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.

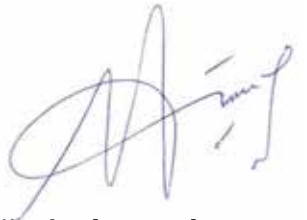
The West Africa Land Use Dynamics (LULC) Project is emblematic of this cooperation. Initiated in 1999, the LULC project has had several phases including training national experts to extract pertinent information from satellite images to characterize vegetation cover and producing tools and supporting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

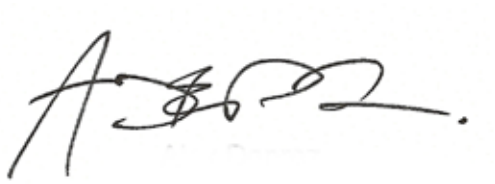
Rapid changes are occurring across West Africa's natural and human landscapes and balancing the need to preserve natural ecosystems with the need to grow more food, together with ensuring resilience in the same ecosystems, is a challenge. USAID West Africa's (USAID/WA) Environmental Threats and Opportunity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

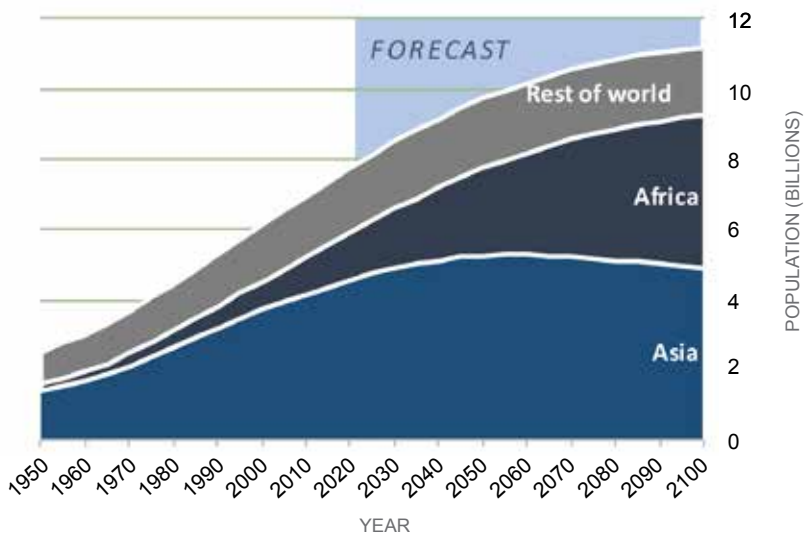
When humankind appeared on Earth around 200,000 years ago the influence of human activity on the environment must have been small and localized. The influence of scattered small groups of people on the global ecosystem would have been overwhelmed by the forces of natural systems (Steffen and others,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

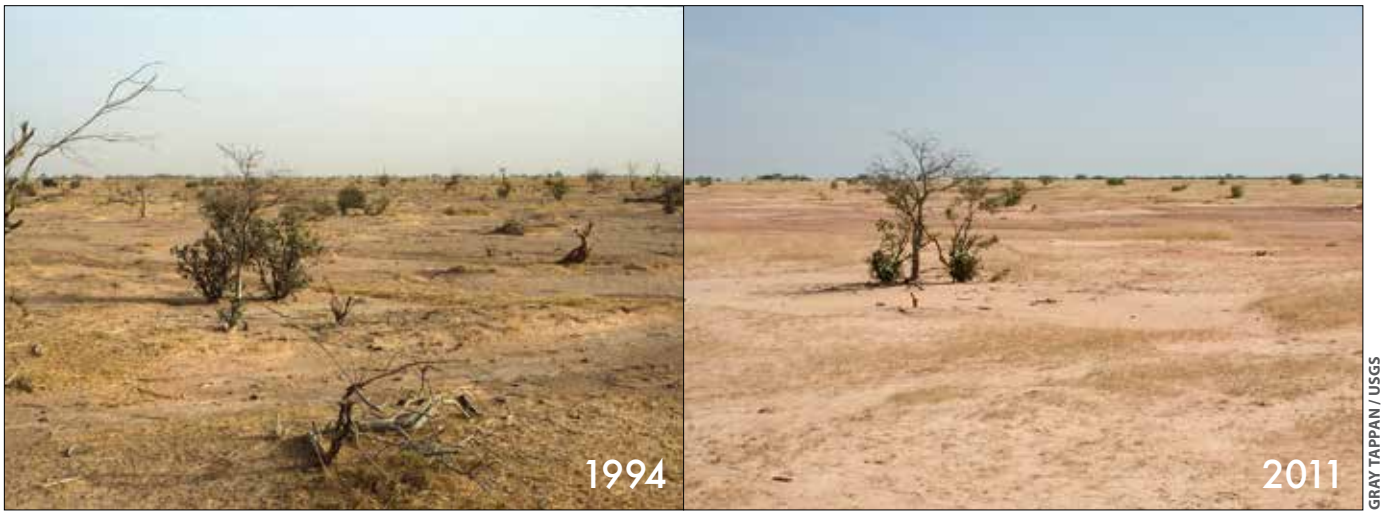
Wooded landscape fragmented by agriculture expansion in western Burkina Faso

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.

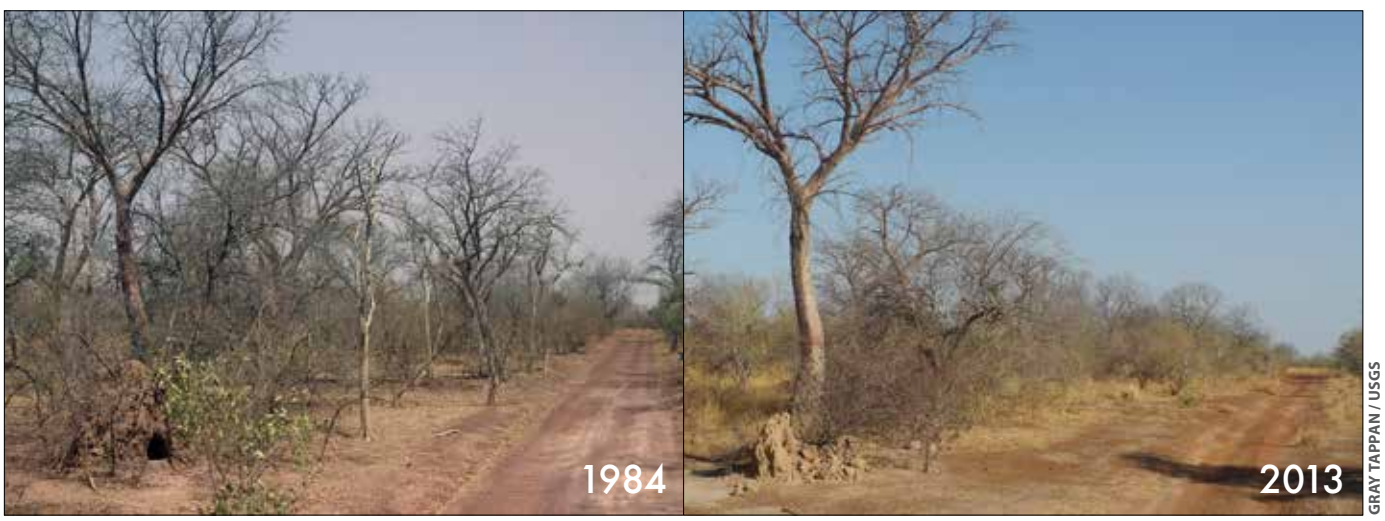
Conversion of the natural landscapes of West Africa to agriculture greatly reduces the natural biodiversity, and exposes the soil to wind and water erosion. The savanna, woodland, forest, and wetland ecosystems that are lost have some relatively tangible impacts such as the loss of natural ecosystem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

