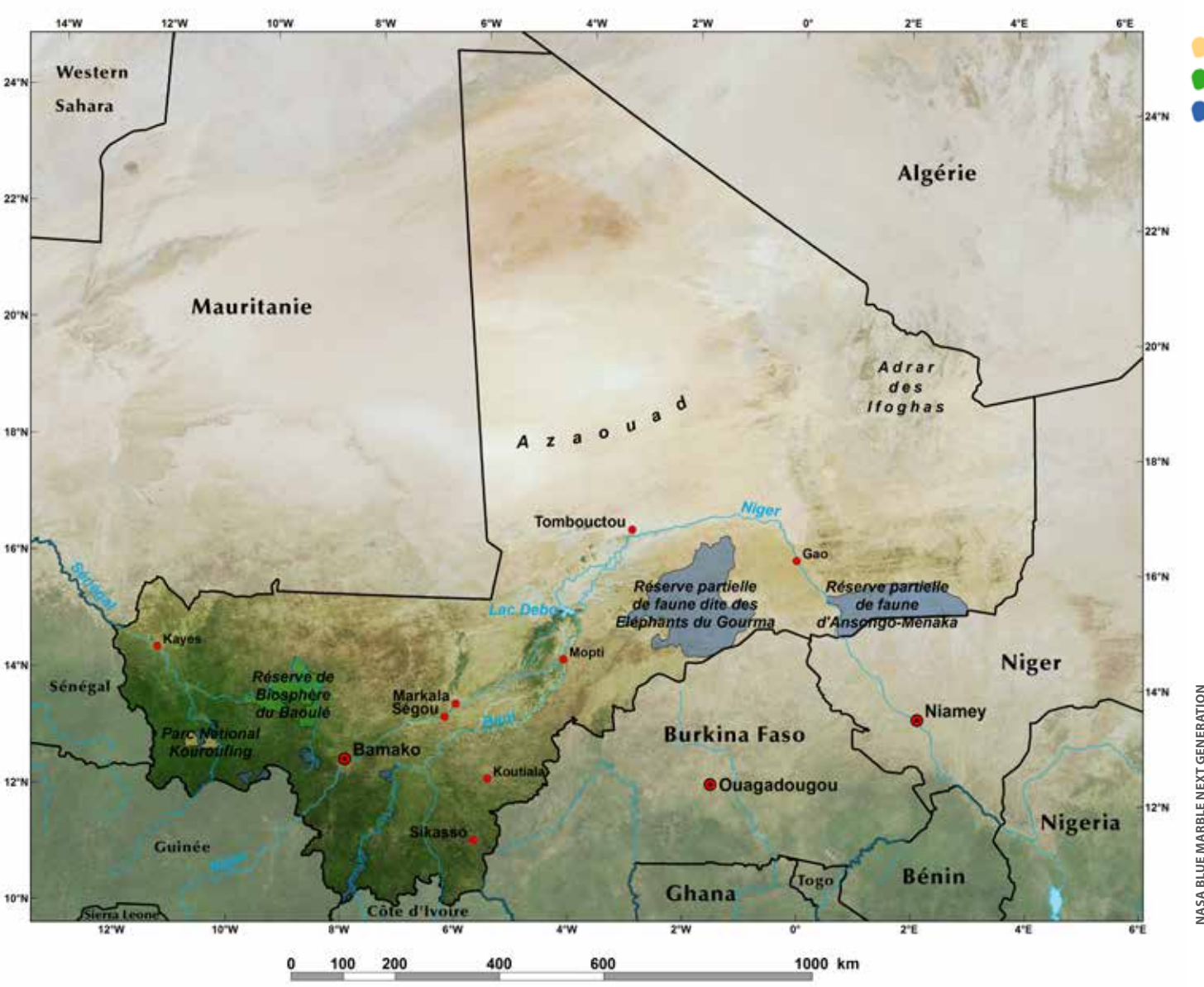
This atlas tells a story of rapid environmental change with both hopeful and worrisome chapters. The story is told with maps and numbers detailing the rate, magnitude, and location of land cover change but also with words and images that seek to make the story more real for the people living in West 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 II

