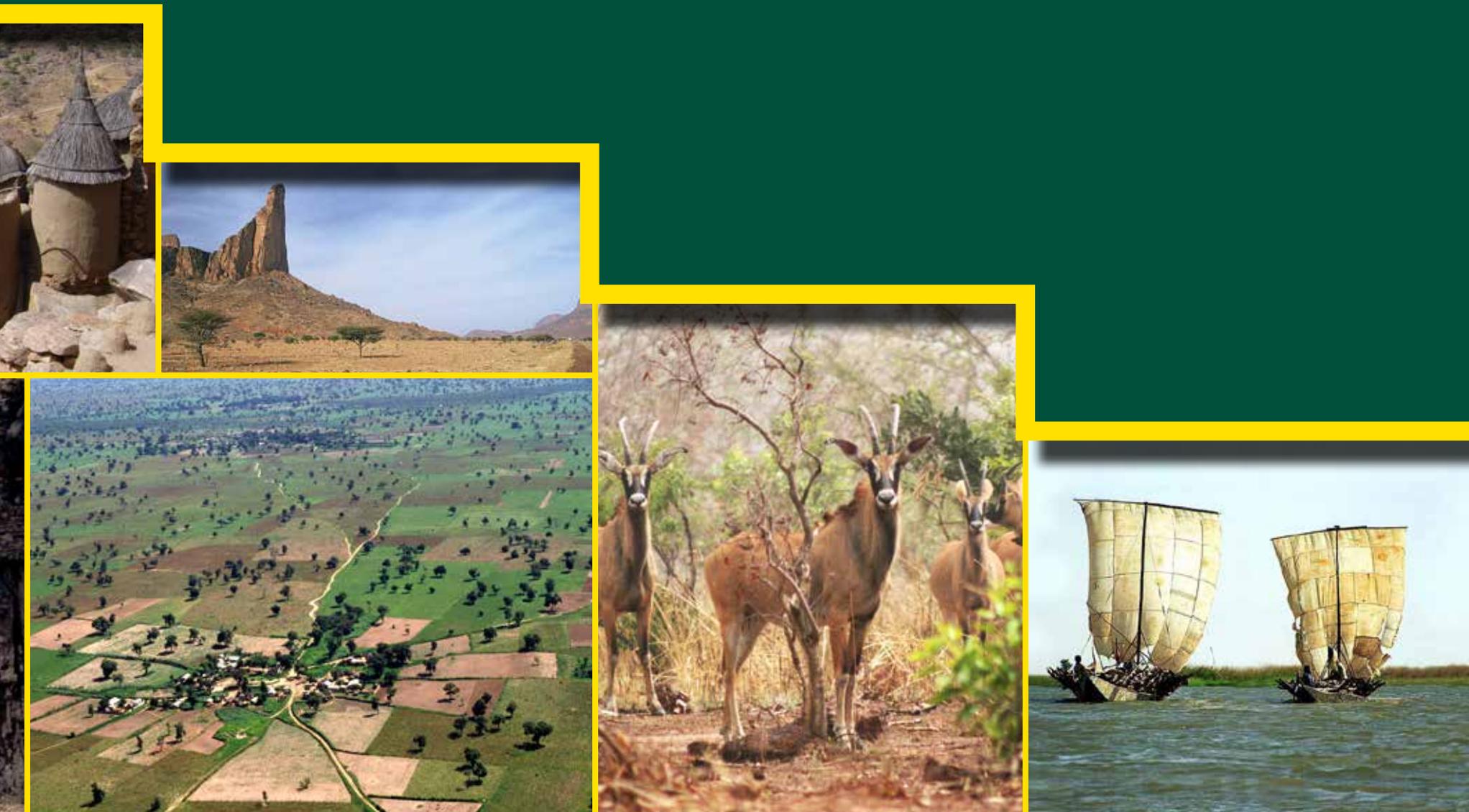


Landscapes of West Africa

A WINDOW ON A CHANGING WORLD



Landscapes of West Africa

A WINDOW ON A CHANGING WORLD



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science for 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.





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.

A handwritten signature in blue ink, appearing to read 'Djimé Adoum'.

Djimé Adoum, Ph.D,

Executive Secretary

CILSS

Ouagadougou, Burkina Faso



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FROM THE AMERICAN PEOPLE

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.

Alex Deprez
Regional Mission Director
USAID/West Africa
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Alex Deprez



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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In Memory

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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

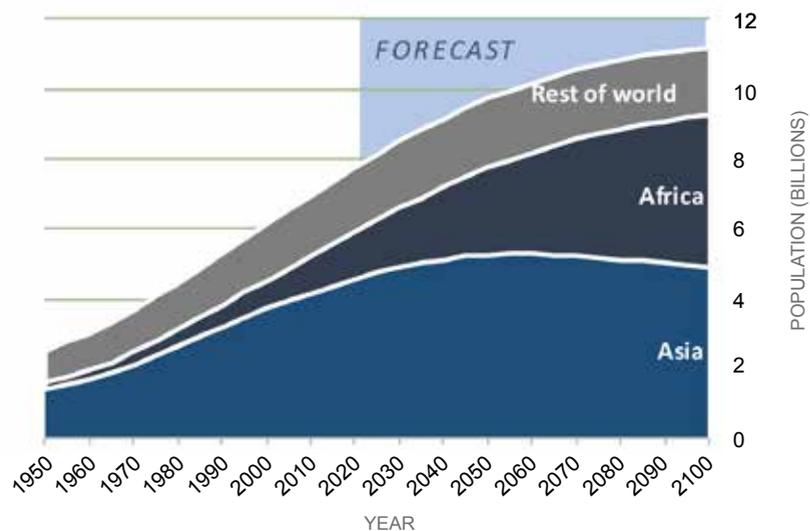
the collapse of natural systems that are essential for humans to thrive, perhaps even threatening the future of all humankind.

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)!

“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



Wooded landscape fragmented by agriculture expansion in western Burkina Faso



JAMES ROWLAND / USGS

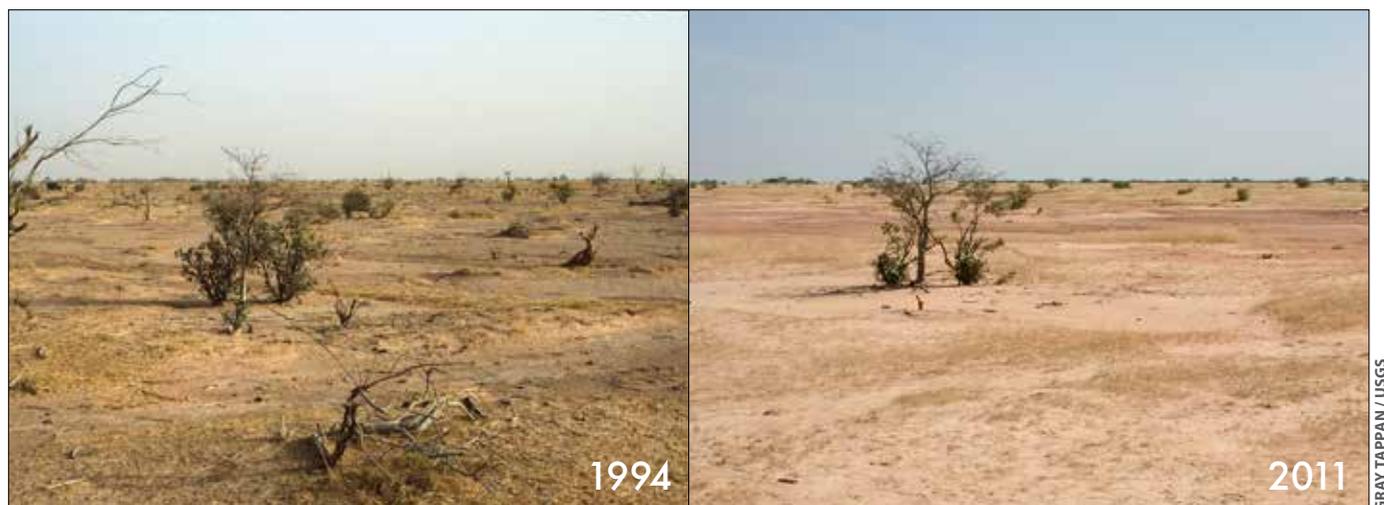
Parallel trends can be seen in the land cover changes of West Africa. With so many new families to feed, West Africa doubled the area covered by farms between 1975 and 2013. Vast areas of savanna, woodland, and forest landscape have been replaced or fragmented by cropland. At the same time villages, 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.