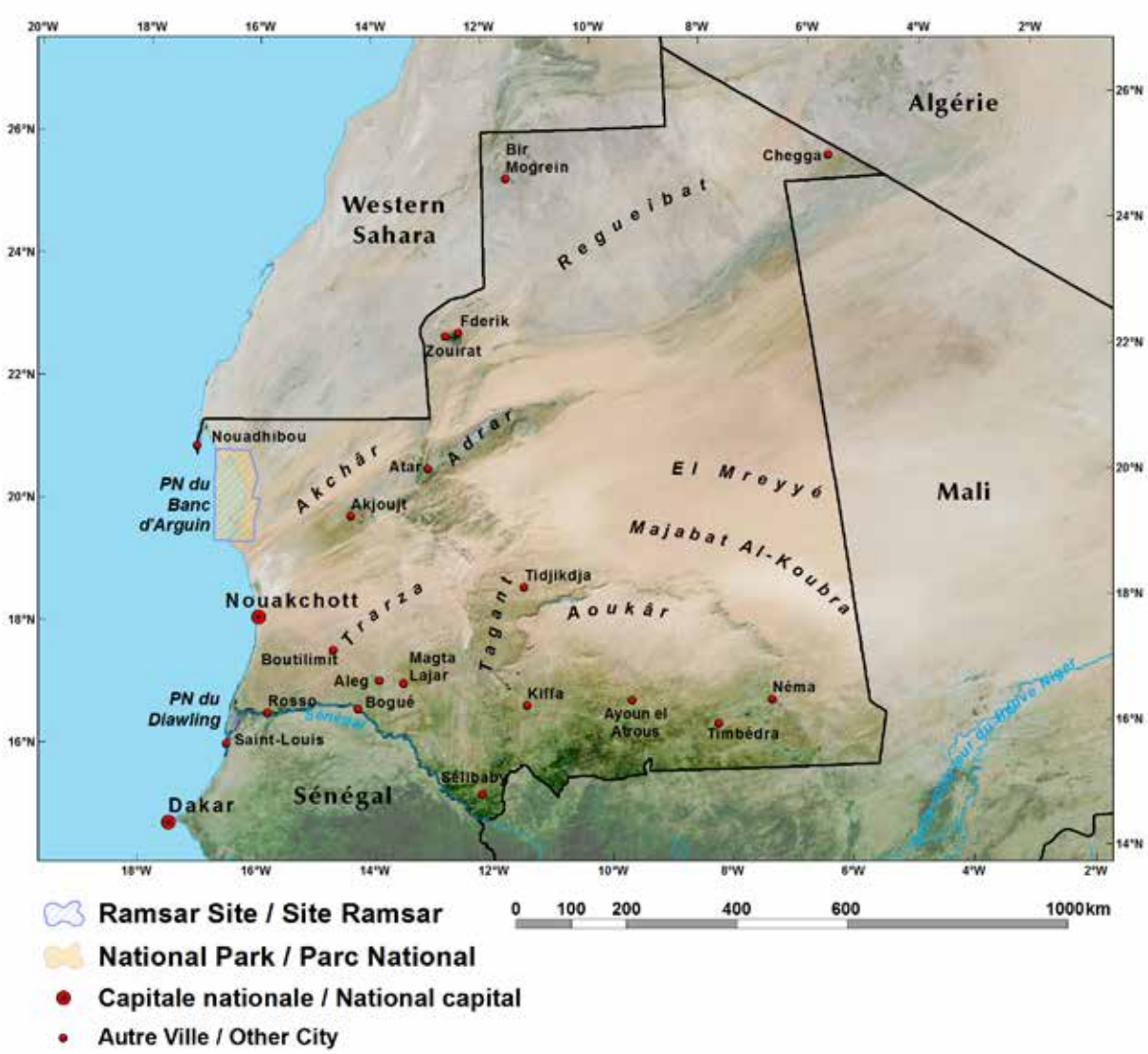
Country Profiles, Land Use and Land Cover, and Trends

Islamic Republic of

Mauritania

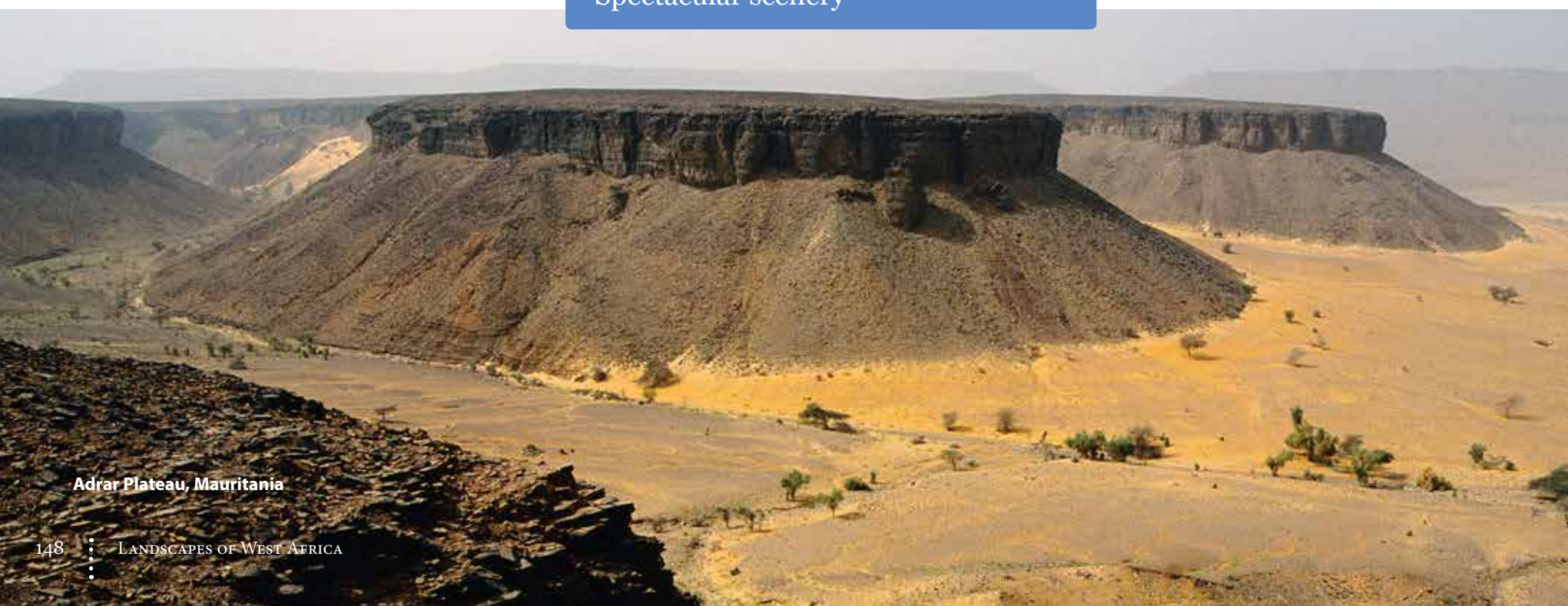
Total Surface Area: 1,030,000 km²
Estimated Population in 2013: 3,873,000