Country Profiles, Land Use and Land Cover, and Trends

Republic of

Mali



Total Surface Area: 1,241,200 km²
Estimated Population in 2013: 16,592,000

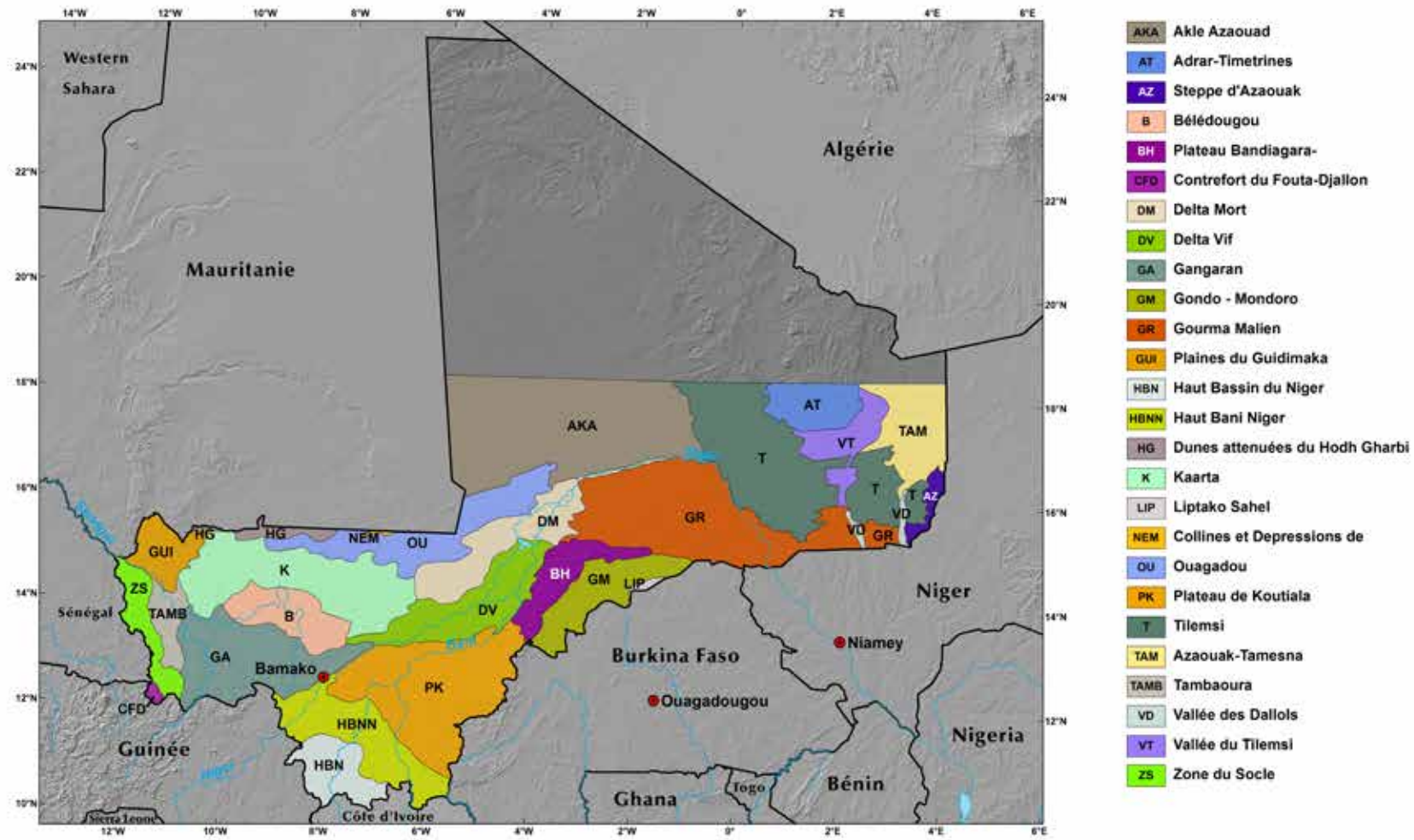
The area occupied by Mali was once home to the Manding Empire (c. 1230 to c. 1600), the largest empire known to exist in Sub-Saharan Africa. In the 1300s, the Manding Empire extended from the Atlantic coast to west of the Niger River, bordered by the Sahara Desert in the North and the equatorial rain forest in the South.

The Inland Delta of the Niger River spreads across central Mali — a unique ecosystem in West Africa. A result of the Niger River flowing into the sandy Sahelian plains, this vast network of channels, swamps, and lakes mitigates the severity of the arid climate and forms the second largest interior delta in Africa. Host to rice farming, fishing, and animal husbandry, the delta plays a critical role in the country's economy. Agriculture, which accounts for about 40 percent of the gross domestic product (GDP) and employs 74 percent of the labor force, remains the main economic sector in Mali, which ranks as Africa's fourth largest cotton producer (CIA, 2013). Gold mining has greatly increased since the beginning of the 2000s, accounting today for about 15 percent of Mali's GDP and making it West Africa's second largest exporter of gold after Ghana (Hale, 2002). Mali has major tourist attractions with sites such as the Bandiagara escarpment, known for its stunning landscapes with centuries-old village architecture, and the famous city of Timbuktu, a UNESCO World Heritage site.

Environmental Highlights:

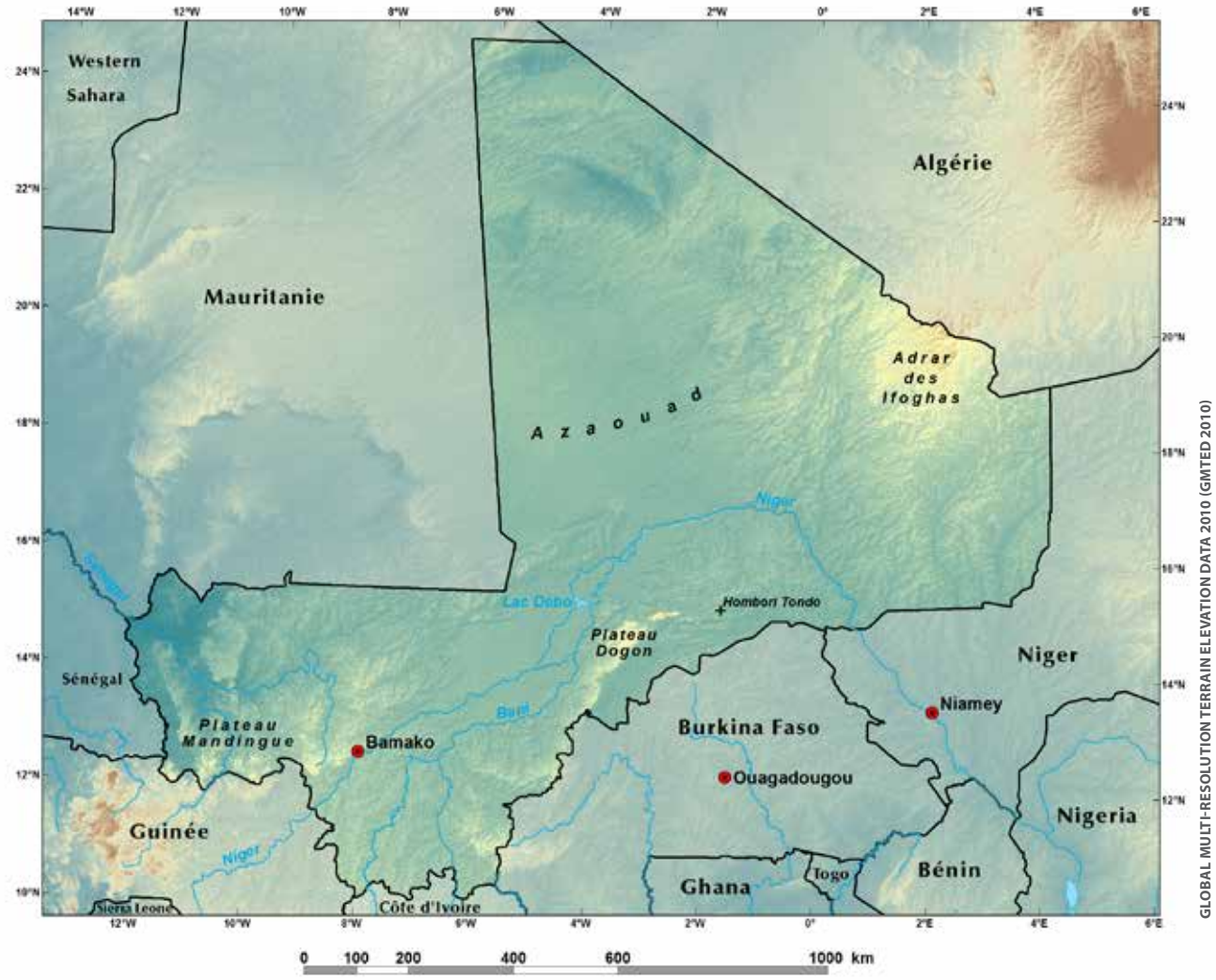
- Soil degradation and loss of vegetation cover
- Desertification
- Rich ecosystem of Inland Niger Delta
- Farmer-managed natural regeneration
- High tourism potential