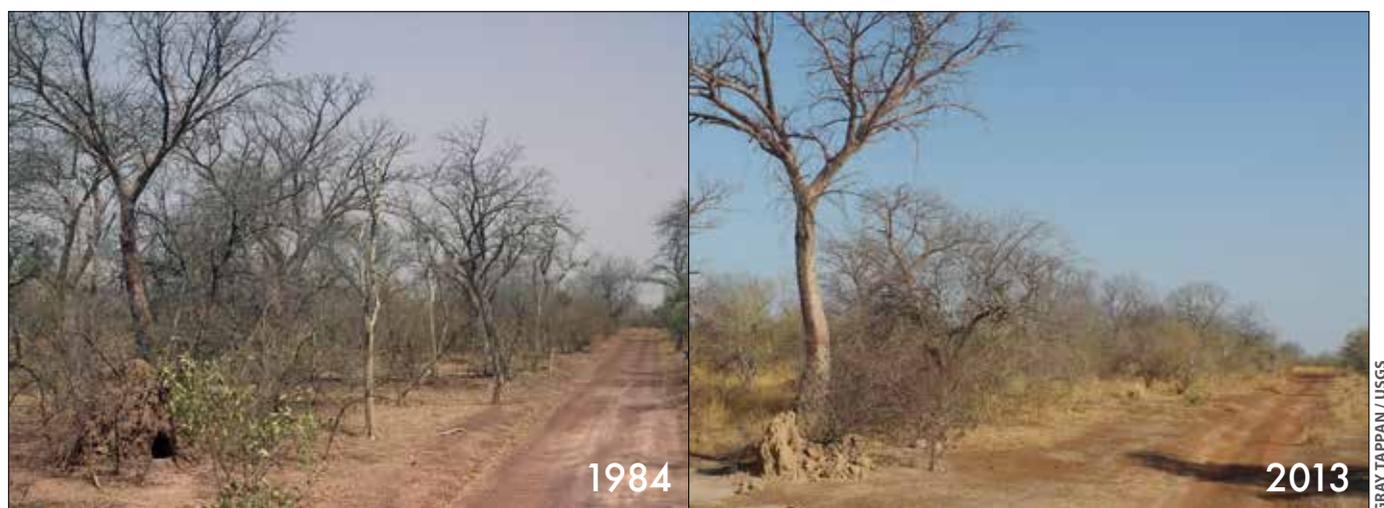
Conversion of the natural landscapes of West Africa to agriculture greatly reduces the natural biodiversity, and exposes the soil to wind and water erosion. The savanna, woodland, forest, and wetland ecosystems that are lost have some relatively tangible impacts such as the loss of natural ecosystem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



Decline in vegetation cover and biodiversity in east-central Senegal



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.

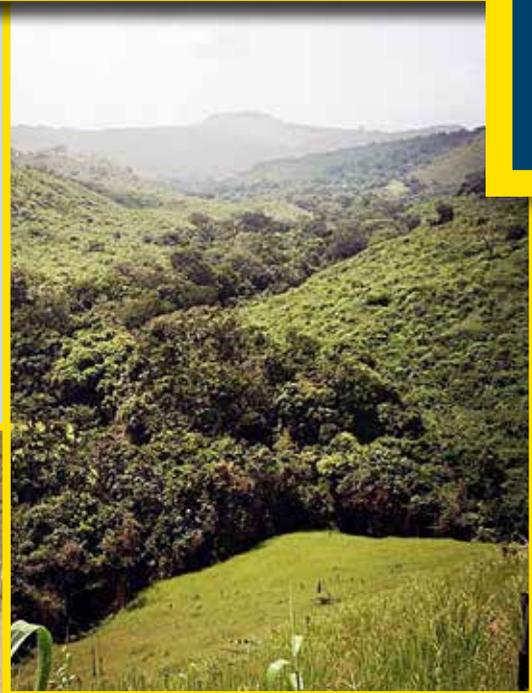
Experts from institutions in 17 countries in West Africa have partnered with the Comité Inter-états de Lutte contre la Sécheresse dans le Sahel (CILSS – The Permanent Interstate Committee for Drought Control in the Sahel), the U.S. Agency for International Development (USAID) West Africa and the U.S 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.





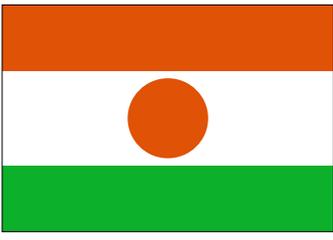


Chapter

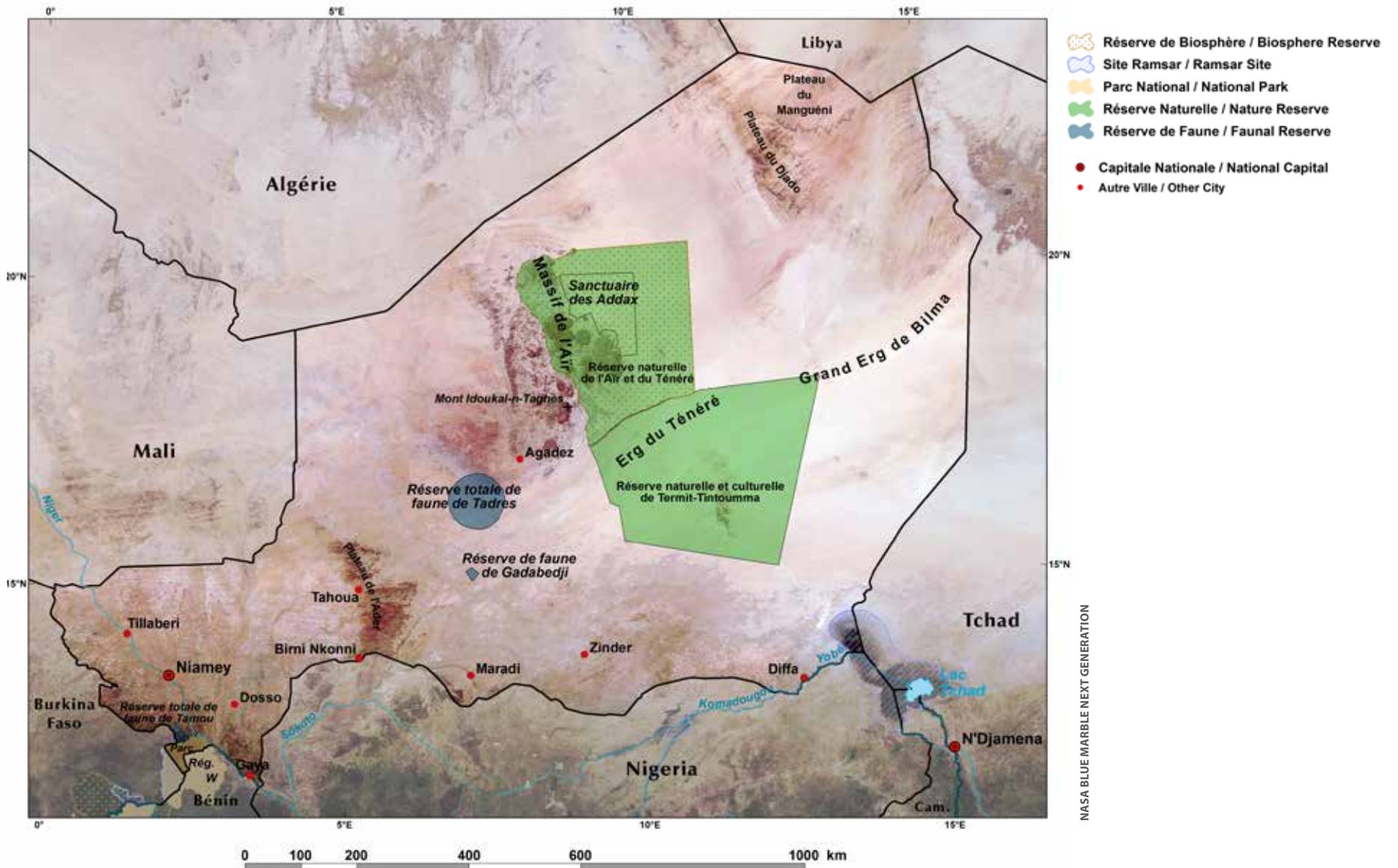
III

Country Profiles, Land Use and Land Cover, and Trends





Republic of Niger



Total Surface Area: 1,267,000 km²
Estimated Population in 2013: 18,359,000

Niger is one of the largest inland countries in West Africa and is historically a gateway between North Africa and sub-Saharan Africa. With two-thirds of the country lying within the Sahara Desert, it is one of the hottest countries in the world. Niger is mostly a vast plateau, with an average elevation of 500 m, with low local relief. In the Sahelian zone of the country, the climate becomes semiarid and the vegetation cover increases. The central part of Niger is dominated by an extensive pastoral zone — mostly steppes or short grass savannas with shrubs and sparsely scattered trees. Most of the people derive their income from agriculture and stock raising and are highly vulnerable to periodic droughts and desertification. Moreover, land potential for agriculture is very unevenly distributed among Niger's regions, with the southern regions providing nearly 98 percent of the arable land. The Niger River, for which the country is named, nourishes a ribbon of life as it flows about 550 km through western Niger. The river is the main source of freshwater and an important part of the economy through transportation and irrigation. Niger is a leading producer of uranium and is rich in many other minerals.