Mauritania is situated at the crossroads of the Maghreb region and sub-Saharan Africa. With roughly four-fifths of its land area within the Sahara Desert (less than 200 mm mean annual rainfall), the population of this vast and sparsely populated country is mostly concentrated in the slightly less arid south, as well as in the Atlantic port cities of Nouakchott and Nouadhibou. Mauritania's historically nomadic population has seen a trend toward sedentarization and urbanization since independence in 1960, especially in response to increasingly dry climatic conditions. Mauritania is susceptible to periodic droughts and hot, dry dust- and sand-laden Harmattan winds, which threaten the small fraction of its land surface that is arable. Some irrigation potential has been developed in the Senegal River basin to increase food security in the face of vulnerability to drought. The country's wealth lies in its extensive mineral deposits and rich fishing grounds in the Atlantic Ocean. Key biological resources include extensive seasonal wetlands in the southeast of Mauritania as well as coastal wetlands on the Atlantic shore. These wetlands stand out as hotspots of biodiversity against the vast stretch of sand dunes and rock formations of the Sahara and the sparsely vegetated Sahel zone, where freshwater is scarce. They constitute critically important breeding, transit and wintering grounds for millions of migratory birds.



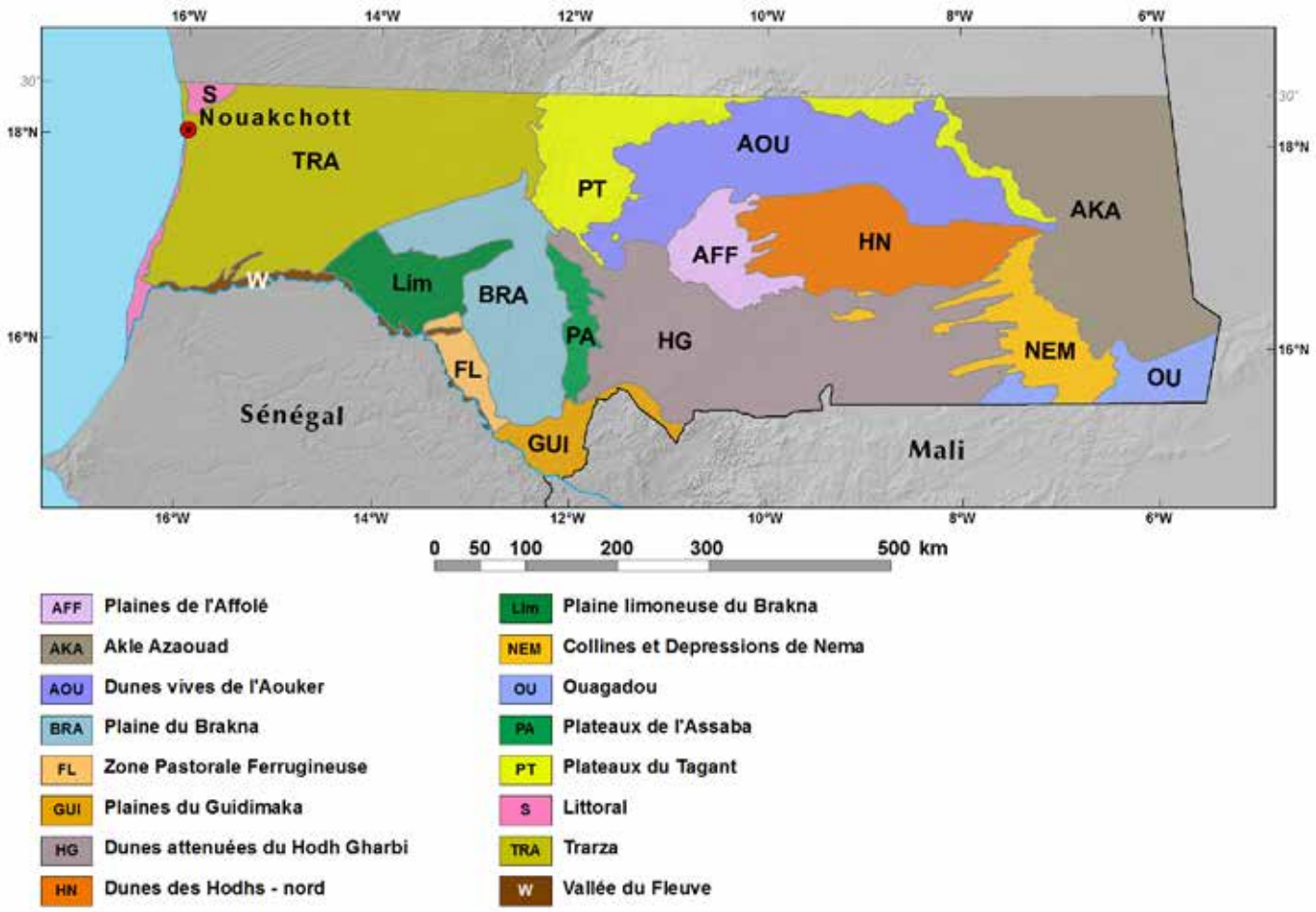
Environmental Highlights:

- Soil erosion
- Desertification
- Scarcity of freshwater resources
- Marine fishery resources
- Spectacular scenery