Ecoregions



AKA Akle Azaouad
AT Adrar-Timetrines
AZ Steppe d'Azaouak
B Bélédougou
BH Plateau Bandiagara-
CFD Contrefort du Fouta-Djallon
DM Delta Mort
DV Delta Vif
GA Gangaran
GM Gondo - Mondoro
GR Gourma Malien
GUI Plaines du Guidimaka
HBN Haut Bassin du Niger
HBNN Haut Bani Niger
HG Dunes attenuées du Hodh Gharbi
K Kaarta
LIP Liptako Sahel
NEM Collines et Depressions de
OU Ouagadou
PK Plateau de Koutiala
T Tilemsi
TAM Azaouak-Tamesna
TAMB Tambaoura
VD Vallée des Dallols
VT Vallée du Tilemsi
ZS Zone du Socle

Shaded Relief



Élevée / High

Faible / Low

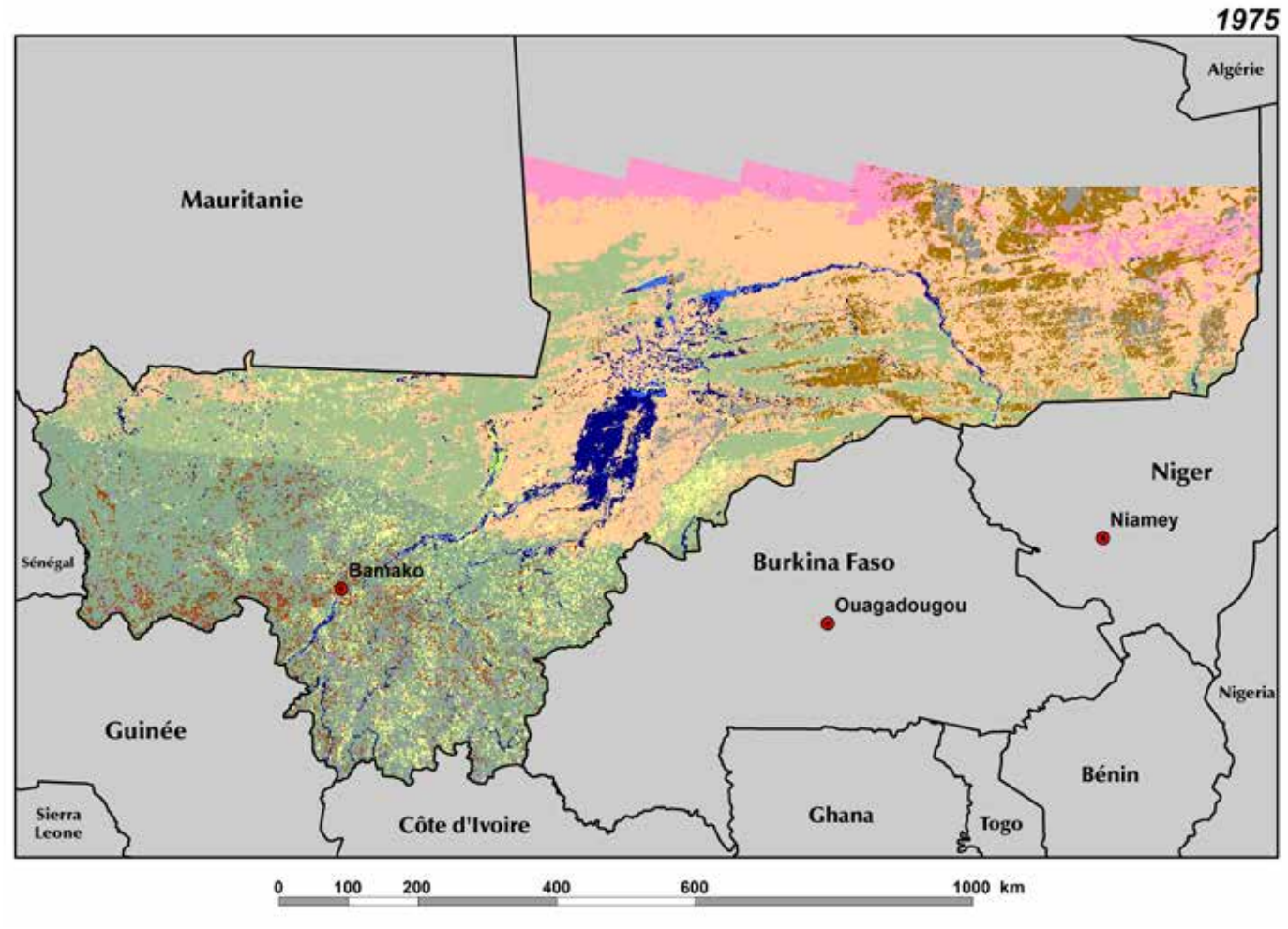
GLOBAL MULTI-RESOLUTION TERRAIN ELEVATION DATA 2010 (GMTED 2010)