Environmental Highlights:

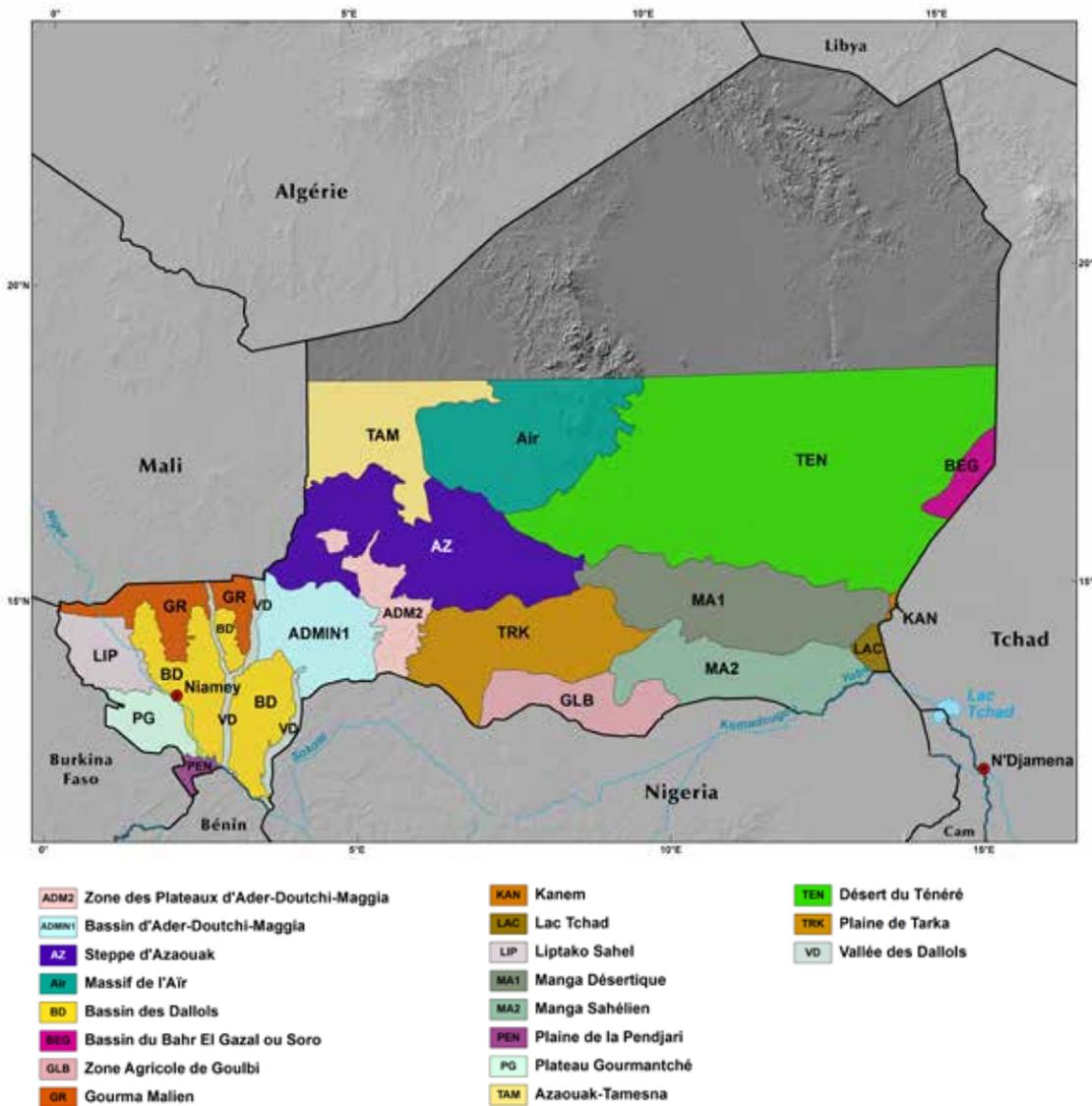
- Desertification
- Land degradation
- Re-greening of its agricultural lands
- Spectacular desert scenery



Timia, Air Mountains, Niger

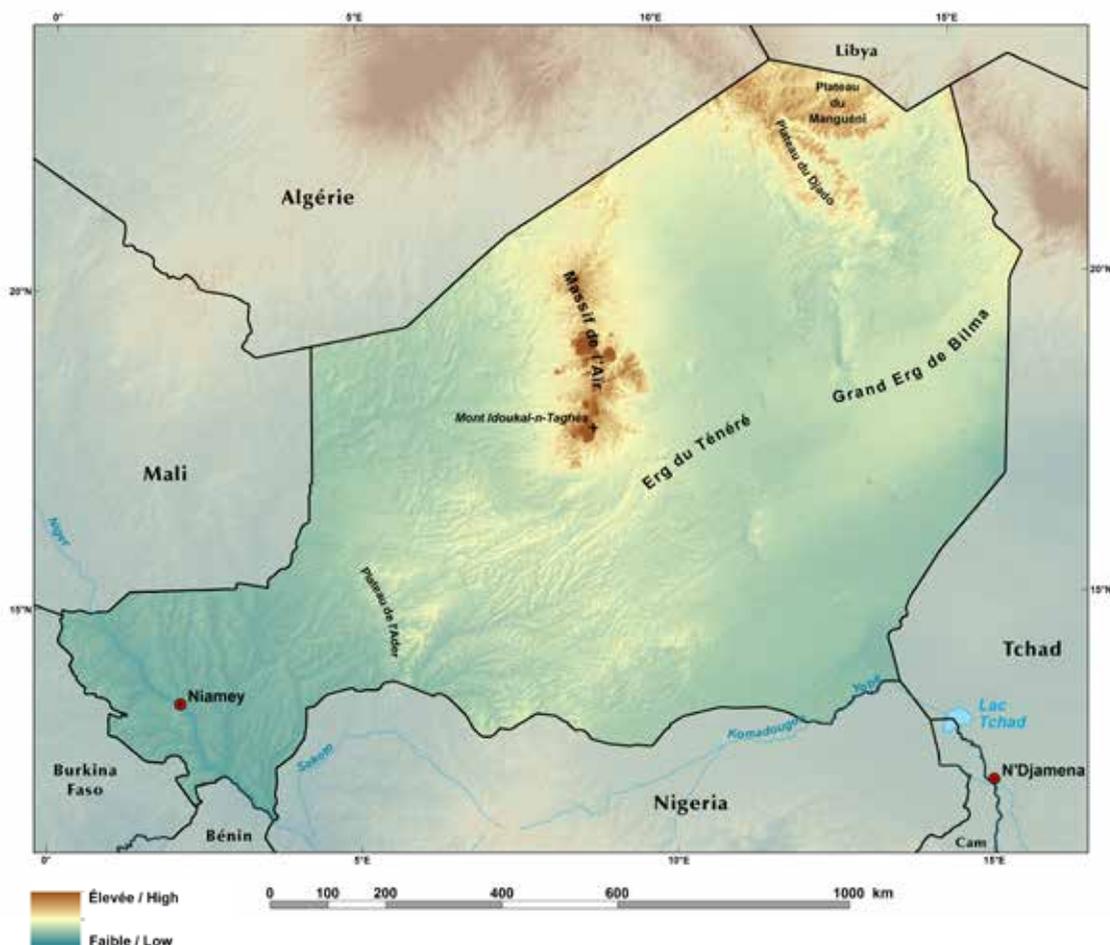
MICHEL KUPERS

Ecoregions



The Sahara Desert landscape, which covers about 65 percent of Niger, is made up of endless stretches of shifting sand dunes and broad gravel and stony plains. In years when the monsoon rains reach the southern Sahara, the wadis of the Aïr Massif and the plains of the Tamesna (TAM) are relatively more productive than the surrounding plateaus. To the south, the rest of the country is located within the Sahel, a transition zone between the desert and tropical West Africa. Across central Niger, from the Malian border to Chad, the pastoral zone of the Manga (MA1 and MA2) and Azouak (AZ) regions forms a wide strip of steppes and savannas. The Maradi-Zinder region (TRK and GLB) constitutes the largest agricultural region of Niger. In these ecoregions, the average bioproductivity gradually increases toward Niger's southern border, where farmers are conserving trees in their fields by encouraging natural regeneration. In western Niger, the productive ancient alluvial valleys of the Bassin des Dallols (BD) contrast with the less productive steppes and tiger bush of the surrounding plateaus and terraces.