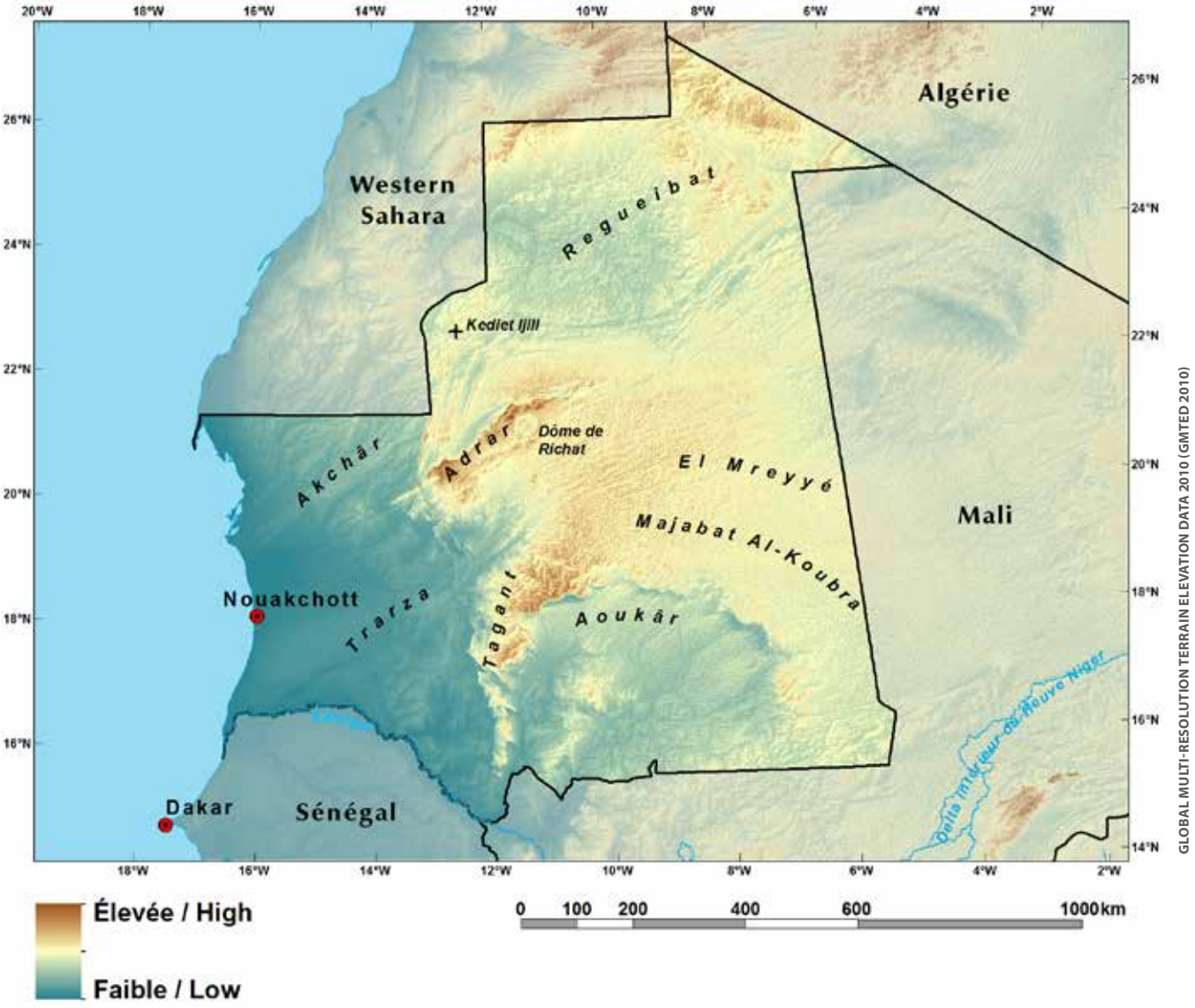


Adrar Plateau, Mauritania

Ecoregions



Shaded Relief

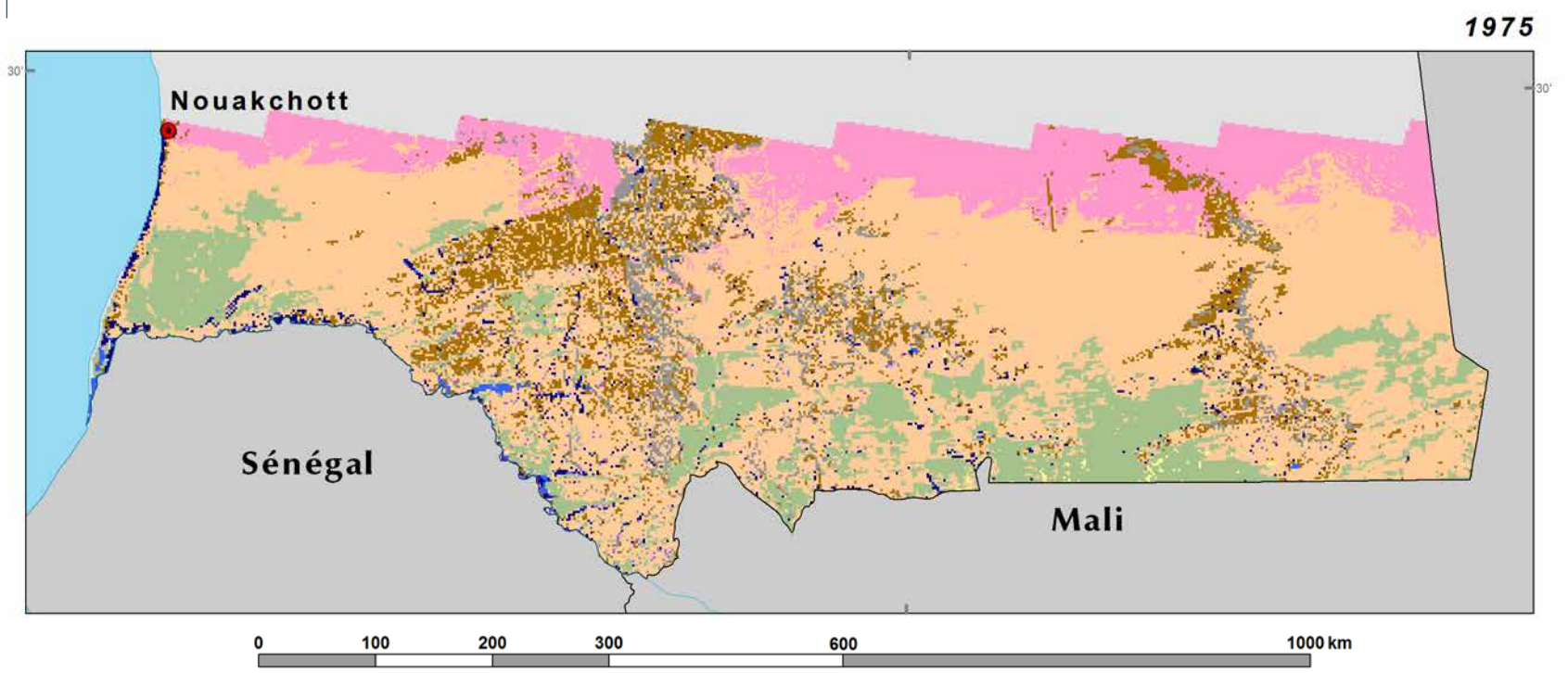


GLOBAL MULTI-RESOLUTION TERRAIN ELEVATION DATA 2010 (GMTED 2010)

Mauritania is a generally flat country, with vast arid plains interrupted by impressive rocky plateaus and escarpments. These give rise to some of the most spectacular scenery found anywhere in both the Sahel and the Sahara. In the west, the extensive Trarza (TRA) is a plain mostly covered by old, longitudinal dunes that are stabilized by Sahelian short grass savanna and steppe. To the south, the plain is interrupted by the Senegal River Valley, with its unique *Acacia nilotica* forests. To the east, the broad plains are flanked by the Plateau du Tagant (PT) and Plateau de l'Assaba (PA), both rugged sandstone plateaus, with deep canyons and occasional springs that feed oasis settlements. East of the high plateaus, vast sandy plains with undulating sand dunes stretch nearly 500 km to the escarpment at Néma. Here lie the regions of the Hodhs — the North Hodh (HN) with increasingly mobile sand dunes, and the Hodh Gharbi (HG) to the south with ancient stabilized dunes that support extensive rangelands and relatively productive ferruginous soils with agricultural potential.