Mali has flat to rolling landscapes, occasionally interrupted by high rising plateaus. In the north, the Sahara Desert covers almost half of the country. The open steppes of the Akle Azaouad (AKA) plateau and rocky terrain of Adrar-Timetrines (AT) and of Tilemsi (T and VT) make large east-west swaths across the country. The southern Sahara transitions into the semiarid Sahel Region — the domain of pastoralists — interrupted in central Mali by the seasonally flooded alluvial plain of the Inland Niger Delta (DV, DM). The southern strip of this large plain is bordered by the Koutiala (PK) and Bandiagara-Hombori (BH) plateaus, the latter rising to 1,155 m. In southern Mali, the plains of the Sudanian Region account for the majority of the country's agricultural land.

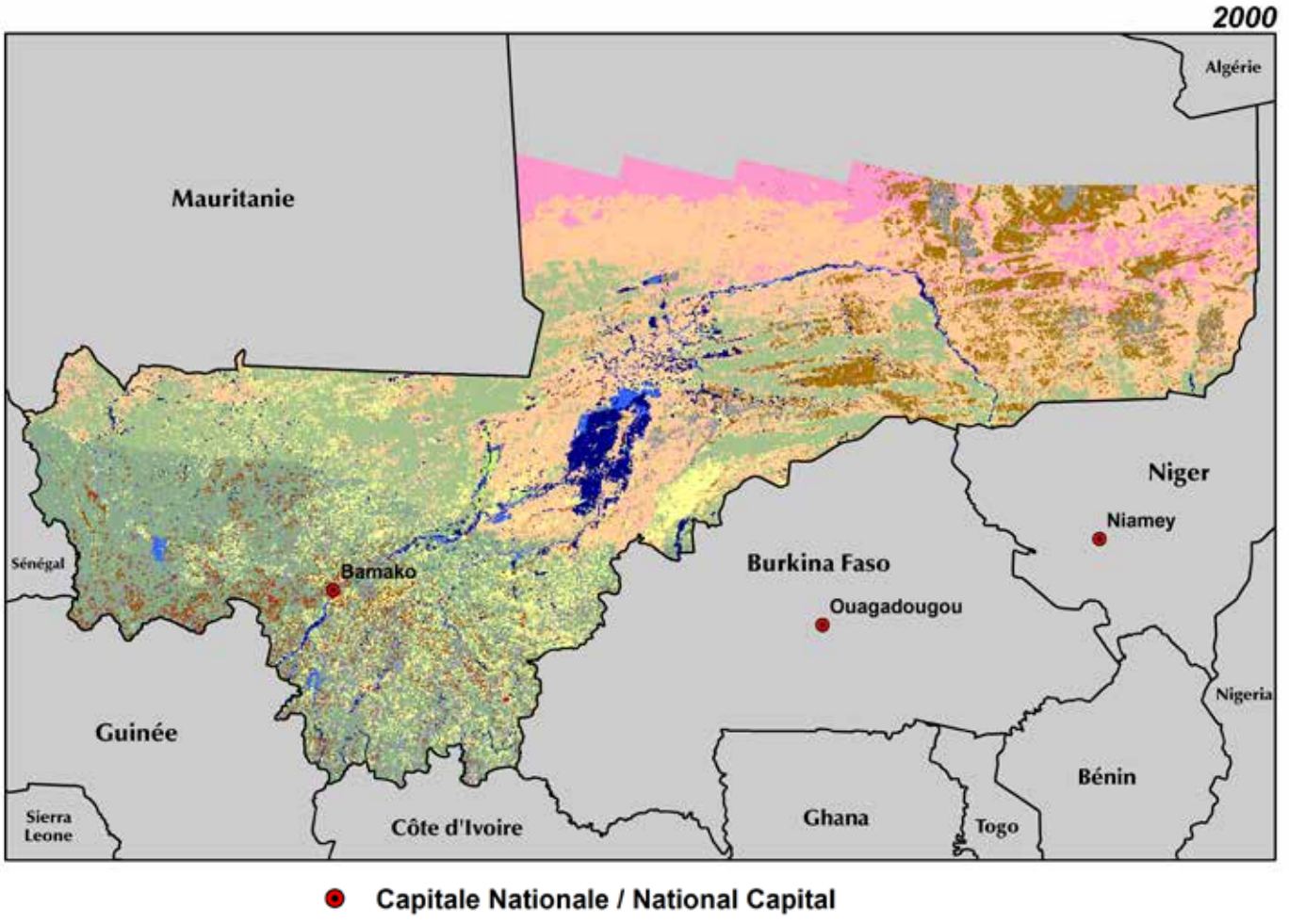
Land Use, Land Cover and Trends

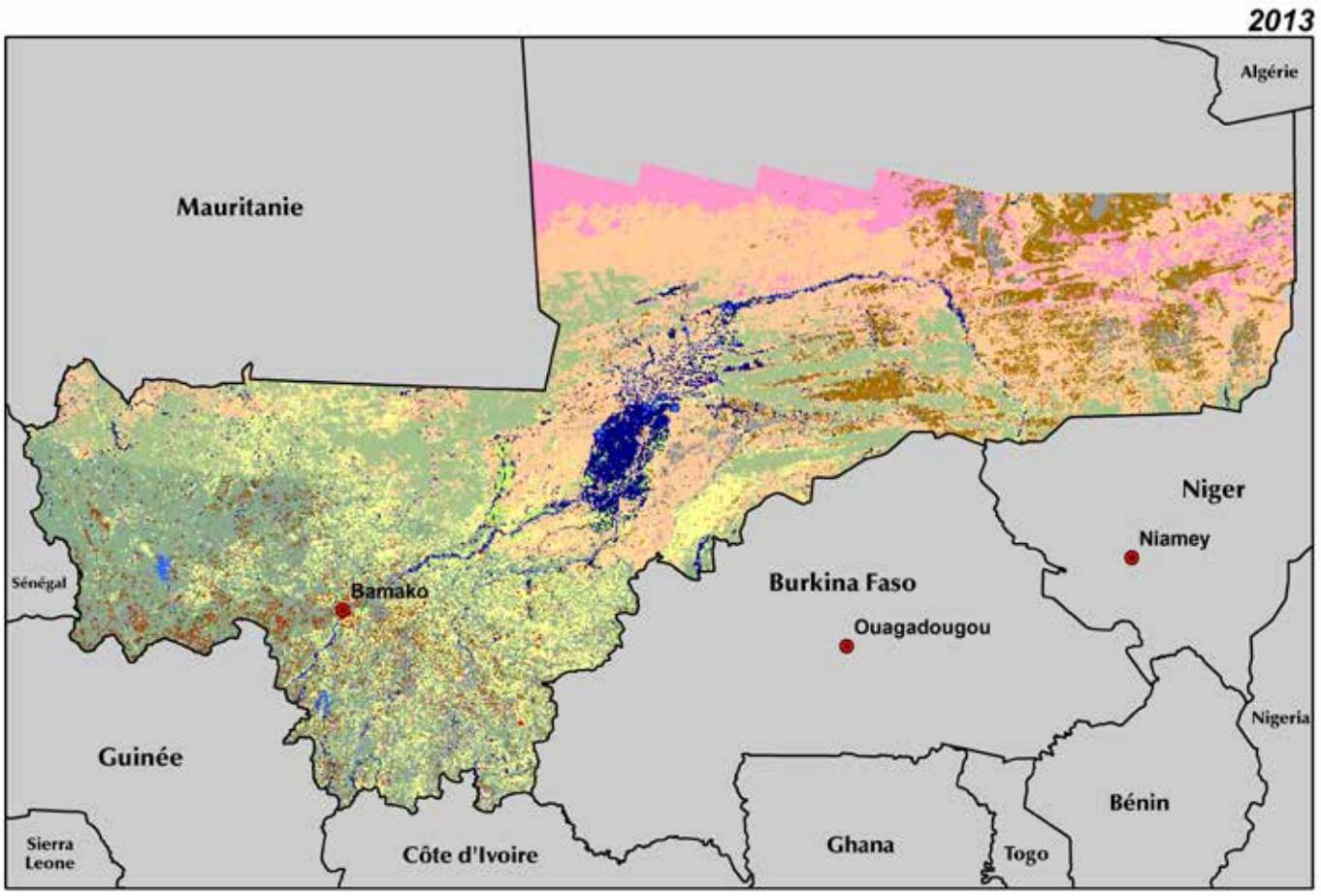
Overall, steppes, Sudanian savannas and Sahelian short grass savannas have experienced dramatic losses during the last 38 years, yet they remain the predominant land cover classes, accounting for 30 percent, 18.5 percent, and 15 percent of the mapped area, respectively, in 2013. The decrease in steppe is largely explained by the expansion of sandy areas in the Akle Azaouad (AKA) and Tilemsi (T) ecoregions. Increasing aridity also impacted the steppes, pushing them southward, in places encroaching on the Sahelian savannas. Losses of Sahelian and Sudanian savannas, however, result more from human activity — the expansion of agriculture that has occurred across southern Mali.

