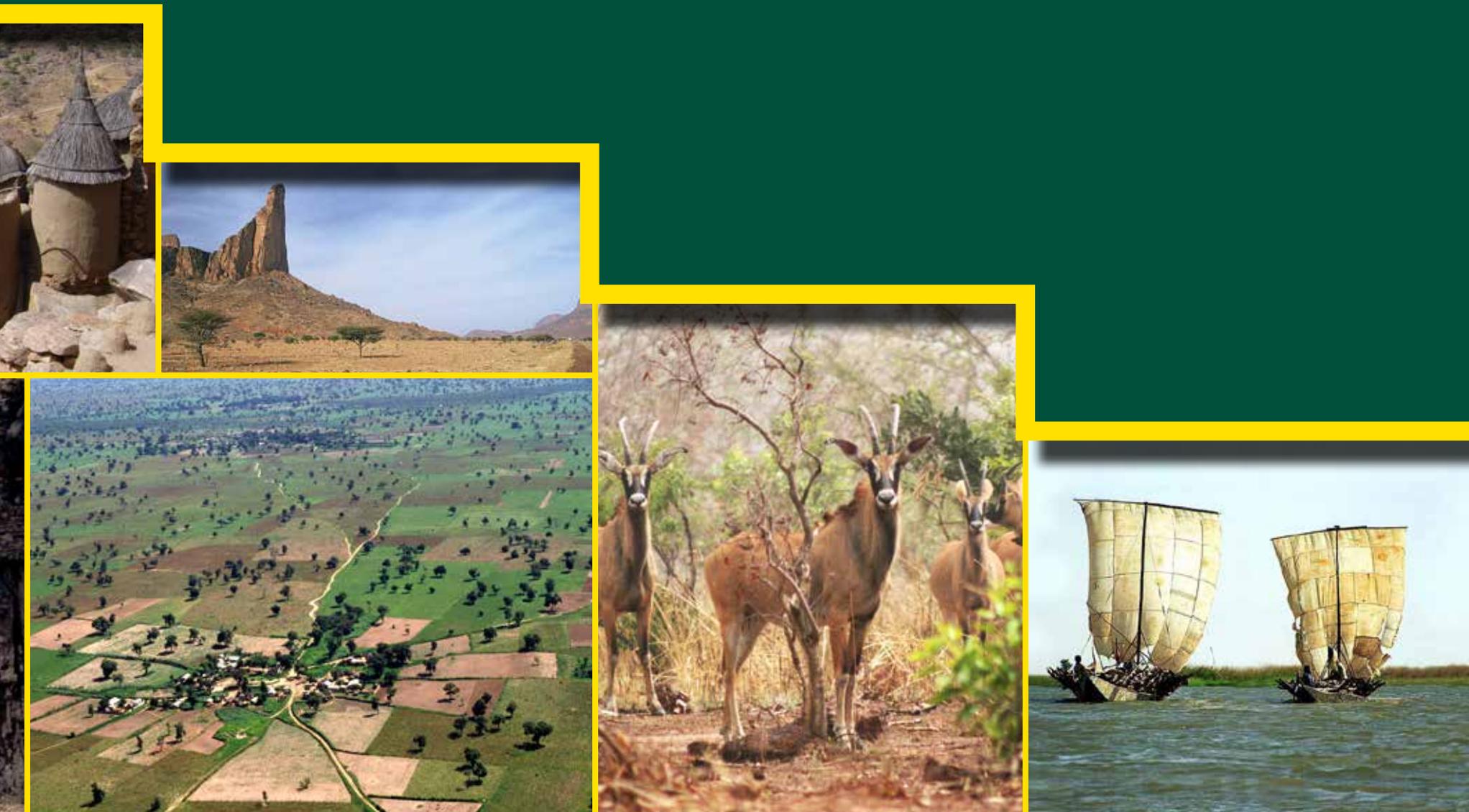


Landscapes of West Africa

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



USAID | WEST AFRICA

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

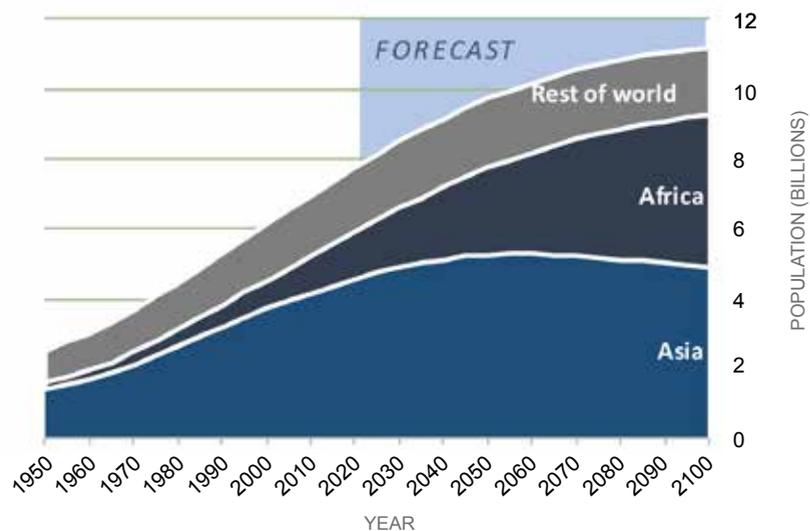
the collapse of natural systems that are essential for humans to thrive, perhaps even threatening the future of all humankind.

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