Shaded Relief

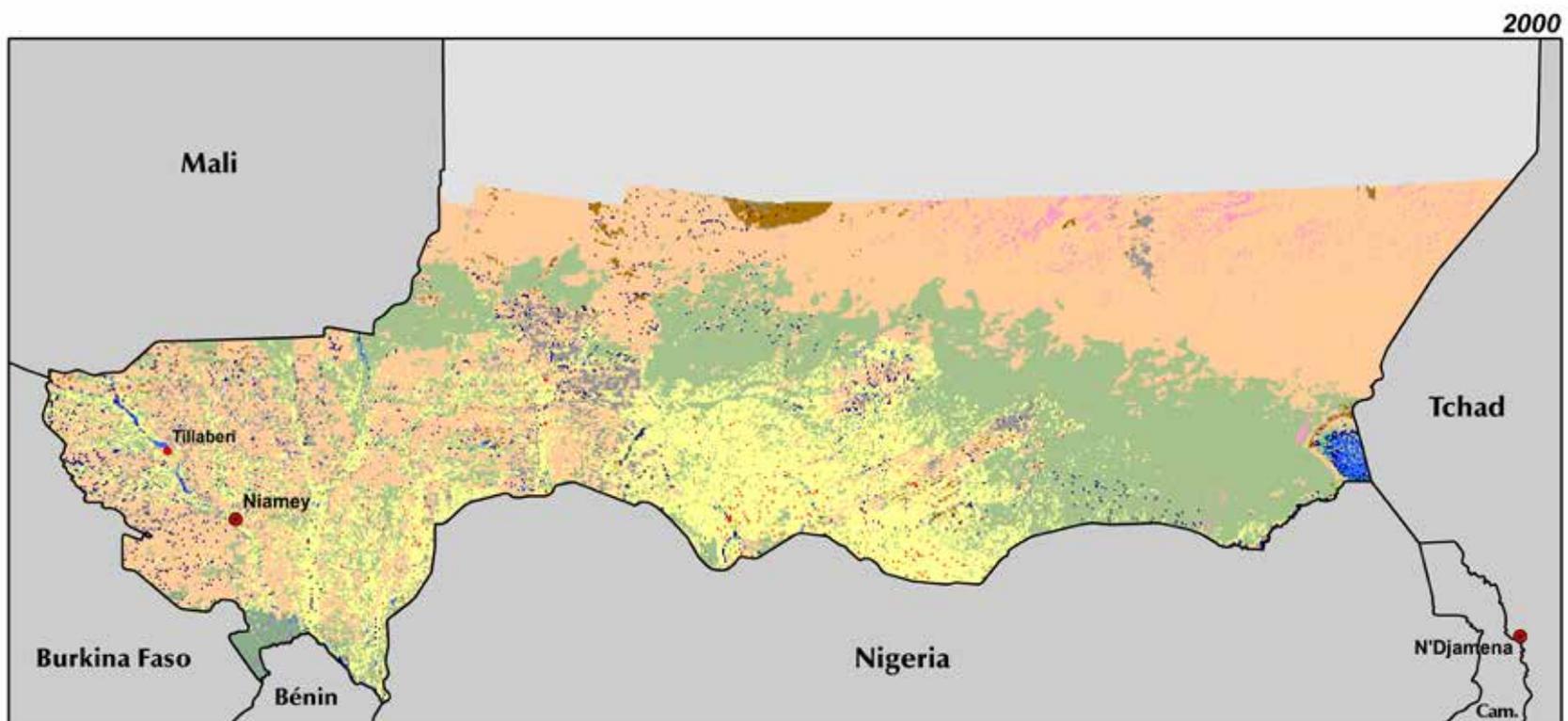
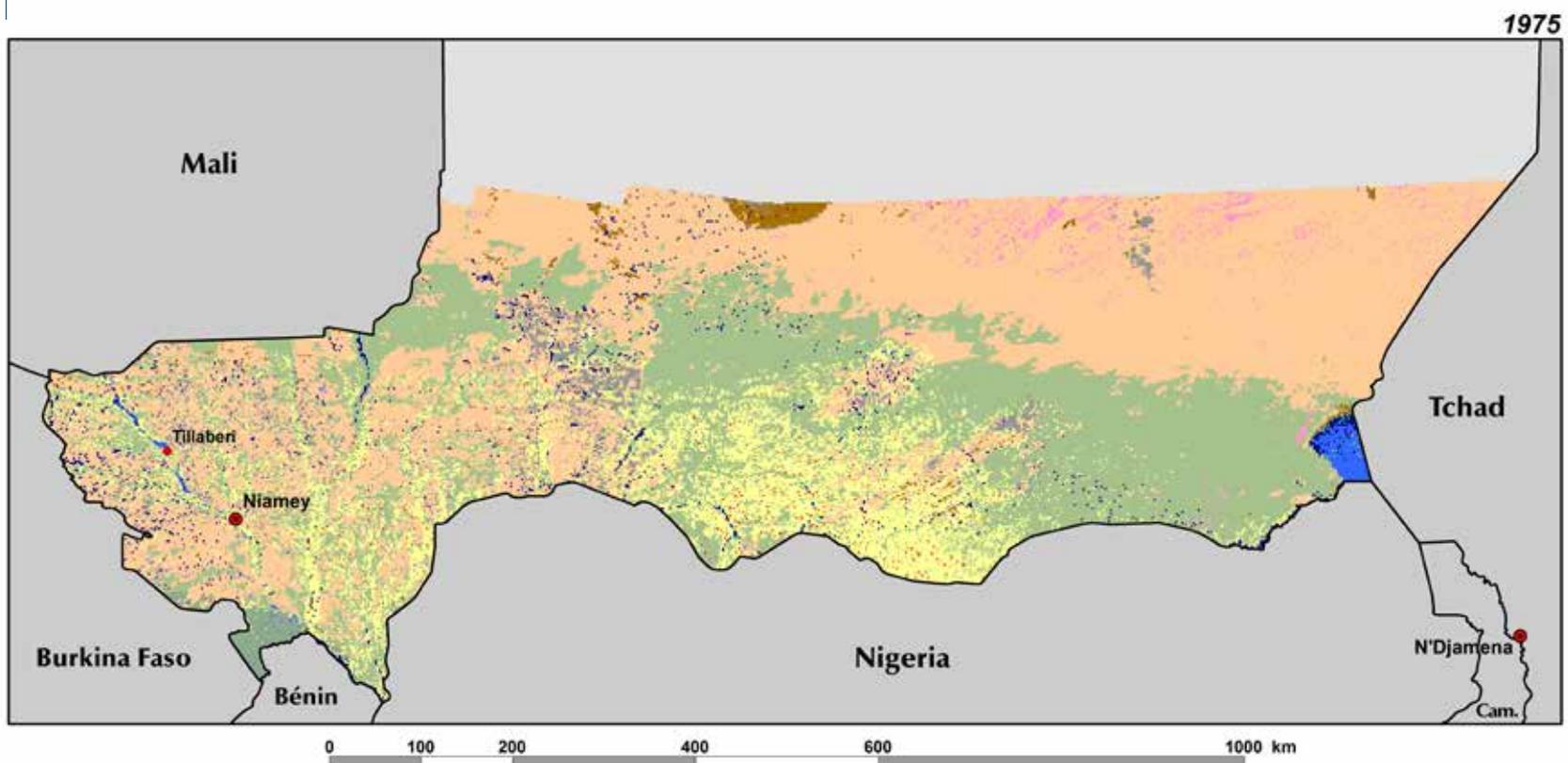


The sand-colored giraffes near Kouré, Niger are the last herd of these majestic animals in West Africa.