Cropland area increased by a factor of 2.3 over the 38-year period, which is equivalent to an average annual increase of 3.5 percent, or 1,300 sq km per year. Agricultural expansion can be seen across the south, especially in Haut Bani Niger (HBNN – Upper Bani Niger), Koutiala Plateau (PK) and Kaarta (K) ecoregions. In these regions, agricultural landscapes now predominate over natural ones. In 1975 the Séno Plain, east of the Plateau Dogon in the Gondo-Mondoro (GM) ecoregion, was already predominantly agricultural. By 2013 it is uniformly devoted to cropland (see pages 144–145). Cropland expansion is driven by the need to feed a rapidly increasing population and has accelerated between 2000 and 2013, facilitated by modern technology. Likewise, irrigated agriculture areas have increased



Mali's northern half is a desert, with a sparse but relatively stable vegetation cover. Consequently, only the southern half of the country was mapped in order to monitor and analyze land use and land cover dynamics.





Occupation des Terres / Land Cover

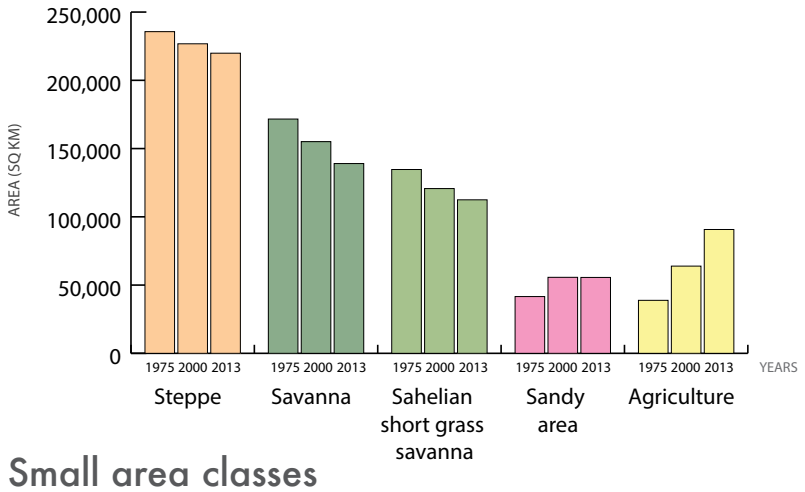
- Forêt galerie & formation ripicole / Gallery forest & riparian forest
- Forêt claire / Woodland
- Forêt marécageuse / Swamp forest
- Savane / Savanna
- Savane sahélienne / Sahelian short grass savanna
- Steppe
- Bowé
- Zone de culture / Agriculture
- Cultures irriguées / Irrigated agriculture
- Cultures des bas-fonds et de décrue / Agriculture in shallows and recession
- Plantation
- Habitation / Settlements
- Sols dénudés / Bare soil
- Terrains rocheux / Rocky land
- Surfaces sableuses / Sandy area
- Carrière / Open mine
- Plans d'eau / Water bodies
- Prairie marécageuse - vallée inondable / Wetland - floodplain

by 400 percent, or 4,600 sq km, mainly along the Niger River and its tributaries in the southern part of the Inland Delta.