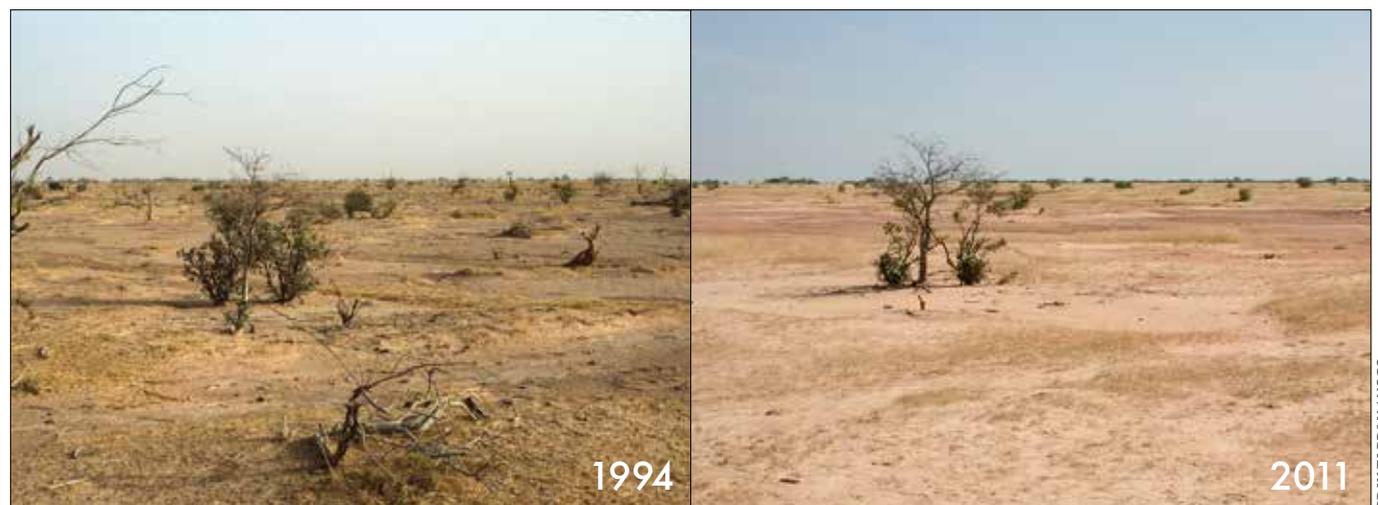
Parallel trends can be seen in the land cover changes of West Africa. With so many new families to feed, West Africa doubled the area covered by farms between 1975 and 2013. Vast areas of savanna, woodland, and forest landscape have been replaced or fragmented by cropland. At the same time villages,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