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

GRAY TAPPAN / USGS

Land Use, Land Cover and Trends



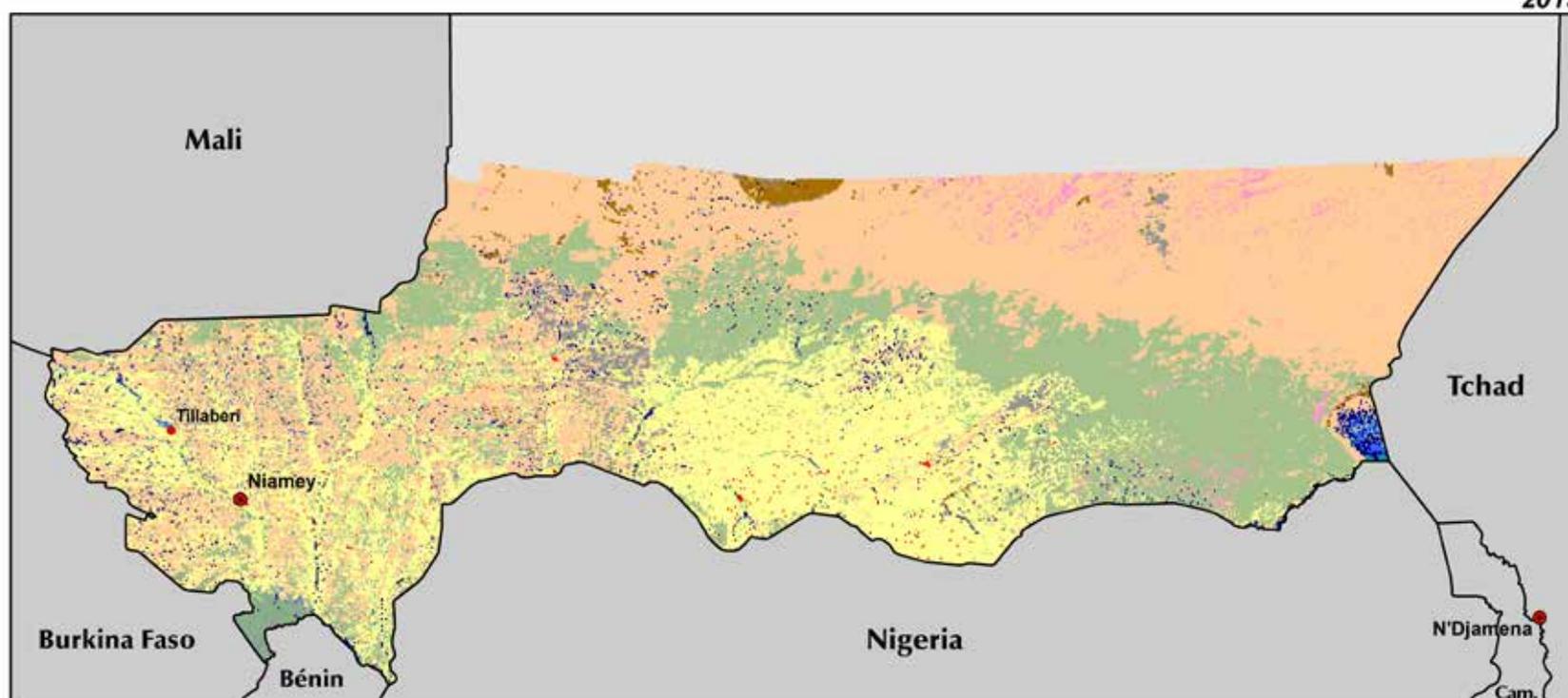
Because most of the northern part of Niger is covered by desert, only the southern half of the country was mapped in this atlas to analyze land cover and vegetation change.

● Capitale Nationale / National Capital

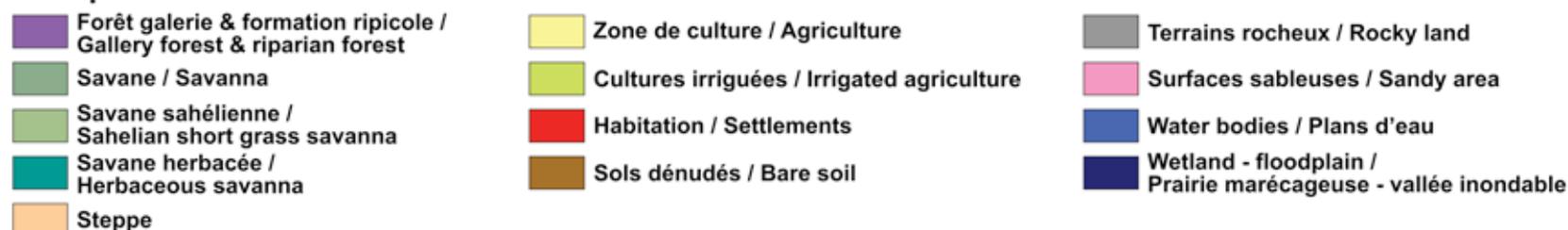
With an annual rate of 4.0 percent, Niger has one of the highest population growth rates in West Africa. Driven by the rapid population growth and the increasing demand for food, agricultural expansion is the most dramatic change in Niger's landscapes. Over the period 1975–2013, cultivated areas have increased from 12.6 percent in 1975 to 18.1 percent in 2000 and 24.5 percent in 2013. This represents a total increase of 94.2 percent. Agriculture expansion mostly occurred on the productive sandy soils of the valleys in the Tillabéri region, where cropland is now encroaching on traditional pastoral lands. On the surrounding plateaus and terraces of western Niger, a mosaic of steppe and short grass savanna dominates. The Zinder-Maradi region, already heavily cultivated in 1975, is now a wall-to-wall homogeneous agricultural landscape. However, agriculture is still expanding eastward on the remaining short grass Sahelian savannas

of the Manga regions. In addition, an increase of 50 percent in irrigated agriculture was observed along the Niger River.

Across the whole country, steppes remain the dominant land cover class and have remained more or less stable (about 45 percent of the mapped area). The more productive natural vegetation, however, suffered a sharp decline. The Sahelian short grass savanna (usually present on sandy soils) contracted in area by 26.7 percent from 1975 to 2013. Gallery forests, representing the most dense and biologically diverse vegetation in Niger, have also significantly declined. Their total area has always been low (about 470 sq km in 1975) but significantly decreased (66 percent) in the 38-year period. Indeed, these forests mainly occupy the narrow valleys which are now heavily cultivated.



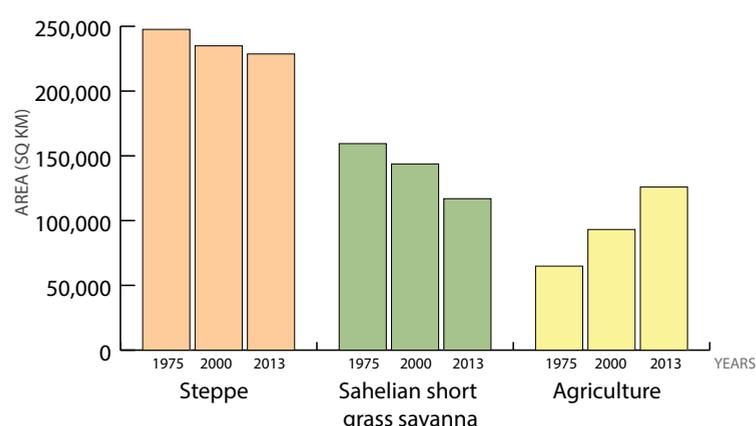
Occupation des Terres / Land Cover



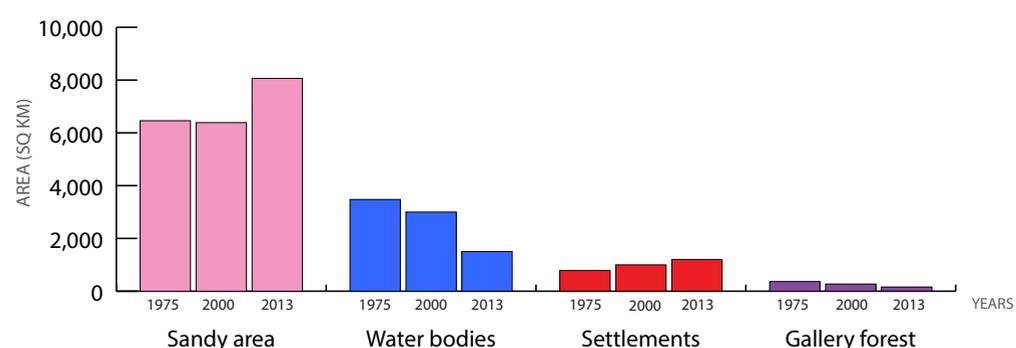
Sandy areas have increased by 24.8 percent since 1975. This trend is a concern because it indicates a decrease in soil stability and a loss of vegetation cover in some areas of Niger. Moreover, the trend appears to have become more acute since 2000. This change occurs mainly in the Manga pastoral ecoregions (MA1 and MA2) characterized by ancient sand dunes stabilized by the natural Sahelian short grass savanna. During the drought years of the 1970s and 1980s, many of these dunes became active when vegetation cover was lost. In addition, wind erosion, overgrazing on low vegetation, and loss of woody cover from drought and deforestation, often result in land degradation and enhance the process of desertification.