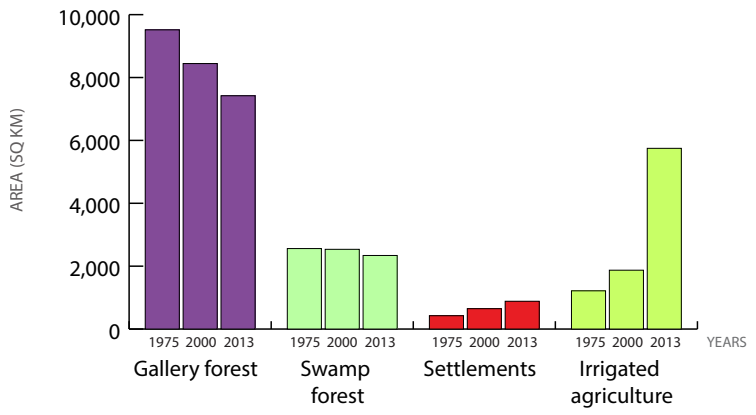
The Inland Niger Delta is a highly dynamic and complex ecoregion of landscapes that interact with the ebb and flow of seasonal flooding (see pages 146–147). There is also considerable year-to-year variation in the extent of flooding. Despite this, the land cover types within the Delta have remained relatively stable, although there has been some encroachment of irrigated cropland in the southern Delta.

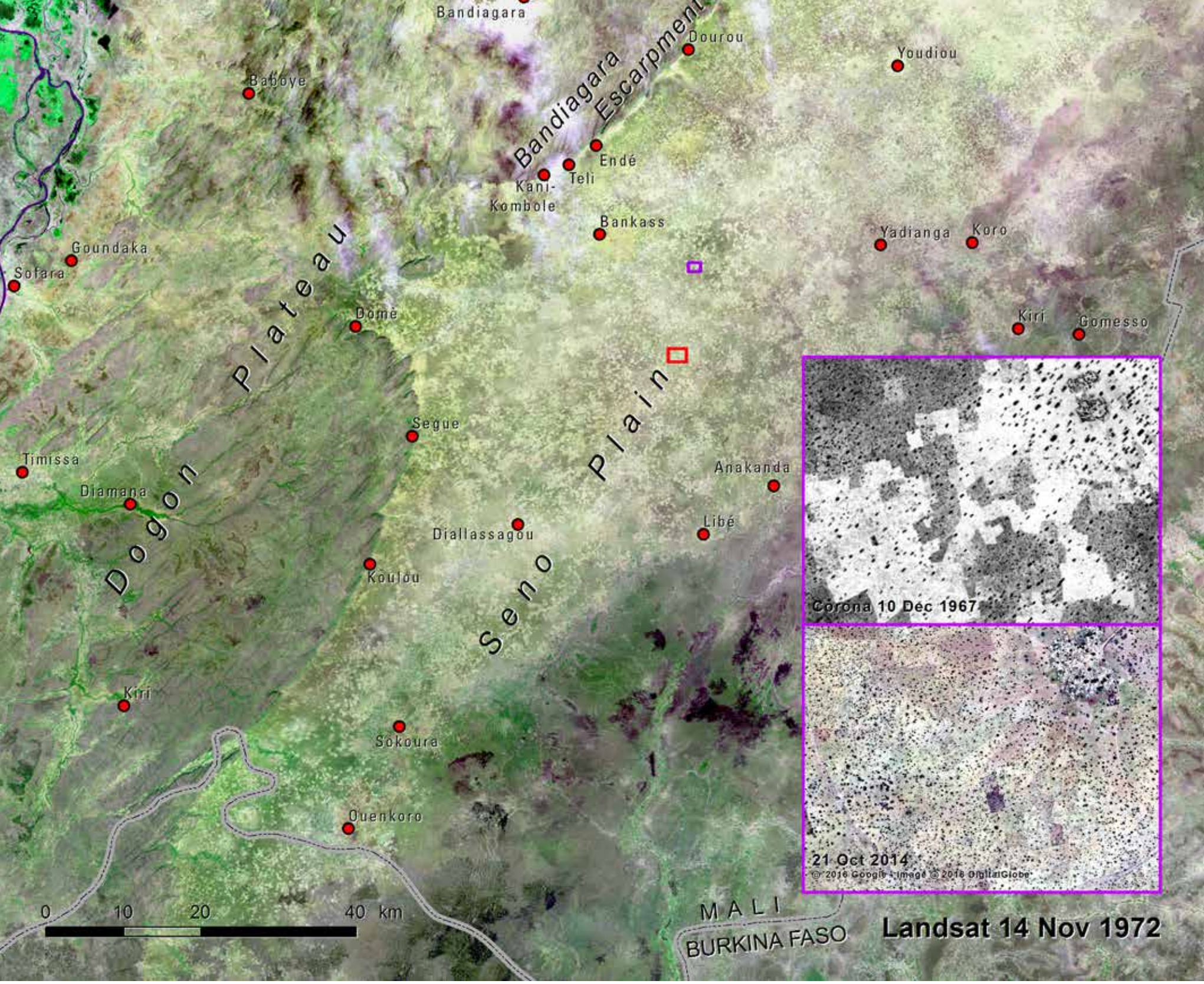
Natural habitat destruction is a major environmental issue in Mali. In addition to savannas, gallery forests have decreased by 23 percent due to population and agriculture pressures between 1975 and 2013. Clearing these forests causes severe water erosion, which removes the topsoil, reducing land productivity and creating conditions that lead to desertification. On a positive note, the hundreds of swamp forests that occur in natural depressions across the semiarid Sahel remain largely intact, providing critical habitat for wildlife.