MICHIEL KUPERS

PHOTO (OPPOSITE PAGE): MICHIEL KUPERS

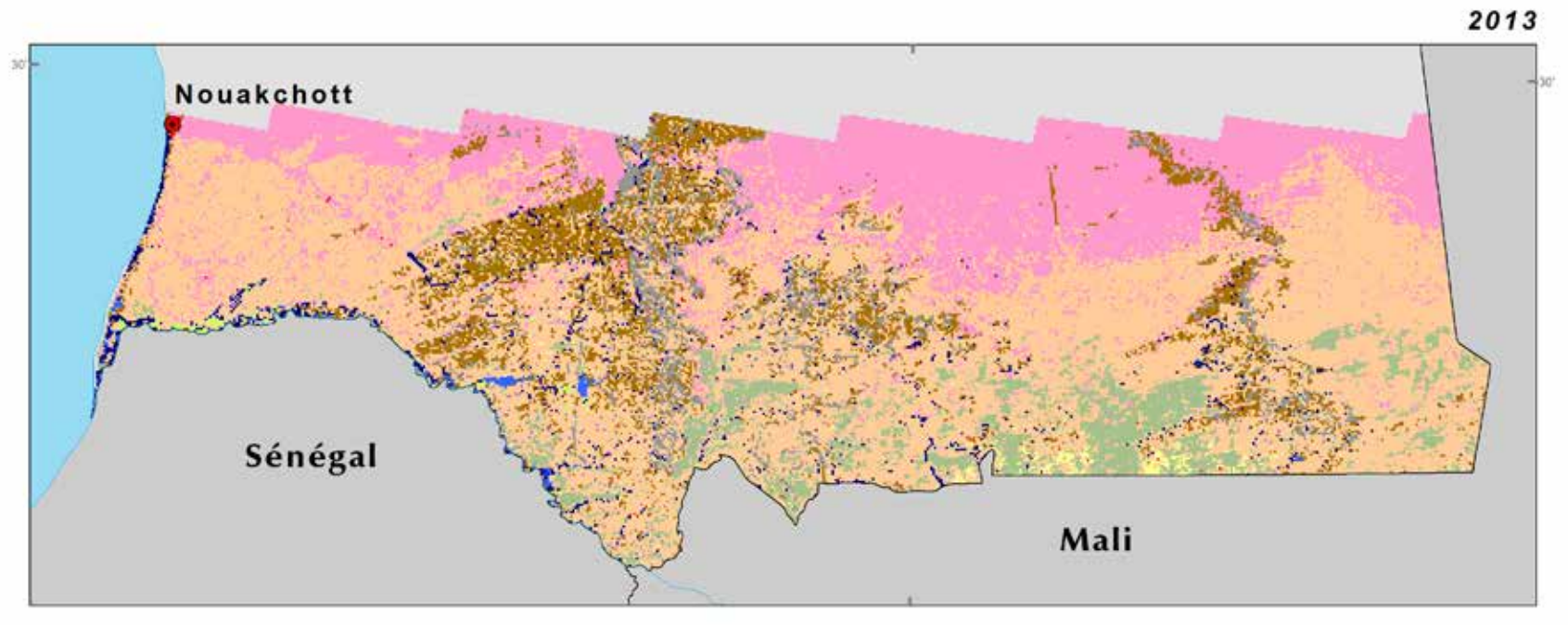


Large areas of northern Mauritania are occupied by mainly nonvegetated arid land cover types which are quite stable over time. For this reason, only the southern part of the country (south of approximately 18 degrees north latitude) was mapped.

Steppe is the dominant land cover type in southern Mauritania, occupying more than 50 percent of the mapped area. The second most common are sandy areas, which made up almost 25 percent of the mapped area in 2013, and, in descending order, bare soil, Sahelian short grass savanna, rocky land, and wetland and floodplain, all of which occupy between 1 percent and 10 percent of the mapped area. Less than 1 percent is mapped as agricultural land. This makes Mauritania the least cultivated country of the 17 West African countries. Likewise, other "bioproductive" land cover types — forest, gallery forest and swamp forest — make up only tiny fractions of the land area. Although these bioproductive land cover types are small in area, their importance in both ecological and economic terms is large.

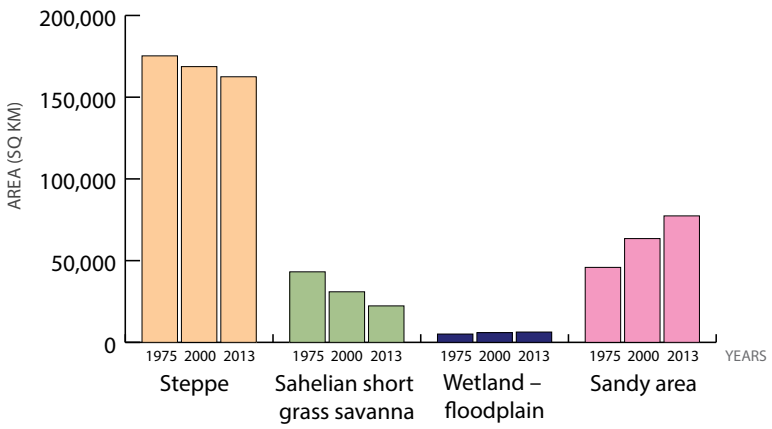
The overall rate of change in land use and land cover has accelerated from 0.4 percent per year between 1975 and 2000 to 0.7 percent per year between 2000 and 2013. Compared to the annual rates of change for the entire region of West Africa — 0.6 percent and above 1 percent, respectively — the land cover in Mauritania has changed relatively slowly. Lower rural population densities in Mauritania compared to the average in the region might offer one explanation for the relatively slower conversion of land use and land cover.

Over both time periods, the two most widespread natural vegetation cover types and important pasture grounds, steppe and Sahelian short grass savanna, were affected by the largest losses in terms of area. Almost 19,000 sq km of steppe were lost between 1975 and 2000, and over 15,000 sq km between 2000 and 2013. For Sahelian short grass savanna, these figures amount to over 12,000 sq km from 1975 to 2000 and almost 11,000 sq km from 2000 to 2013. Steppe has given way to large swaths of sandy areas — an expression of the classic picture of desertification, where productive and stabilizing vegetation cover is lost and sandy substrate mobilized, giving the impression of an encroaching desert. Sahelian short grass savanna, on the other hand, has largely been replaced by steppe, and to a much lesser extent by sandy area. These changes point to a progressive aridification and subsequent southward shift of the major vegetation cover types in southern Mauritania.