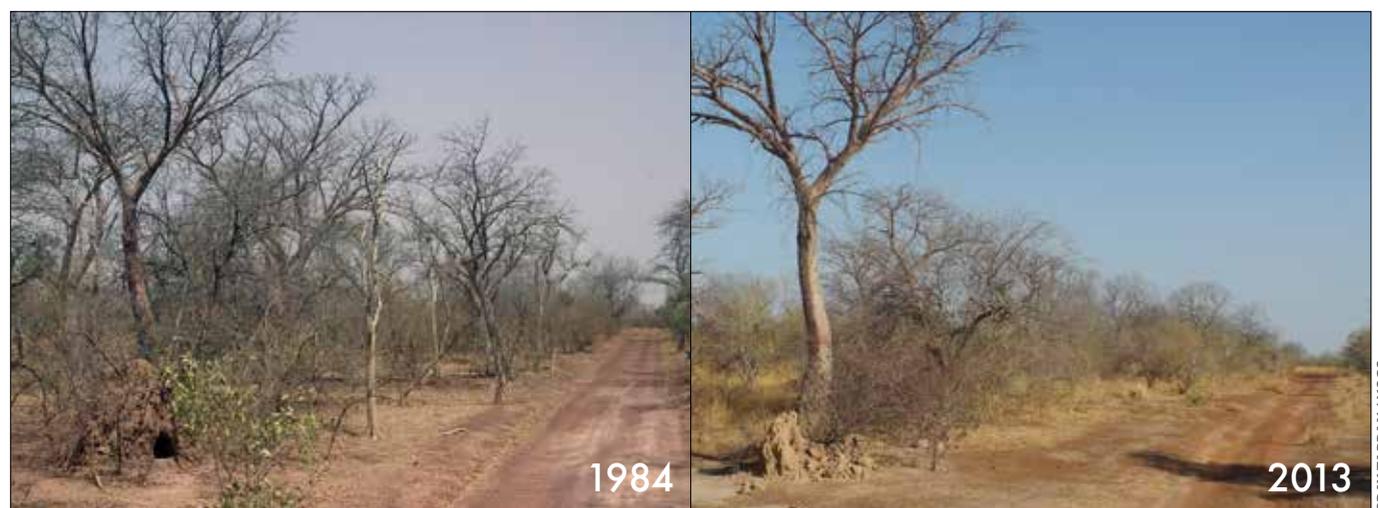
Conversion of the natural landscapes of West Africa to agriculture greatly reduces the natural biodiversity, and exposes the soil to wind and water erosion. The savanna, woodland, forest, and wetland ecosystems that are lost have some relatively tangible impacts such as the loss of natural ecosystem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

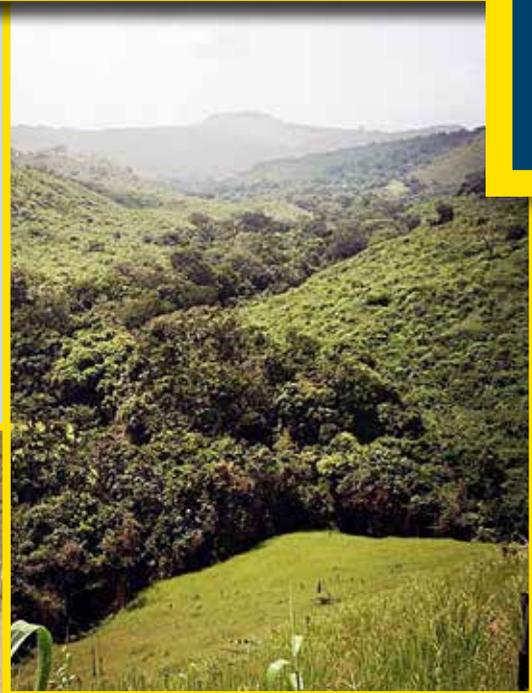
Experts from institutions in 17 countries in West Africa have partnered with the Comité Inter-états de Lutte contre la Sécheresse dans le Sahel (CILSS – The Permanent Interstate Committee for Drought Control in the Sahel), the U.S. Agency for International Development (USAID) West Africa and the U.S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