Large area classes



Small area classes





Building land-based resilience to drought and climate change on the Seno Plain

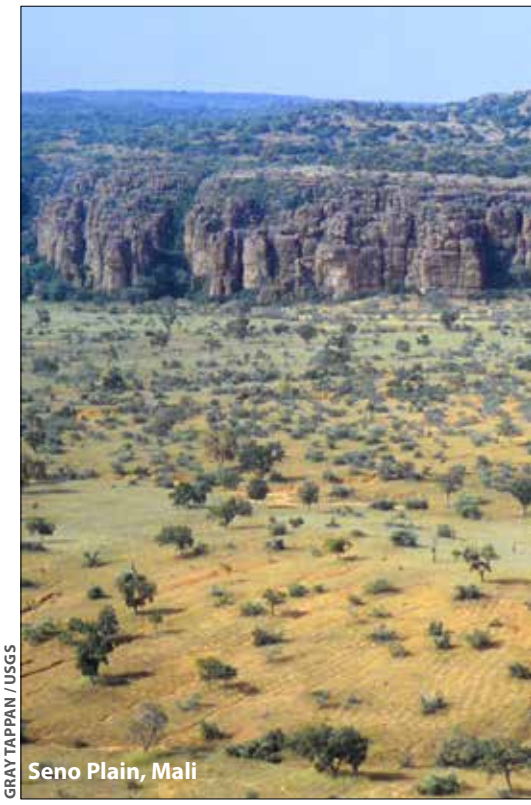
Between the rocky Dogon Plateau in central Mali and the border with Burkina Faso stretches the Seno Plain and its densely settled farmland. The Seno Plain is located in the Sahel, where limited and highly variable rainfall (500–600 mm per year) makes farming a challenge. Indeed, land degradation, deforestation, and out-migration from the Seno Plain were common during the long series of devastating droughts that affected the entire Sahel from the late 1960s to the 1980s. Despite the earlier out-migration, population has steadily increased in recent decades, increasing human pressure on the land.

The views from space tell a story of change — including a positive development that is often missed. In the 1972 Landsat image, we see a patchwork of cultivated land (light areas) and shrub and tree savanna (darker areas). Farmers still practiced crop rotation that included leaving land in bush fallow. As population increased, more and more land was put into cultivation, virtually eliminating the fallow area. The 2013 image shows the continuous cropland, with hundreds of villages (dark spots) scattered throughout the sandy plain. The villages stand out in part because of their built-up surfaces and shade trees, but also because of the fertilizing effect of household and animal waste in the fields adjacent to each village.

A closer look using detailed imagery shows another feature around every village — a relatively dense parkland of trees (see insets). Indeed, by mapping tree cover with high-resolution imagery, we found that medium to high

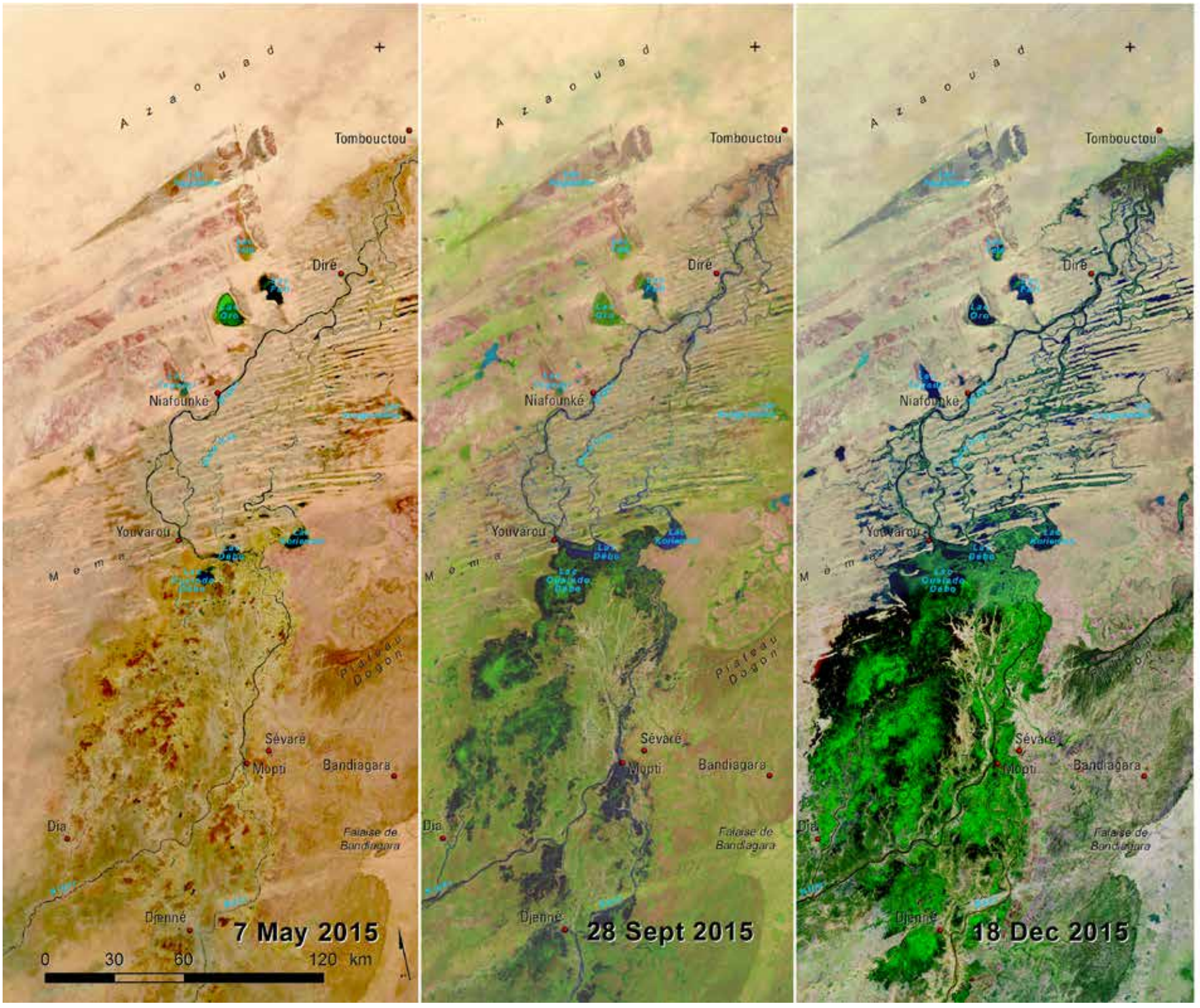
densities of field trees currently cover about 4,500 sq km in the Seno Plain. Field surveys suggest that most of the trees are less than 15 to 20 years old, meaning that much of today's parkland is very young. Corona space photographs taken in 1967 show that most villages maintained a parkland in the fields close to the village, but that tree densities dropped considerably beyond the inner circle of fields. Shrub savanna — rather than tree parklands — characterized the extensive bush fallow between villages.