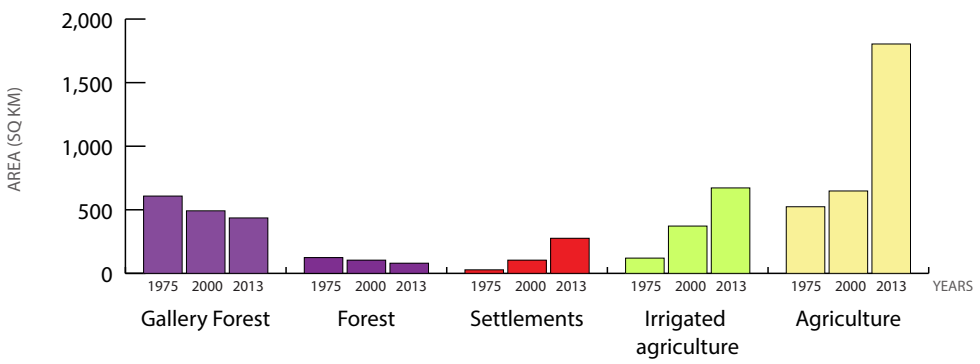


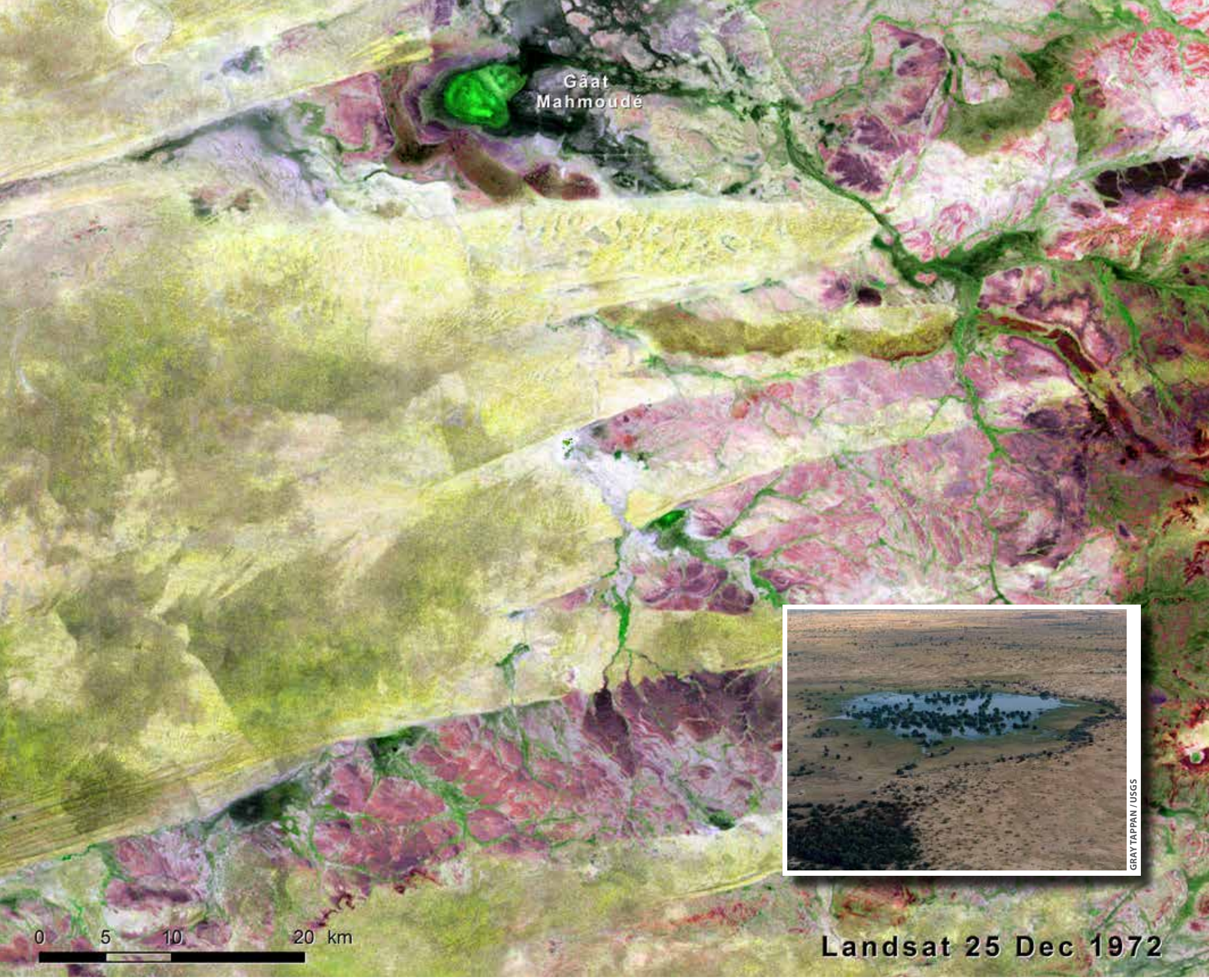
In addition to those changes of large geographic extent, some changes smaller in area are nonetheless significant due to their very high change rates. These include settlements, the area of which increased by a factor of ten between 1975 and 2013, as well as agriculture. The area of rainfed agriculture more than tripled, whereas irrigated agriculture increased almost six-fold over the same time period. The rate of agriculture expansion dramatically increased between 2000 and 2013, reaching an average of 89 sq km of additional cropland each year. In contrast, the already small but ecologically important areas covered by forest and gallery forest have been reduced by 44 percent and 30 percent, respectively, due to drought and agricultural pressure. Mauritania's forests are all located in the Senegal River Valley, whereas the remaining gallery forests are also found along some of the permanent and ephemeral tributaries to the Senegal River, such as the Gorgol, with very few occurring along the wetlands of southeastern Mauritania. The disappearance of forests is concerning, because they constitute hotspots of biodiversity in this predominantly arid country and offer important habitat for wildlife, including migratory birds, as well as repositories of medicinal plants. By contrast, another land cover type of high significance for biodiversity, the wetlands, has been remarkably stable over this almost 40-year period.