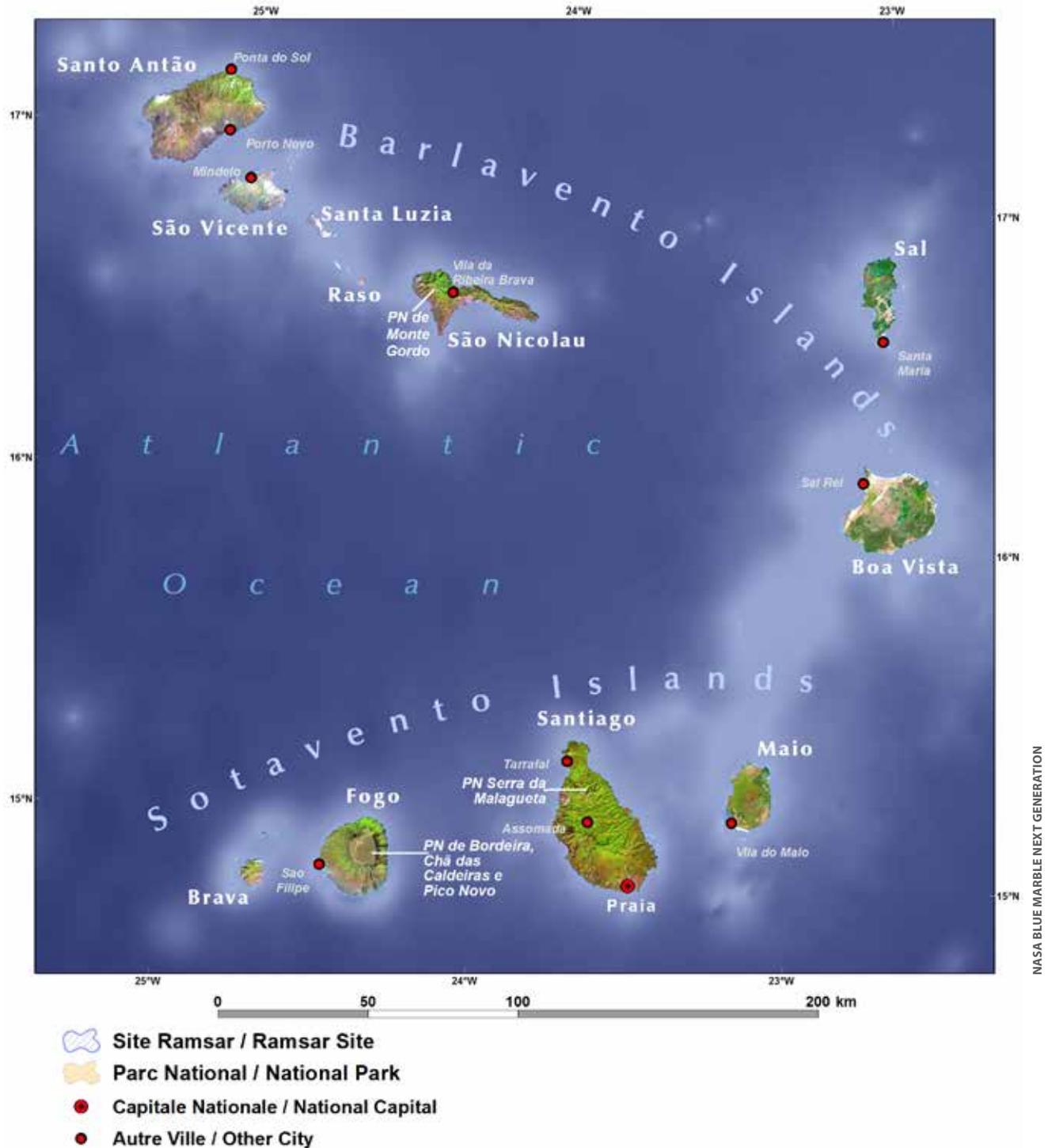


Republic of

Cabo Verde

Total Surface Area: 4,033 km²
Estimated Population in 2013:
507,000

Located approximately 600 km from the West African mainland, Cabo Verde is a volcanic archipelago that consists of 10 larger islands and several uninhabited islets, divided into two ensembles: the leeward islands (Sotavento) in the south and the windward islands (Barlavento) in the north, depending on whether the islands are more or less affected by the trade winds from the northeast (Eklund and Kronhamn, 2002). Before being discovered by the Portuguese in 1456, the Cabo Verde islands were uninhabited. Today, a majority of inhabitants are of mixed Portuguese and African ancestry, and Cabo Verde is known for its Creole Portuguese-African culture and morna music. The climate is tropical dry and rainfall is limited and quite erratic, with an average of less than 300 mm per year. The landscapes of this archipelago are very diverse, formed by volcanic activity 8 million to 20 million years ago. In the mid-20th century, major afforestation and soil and water conservation efforts were undertaken to restore degraded land. The land of the western mountainous islands has undergone extensive conversion that transformed the dry steppe habitat to a heavily human-influenced landscape. Dense forest now covers some of the highest elevations and the more humid windward-facing slopes, while woodlands have been established on some of the drier areas. The potential for agriculture is extremely varied, hampered by aridity, extreme topography, and unequal land ownership.



Environmental Highlights:

- Soil erosion
- Desertification
- Successful afforestation
- Extensive use of agroforestry
- Thriving and expanding tourist trade

Arid landscape in Cabo Verde

Shaded Relief

Îles de Barlavento / Barlavento islands



Îles de Sotavento / Sotavento islands



Élevée / High
Faible / Low

0 20 40 80 km

The mountainous islands of Brava, Santiago, Fogo, Santo Antão and São Nicolau — all with peaks over 1,000 m — are rocky, with relatively productive volcanic soils in deep valleys that support various kinds of agriculture. These islands have the longest histories of human habitation and densest populations in the archipelago. The rugged landscapes consist of high peaks, ridges, plateaus and valleys. The elevations are high enough (the highest point is Mount Fogo at 2,829 m) to produce a strong orographic effect with few, but intense, precipitation events (Mannaerts and Gabriels, 2000). The mountains catch enough moisture to support grassland as well as intensive agriculture in a succession of altitudinal zones. In contrast, Maio, Boa Vista, and Sal, lying to the east, are flat, highly eroded desert islands with an arid climate marked by year-round exposure to dry winds blowing off the Sahara. Open steppe, bare soil, and long sandy beaches are the predominant land cover types. Their economy is primarily based on salt extraction and animal husbandry.