The two detailed comparison images show the transformation that is typical around villages in the Seno Plain over the past 47 years. In the 1967 views, bright fields stand out from the surrounding bush fallow. The parkland of trees tends to be limited to the fields immediately adjacent to each village. In the 2014 image, the villages have visibly increased in size, and the surrounding land is completely saturated with cropland. Many of the large, older trees seen in 1967 did not survive the drought years and the increased pressure for firewood and fodder; however, in a positive development, a parkland of young trees has replaced them — extending well beyond the inner fields to the entire landscape around each village. Many local farmers confirm the decline in tree cover in the 1970s and 1980s, and the widespread re-greening of the Seno Plain since then. While improving rainfall conditions in the past two decades might have helped trees to regenerate on these farmlands, most of the changes can be attributed to human activity (Spiekermann and others, 2015). Since the mid-1990s, international and local non-governmental organizations have jointly promoted farmer-managed natural regeneration, echoing the success stories from the Maradi and Zinder regions of Niger. The new forestry law of 1995 has promoted a more decentralized forest management approach, which has facilitated improved environmental management by local institutions.



GRAY TAPPAN / USGS

Seno Plain, Mali



Landscape diversity and dynamics of the Inland Niger Delta

The Inland Niger Delta is the largest wetland in West Africa. It is spectacular in both its landscape diversity and dynamics. Water from the Niger River, which originates 900 km upstream in the Guinean Highlands, spreads out into a wide floodplain about 380 km long in central Mali. It has a very gentle gradient, dropping only 8 m over its entire length. The floodplain is a highly dynamic complex of wetlands, channels, islands and lakes that provides important habitat for fish, water birds, and other wildlife. The seasonal flooding also supports pasture and rice farming. The delta has provided livelihoods for people for millennia. Today, over 1 million people depend on the resources of the delta. About a quarter of the Delta's population lives in cities like Djenné, Mopti, Niafounké, and Timbuktu.

In the recent geologic past, the Inland Delta area was once a huge lake, fed by the Upper Niger River. At some point in that wet period, the lake overflowed to the east through a breach. The interior lake was drained, although a number of small relic lakes remain.

The three Landsat images capture the dynamics of natural flooding as seen in May, September, and December 2015. The May image shows the extreme dryness of the land at the peak of the hot, dry season. The semi-permanent water bodies (dark blue and green) of the Delta stand out. Several major lakes have dried out since the early 1970s, most notably Lake Faguibine, whose arrowhead-shaped lakebed is clearly seen in the north. The low flood levels of the drier years are insufficient to reach many lakes and depressions. Flooding begins when the Niger and the

PHOTOS: GRAY TAPPAN / USGS; MICHIEL KUPERS; RICHARD JULIA

Bani Rivers begin to rise. Starting in July, the Niger River rises about 4 m in 100 days. Peak level may even reach 6 m in the years of high rainfall (Zwarts and others, 2009). As the center image shows (opposite page), by late September the natural flooding of the Inland Delta is well underway. Acting like a giant sponge, vast wetlands come to life. The southern Delta swells and greens first, while the northern Delta area experiences a two- to three-month delay in flooding. In the December image, the annual high water level has finally reached the northern Delta, while the southern Delta has already been drained of much of its water. Between the southern and northern floodplain, flooding permeates a total area of about 40,000 sq km. Numerous ephemeral lakes, along with the more permanent ones, like grapes on a vine, receive and store the floodwaters, releasing them gradually as the river level subsides.

Vast floating meadows of vegetation occupy the areas of deeper water, dominated by an aquatic grass species known locally as bourgou. During the flooding, bourgou, along with wild rice and other species, produce a considerable amount of habitat for fish and water birds and nutritious fodder for cattle during the dry season. As the water subsides in the dry season, the floodplain vegetation provides green pasture for the millions of cattle, sheep, and goats. Farmers cultivate rice, mainly in the southern Delta. They use a West African rice variety that grows well as the water rises. It is then harvested when the waters recede. This floodplain rice is more extensive than irrigated rice fields, which can also be found in the Inland Delta.

Flood forecasts will become increasingly important as the population grows and pressure on water resources increases. Water level measurements and satellite images help predict the onset of seasonal floods and help achieve food security. An early warning system will help predict drought and monitor food security. Data from both on the ground and satellites help manage water resources.