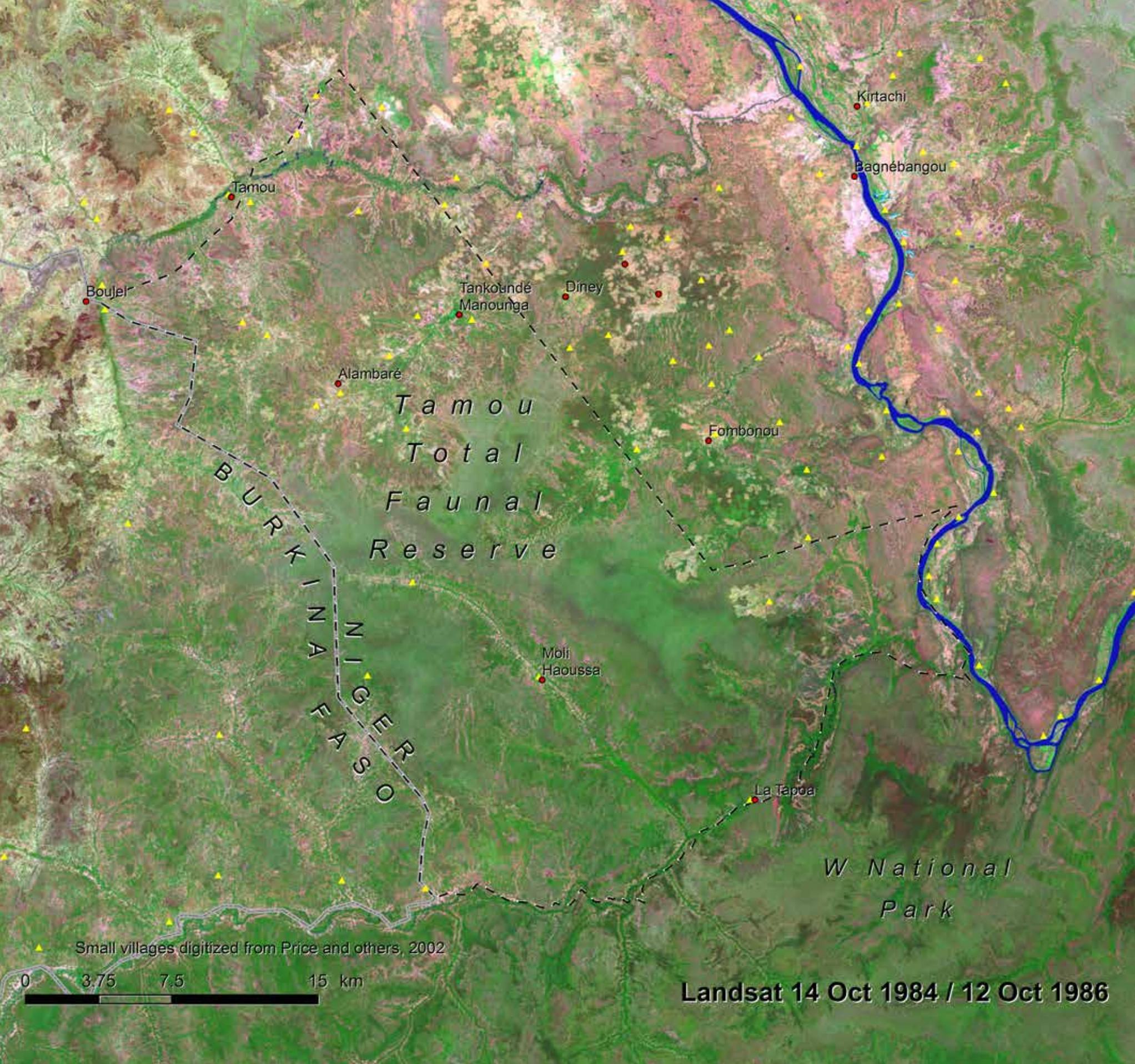
Mapping land use and land cover is an important part of the big picture of how land resources are changing. However, it characterizes an important dimension of land change that of land cover conversion from one type to another. Another type of change, often more subtle but equally important, is a change in the quality of the land cover, often called land cover modification. There are major examples of land cover modification in Niger. In the short grass savanna, there has been much loss of shrub and tree cover following drought periods and from cutting trees for firewood. On the positive side, Niger is the home of one of West Africa's most significant success stories—the re-greening of its agricultural lands by hundreds of thousands of farmers who have adopted an agroforestry practice that increases and maintains on-farm tree cover (see pages 70–71 and 162–163). This is a major development in land cover modification.

Large area classes



Small area classes

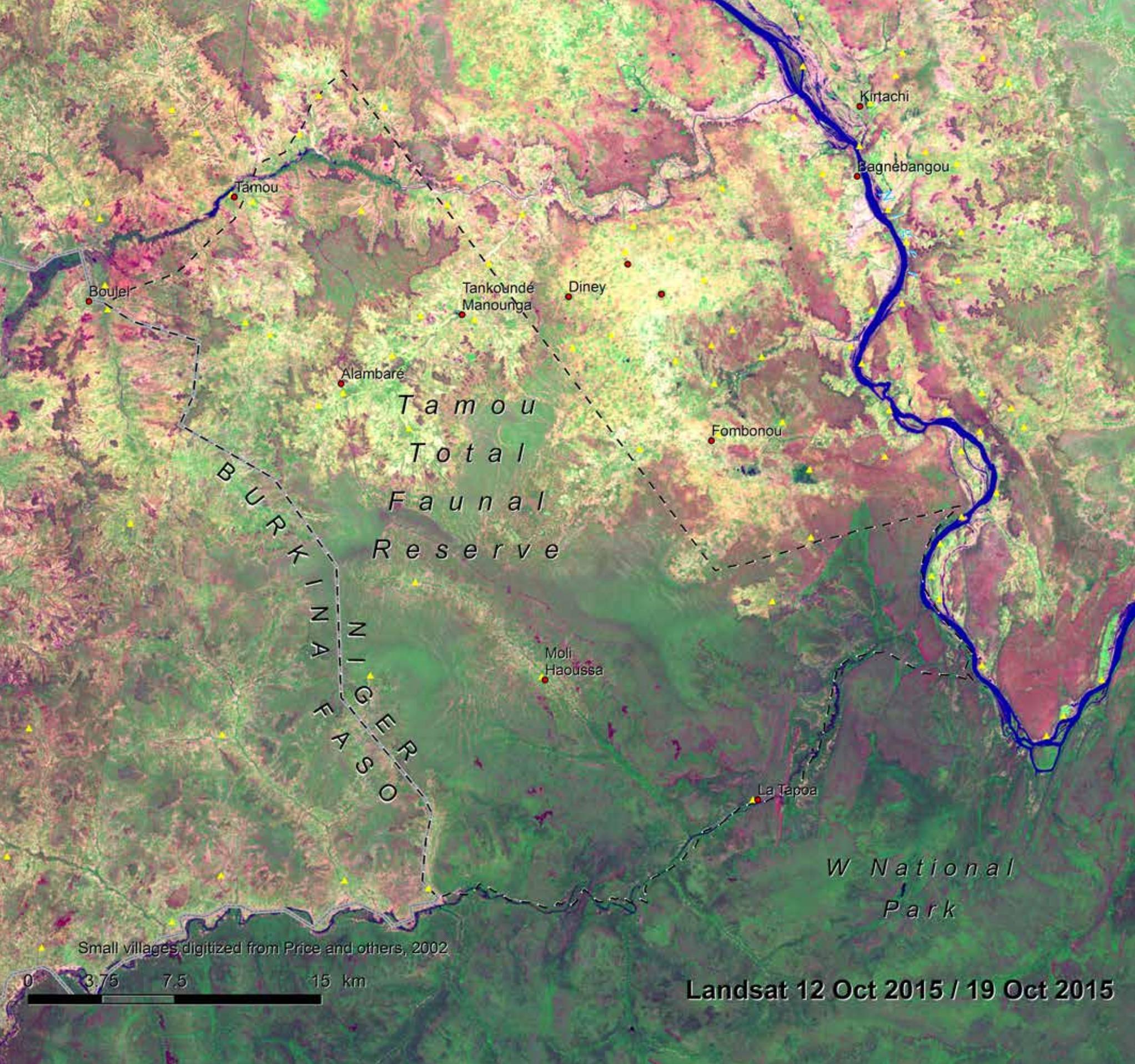




Food insecurity drives deforestation in the Tamou Total Faunal Reserve

The Tamou Total Faunal Reserve was created in 1962 to serve as a buffer zone for the W National Park of Niger and for the large transboundary W Regional Park. The reserve is located in the Rural Community of Tamou in Niger's southwestern corner. Initially covering 1,400 sq km (Bouamrane, 2006), the legal area of the reserve was reduced to only 760 sq km in 1976 when its eastern zone was decommissioned (Benoit, 1998). The Government of Niger decommissioned half of the reserve in response to food insecurity. This triggered a dramatic migration of people to this area along the Niger River floodplain where fertile soils and availability of water promised economic opportunity. Uncontrolled establishment of new villages and farms lead to the loss of large areas of relatively natural savanna habitat.