Large area classes



Small area classes



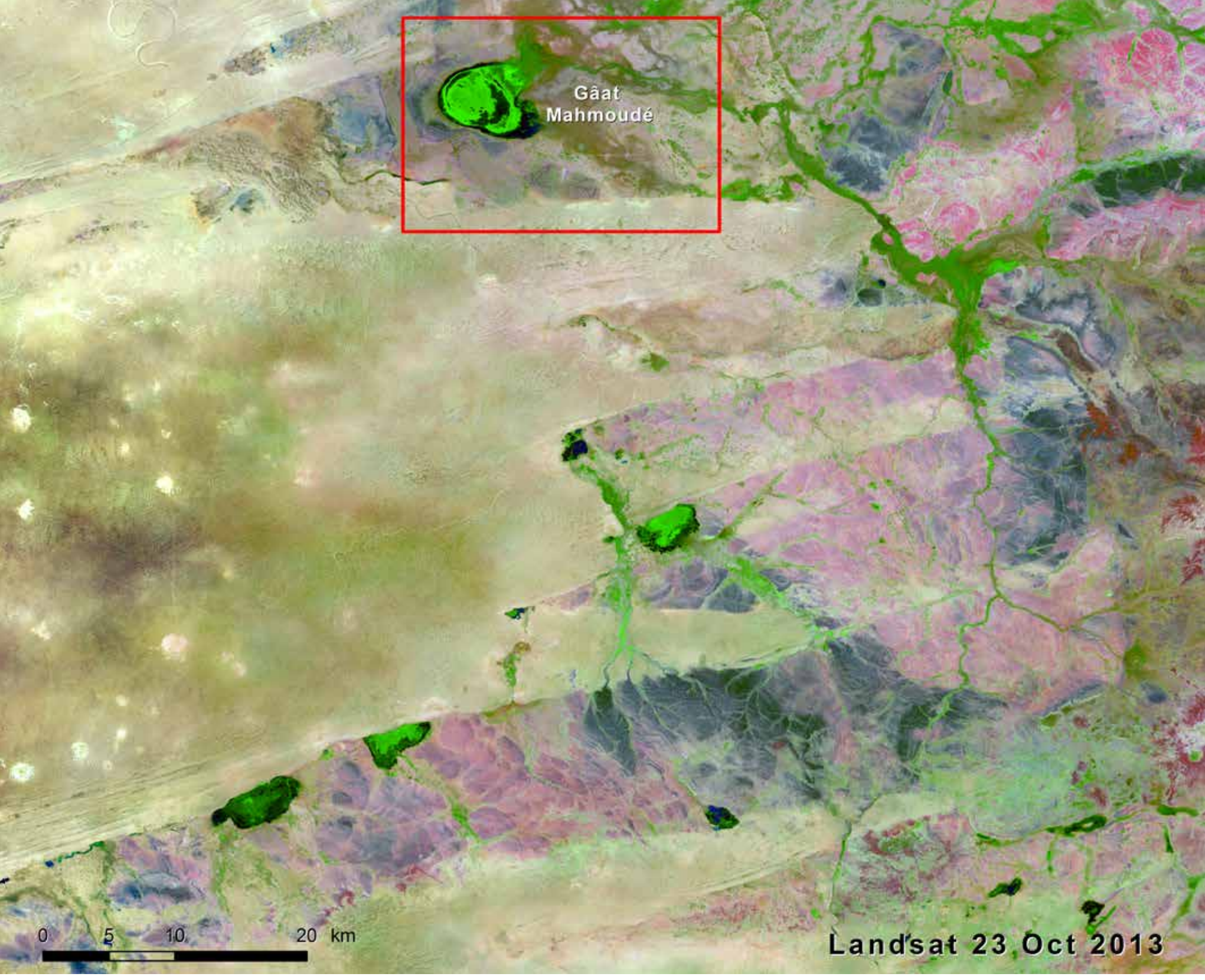


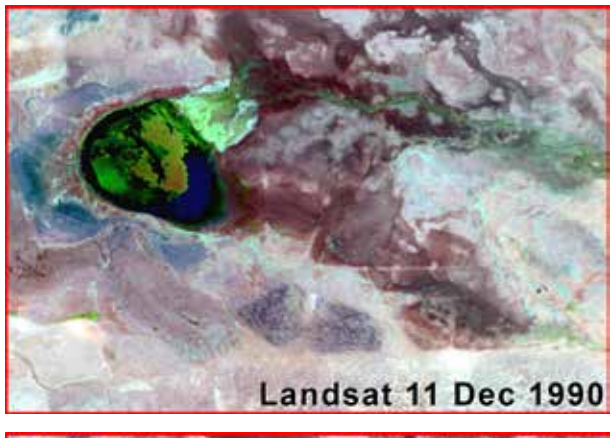
GRAY TAPPAN / USGS

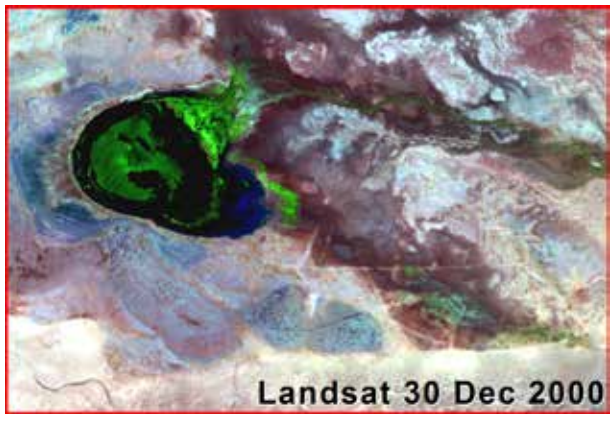
Dynamics of ephemeral wetlands in eastern Mauritania

In the arid northern Sahel, where people, plants, and animals all live on the edge of what is ecologically sustainable, wetlands stand out from their surroundings by the rich and diverse flora and fauna they support. As islands of resources, the ephemeral wetlands of eastern Mauritania fulfill key ecological and economic functions. However, because rainfall varies so much in eastern Mauritania, the water levels and vegetation in ephemeral wetlands fluctuate from year to year, and can even change significantly within a single year.

Landsat images of the Department of Néma in eastern Mauritania from 1972 and 2013 show many wetlands that occupy channels and depressions. These wetlands stand out in imagery from the nearby strips of sandy and bare soils. In the middle of the sandy zones covered by Sahelian short grass savanna, localized eroded areas around boreholes and villages appear as bright aureoles — they are especially visible on the 2013 image. Using local terms, Mauritanian wetlands include tamourts (forested closed basins), gâats (herbaceous closed basins or flats) and oueds (seasonal watercourses). Tamourts are contained in deep depressions, characterized by stands of *Acacia nilotica*, and have the longest mean water duration. Gâats are open wetlands present in a more shallow topography and typically cultivated during the dry season (Shine, 2011). These wetlands are fed by rainfall and runoff from their catchment areas and reach their maximum water level after the rainy season in October or November. On average, this region receives 280 mm of rainfall per year (Shahin, 2007). Because they rely on annual precipitation, the duration, depth, and size of these wetlands vary widely from year to year. A closer view of the Gâat Mahmoudé, the largest wetland in eastern Mauritania, illustrates this dynamic (see adjacent insets).