The W National Park and Tamou Reserve fall in the transition zone between savanna and woodlands in the Sudano-Saharan bioclimatic region. Tamou Reserve's natural habitat is made up primarily of shrub savanna and wooded

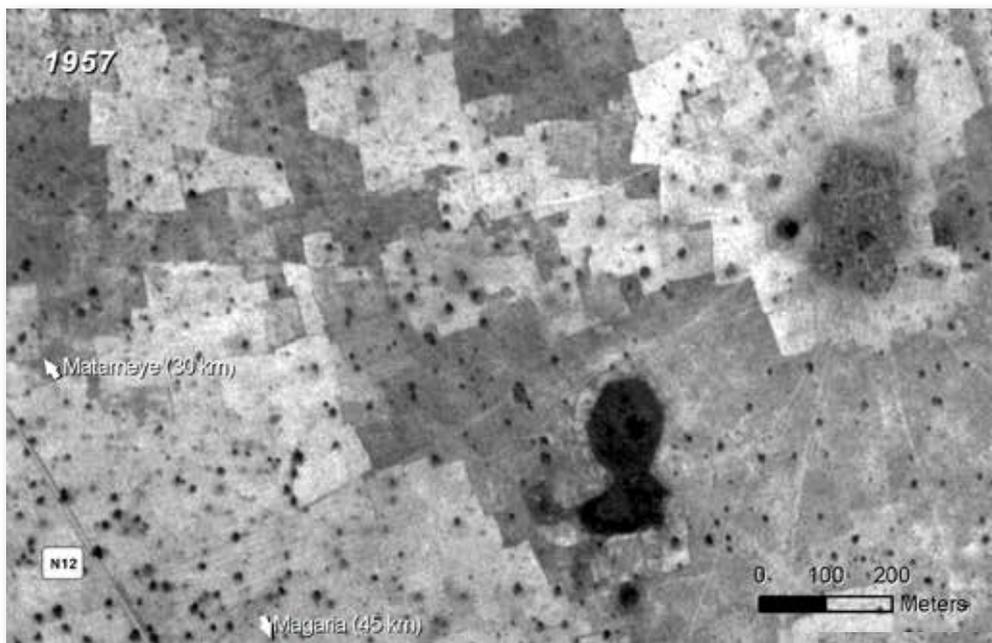


savanna with gallery forests running along the seasonal watercourses. The hundreds of native plant species in the two parks historically supported a range of fauna including elephants, lions, hippopotamuses, hyenas, cheetahs, warthogs, baboons, caracals, red and green monkeys, and a variety of avifauna (UICN/PACO, 2010). The natural flora and fauna are being lost as population pressure converts valuable habitat to farmland and villages.

The Landsat images show the expanding area of farm fields and villages between 1986 and 2015; most of this change followed the decommissioning of the reserve (Price and others, 2002). The changes are especially apparent

surrounding the named villages in the top center of the images. A study of pressure on the W Regional Park identified settlements surrounding the international park's perimeter (Price and others, 2002). The yellow triangles show the settlements they identified in the area around Tamou Reserve, most of them described as recent or new (as of 2002).

Despite the strong presence of rangers in the Tamou Reserve, who are there to enforce rules protecting the remaining reserve area, illegal activities persist, including clearing bush for new fields, poaching of both small and large game, illegal transhumance, felling of protected trees, and deliberate setting of fires.



CHRIS REU / WRI

Transforming farmlands through farmer-managed re-greening: The success story in southern Niger



A quiet but momentous agricultural and environmental transformation has been developing across southern Niger since the mid-1980s. As a result of an autochthonous process called farmer-managed natural regeneration (FMNR), farmers increased the number of on-farm trees in response to demographic and

resource-related constraints. Thus, they successfully restored degraded land and increased resilience in dryland areas.

The regions of Maradi and Zinder are located on the lowest part of the Niger Plateau in south-central Niger and cover about 105,000 sq km. Both areas are located within the Sahelian bioclimatic region, which typically receive between 200 and 600 mm of rainfall per year and have high temperatures. These regions have high population densities and “wall-to-wall” agriculture, where cultivated fields extend across virtually the entire landscape (Reij and Winterbottom, 2015).

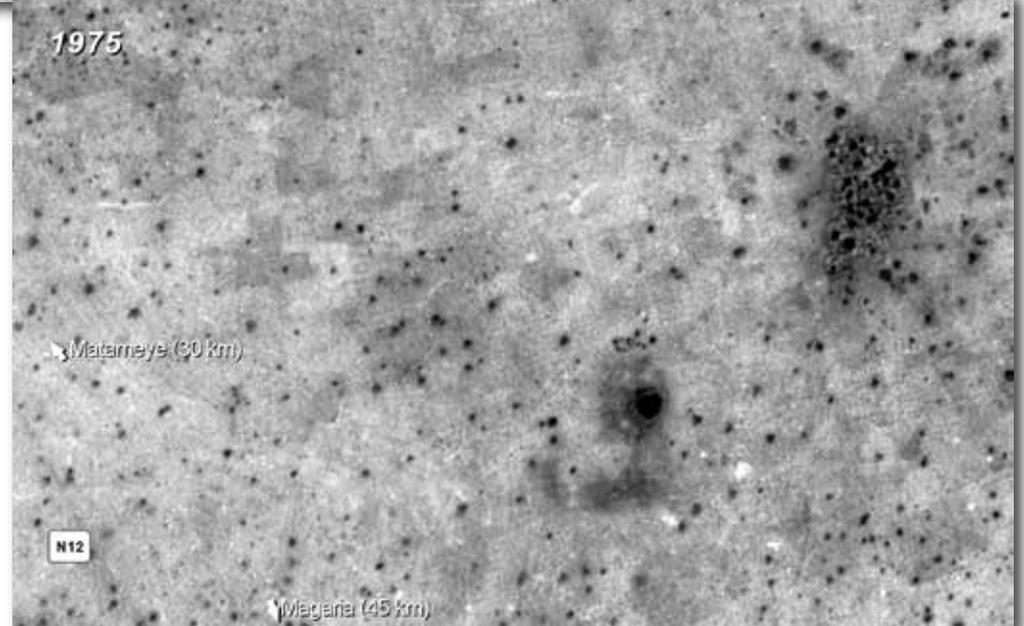
The second half of the 20th century witnessed a dramatic reduction in mean annual rainfall throughout the Sahelian region. According to a report by the Intergovernmental Panel on Climate change (IPCC), a rainfall decrease of 29–49 percent has been observed in the 1968–1997 period, compared to the 1931–1960 baseline period within the Sahel region (IPCC,

2001). Farmers faced significant tree losses in the 1970s and 1980s, as a result of drought, the expansion of cropland, and human pressures (Reij and others, 2009). Because few trees remained on the fields, farmers often witnessed their newly planted crops being destroyed by wind erosion. These environmental and economic crises induced farmers to invest in trees to fight desertification (Reij and Winterbottom, 2015). In the early 1980s, farmers in southern Niger started experimenting with a process known as farmer-managed natural regeneration (FMNR)—a low-cost way of encouraging the natural and spontaneous growth of trees and shrubs that provide useful food, fuel, and fodder (Reij and others, 2009). This practice spread from farmer to farmer, and currently about 3 million hectares (or 30,000 sq km) of land have been improved across the Maradi and Zinder regions.



The “magic tree,” *Faidherbia albida*

GRAY TAPPAN / USGS

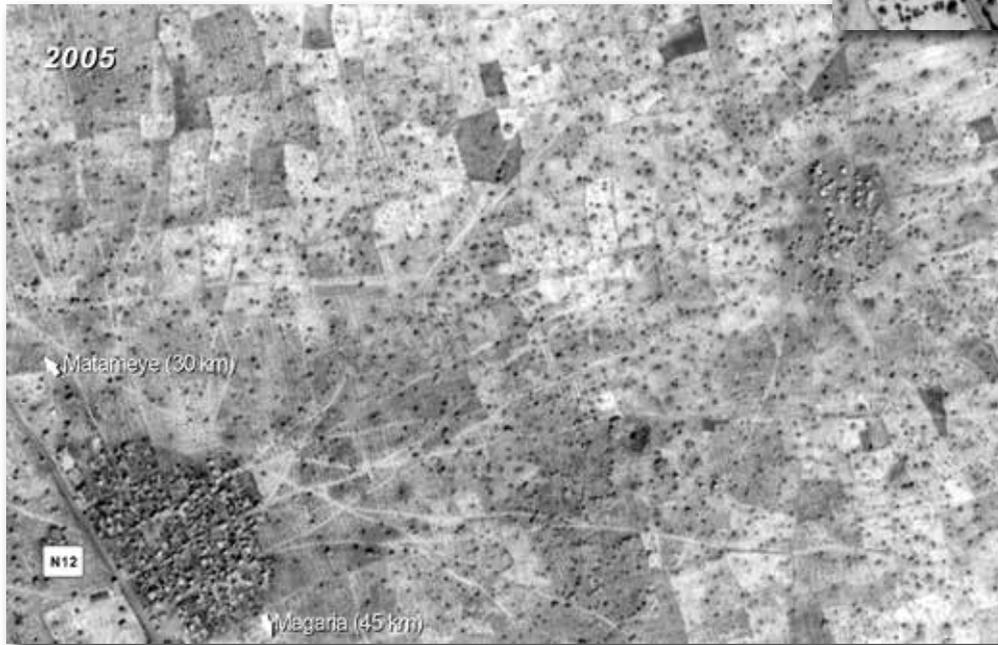
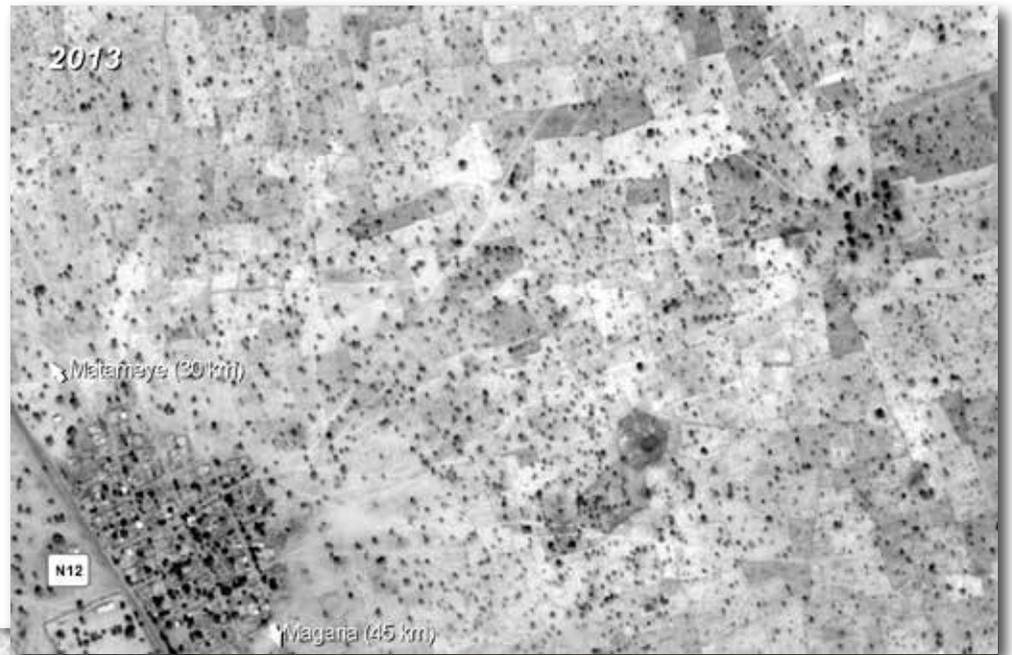
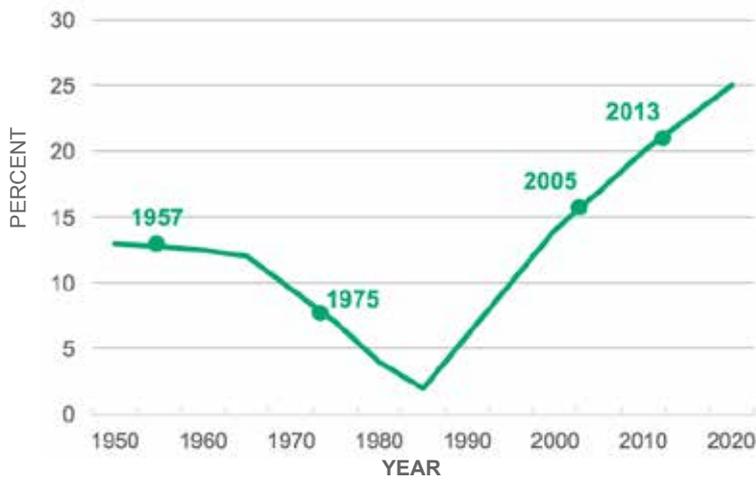


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The high-resolution images present a time-series view of an agricultural landscape typical of the heavily settled plains south of Zinder, in 1957, 1975, 2005, and 2014. It highlights the increase in on-farm tree density between 1957 and 2014 (on-farm trees are seen as black spots on the images). The low on-farm tree densities in 1957 reflected colonial agricultural development policies. In those days, a farmer was perceived to be modern if he farmed his crop as a monoculture and had removed most on-farm trees to facilitate ploughing the land. Extensive areas of grassy fallow can be seen in the 1957 photograph — a practice that has almost disappeared. In 1975, the number of on-farm trees approached its lowest point. After

Evolution of tree density in south-central Niger since 1950

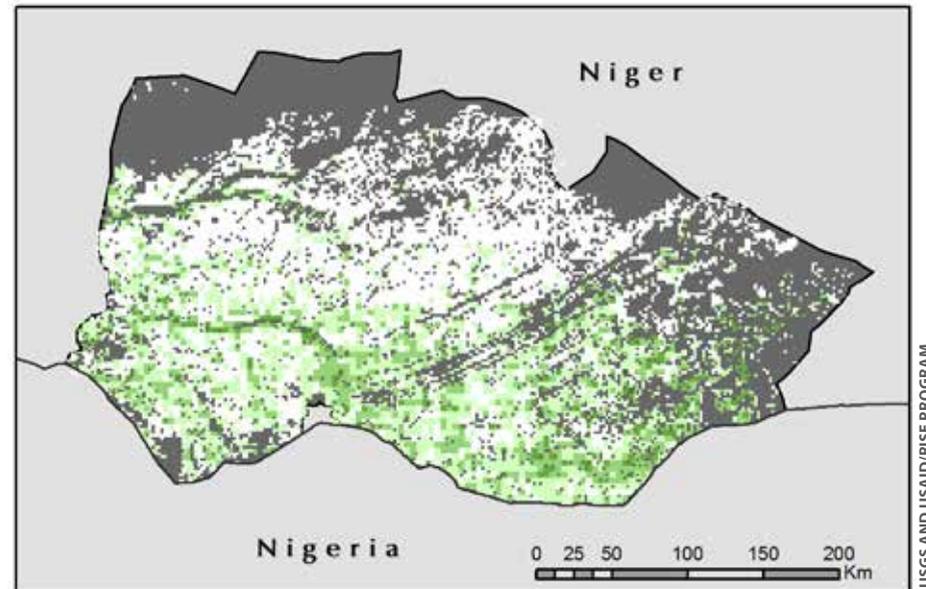


Aerial view of FMNR around a village in south-central Niger

the mid-1980s, tree densities steadily increased as farmer perceptions about tree ownership changed. By 2005, satellite images confirmed that a vast transformation was taking place. There were more villages, more people, but also many more trees (Reij and Winterbottom, 2015). This renewed resource generates a range of benefits for the population. Trees reduce wind speed and evaporation, produce at least a six-month supply of fodder for livestock, and provide firewood, fruit, and medicinal products that farm households can consume or sell. Moreover, certain tree species, such as the winterthorn acacia (*Faidherbia albida*), enhance fertility by adding nitrogen to the soil (Reij and others, 2009).

In the 1970s, it seemed as if Niger would be blown from the map. Drought and strong Harmattan winds from the desert created a general feeling of despair among the rural development community. No one could have imagined that farmers in densely populated parts of Niger would significantly increase on-farm tree densities with minimal external support. Today, the agricultural landscapes of southern Niger have considerably more tree cover than they did 30 years ago. These findings suggest a human and environmental success story at a scale not seen anywhere else in Africa.

On-farm tree cover density in south-central Niger



On-farm tree cover / Couvert arboré des terres agricoles

- Non farmland / Terres non-agricoles
- No tree cover / Pas d'arbres
- Open with isolated trees / Ouvert avec quelques arbres isolés (0-2%)
- Low density tree cover / Couvert arboré faible (2-5%)
- Medium density tree cover / Couvert arboré moyen (5-15%)
- High density tree cover / Couvert arboré élevé (15-25%)
- Very high density tree cover / Couvert arboré très élevé (>25%)

Patterns and extent of on-farm tree cover across the Maradi-Zinder agricultural region in 2013. This phenomenon is also visible in other regions (locally present in Tahoua and Dosso regions and in the northern part of the Tillabéri Region). Many of the trees are young, the hallmark of a recent and rapidly developing agricultural parkland still increasing in density and cover.