The runoff washes fine clay particles and organic matter into the wetland depressions, which makes the wetland soils more productive than the surrounding sandy soils. The increased nutrient availability and moisture in the wetlands attract a variety of economic activities. Indeed, livestock rely on the surface water and pasture in the wetlands for part of the year, bringing additional nutrients into the system. Flood recession agriculture is also practiced in some of the wetlands, as well as fishing and hunting. The tamourts provide wood for construction and fuel, wild foods and medicinal plants.

Wildlife also depends on water and vegetation resources offered by the wetlands and oftentimes competes with economic activities, sparking debate about conservation and management. The role of wetlands as stop-over, over-wintering sites and breeding grounds for migratory birds has received particular attention. Aerial surveys have been used to monitor Black Stork populations, whose concentrations in the wetlands vary from year to year in response to the variable and unpredictable surface water. In favorable years, Black Storks over-winter in the Gâat Mahmoudé; in other years they continue to more permanent wetlands in Mali, Niger, and Burkina Faso (Shine, 2001).

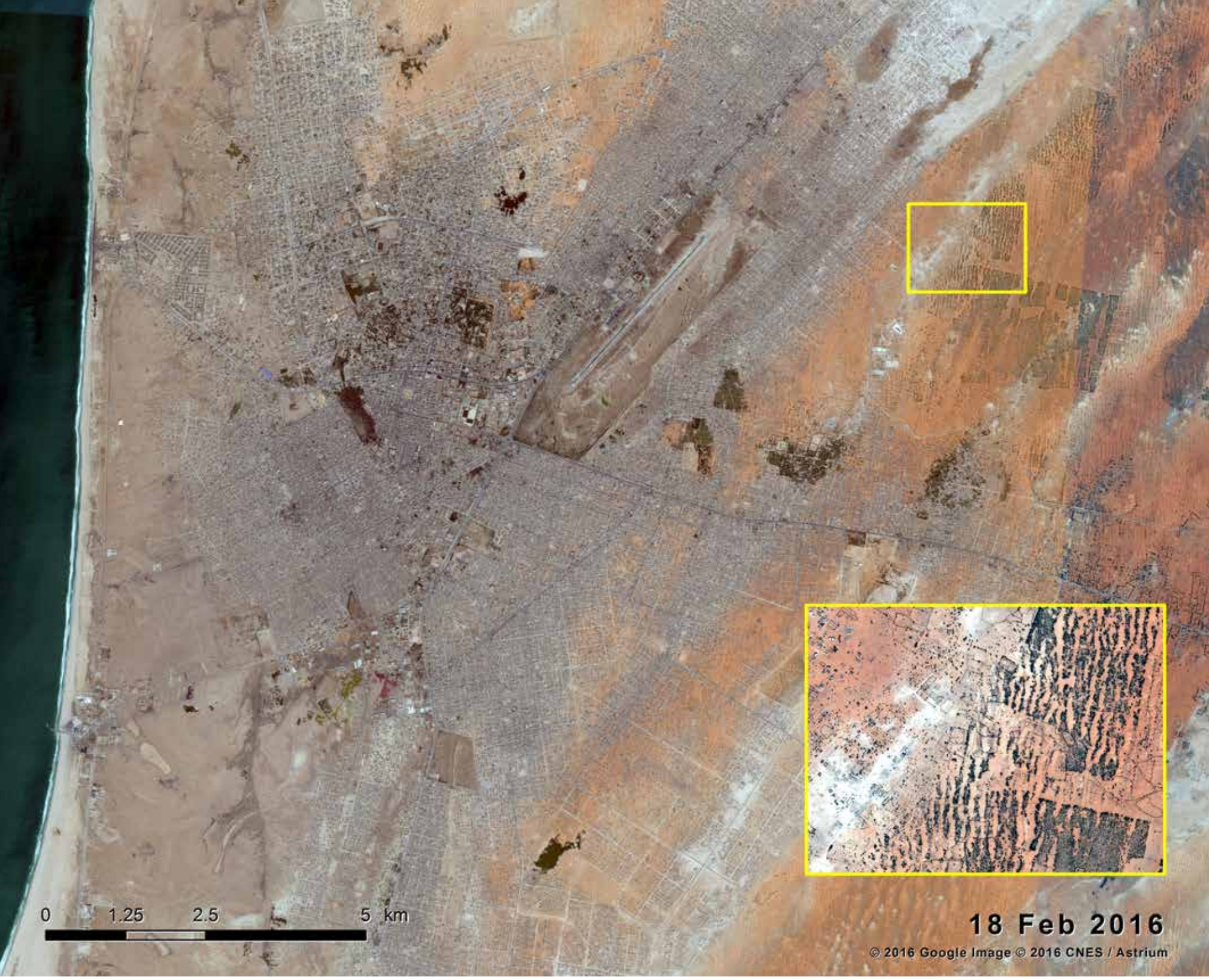
Nouakchott: urbanization at the gates of the desert


Nouakchott, Mauritania

RICHARD JULIA

Unlike other capital cities in West Africa, Nouakchott did not serve as capital of Mauritania for most of the colonial time, inheriting this function from Saint Louis only in 1958, shortly before independence in 1960. Until that time, Nouakchott was a small fishing town of only 200 inhabitants. In the following decades, Mauritania underwent very rapid urbanization from 858,000 to 3,873,000 inhabitants between 1960 and 2013. The urban growth occurred primarily in the coastal cities of Nouakchott and Nouadhibou. A study of settlement patterns in Nouakchott showed that much of the city's rapid growth has been in informal settlements with limited access to urban services (Urban Habitat, 2016).

The rapid growth of the city was driven by a long series of drought years since the beginning of the 1970s, and by the degradation of the land and vegetation resources that ensued. As wells dried up and forage and firewood became harder to find, many rural Mauritanians migrated to Nouakchott in search of work and a better life. Those



environmental refugees added to the refugees displaced by the Western Sahara war in the 1970s, who had swelled the population of the city.

A comparison of a Corona satellite image from 1965 and a high-resolution image from 2016 illustrates the dramatic expansion of the city, whose urbanized area sprawled from only 5 sq km in 1965 to 150 sq km in 2016. Low density development, including considerable undeveloped open space, predominates in the urbanized area, due to a cultural preference for detached single-family houses on large tracts of land.

Sand dunes advancing from the east are threatening buildings and infrastructure, particularly in the rapidly growing peri-urban areas. In a major dust storm, dunes may move several meters. In order to protect the city from the encroaching sands, the Nouakchott Green Belt was first established in 1975; however, it had to be extended in the 2000s as the city had grown beyond its boundaries. Up until today, a total of 12.7 sq km have been stabilized by afforestation with *Prosopis julifora, Euphorbia balsamifera, Leptadenia pyrotechnica, Acacia senegal* and *Balanites aegyptiaca* as well as sowed with grasses such as *Aristida pungens* and *Panicum turgidum* (see above inset and adjacent picture). In addition to curbing sand encroachment, the green belt has provided employment opportunities and fostered agro-silvo-pastoral development (Berte, Ould Mohamed, and Ould Salek, 2010).

BERTE, OULD MOHAMED, AND OULD SALEK, 2010

Dune stabilization