GRAY TAPPAN / USGS

Forest on the mountain slopes of Santo Antão

Land Use, Land Cover and Trends

Centuries of land alteration to expand agricultural production has created a highly engineered, complex mosaic of land use in Cabo Verde. A few early records describe the original vegetation of the islands. Grasses and shrubs likely constituted the vegetative communities of the arid lowlands. The more humid highlands probably consisted of woody shrubs interspersed with herbaceous species, and a handful of tree species colonizing the most favorable waterways. Closed-canopy forests likely never existed (Benton, 2013). After the Portuguese colonization, the land underwent vast land use changes. Intensive agricultural practices, livestock (primarily goats), and other introduced plant and animal species greatly altered the native vegetation and decimated the native tree populations. The reduction of natural vegetation in many areas also contributed to soil erosion. By the early 20th century many parts of the islands were heavily degraded.

Afforestation and soil and water conservation efforts to restore degraded land were begun in earnest in the mid-20th century by the Portuguese (Benton, 2013). From 1928 to 1975, Cabo Verde gained about 30 sq km of afforested areas, mostly in Santo Antão, Fogo, and São Nicolau (WOCAT, 2015; Lopes and Santos, 2010). Both the mountainous parts of the islands and the arid and semiarid zones benefited from the afforestation programs. After Cabo Verde's independence in 1975, critical forest regulations were established and the expansion of forests continued. These afforestation efforts were already highly visible on the landscape in 2000. The earliest plantations (*Pinus spp.*, *Cupressus spp.*, and *Eucalyptus spp.*) on the highlands of Santo Antão and São Vicente have become dense forests and woodlands on the highest slopes, where cultivation is not possible. These forests are still expanding. Forest area increased by 21 percent (6 sq km), and woodland by 24 percent (34 sq km), between 2000 and 2013. The more recent afforestation projects of the last two decades have focused mainly on the drier lands of the Sotavento islands (i.e. Santiago, Maio, and Brava). The main species being planted were *Prosopis juliflora*, *Acacia spp.* and *Ziziphus mauritiana*, all well adapted to the arid climate. A total of 248 sq km of plantations were mapped in 2000, decreasing



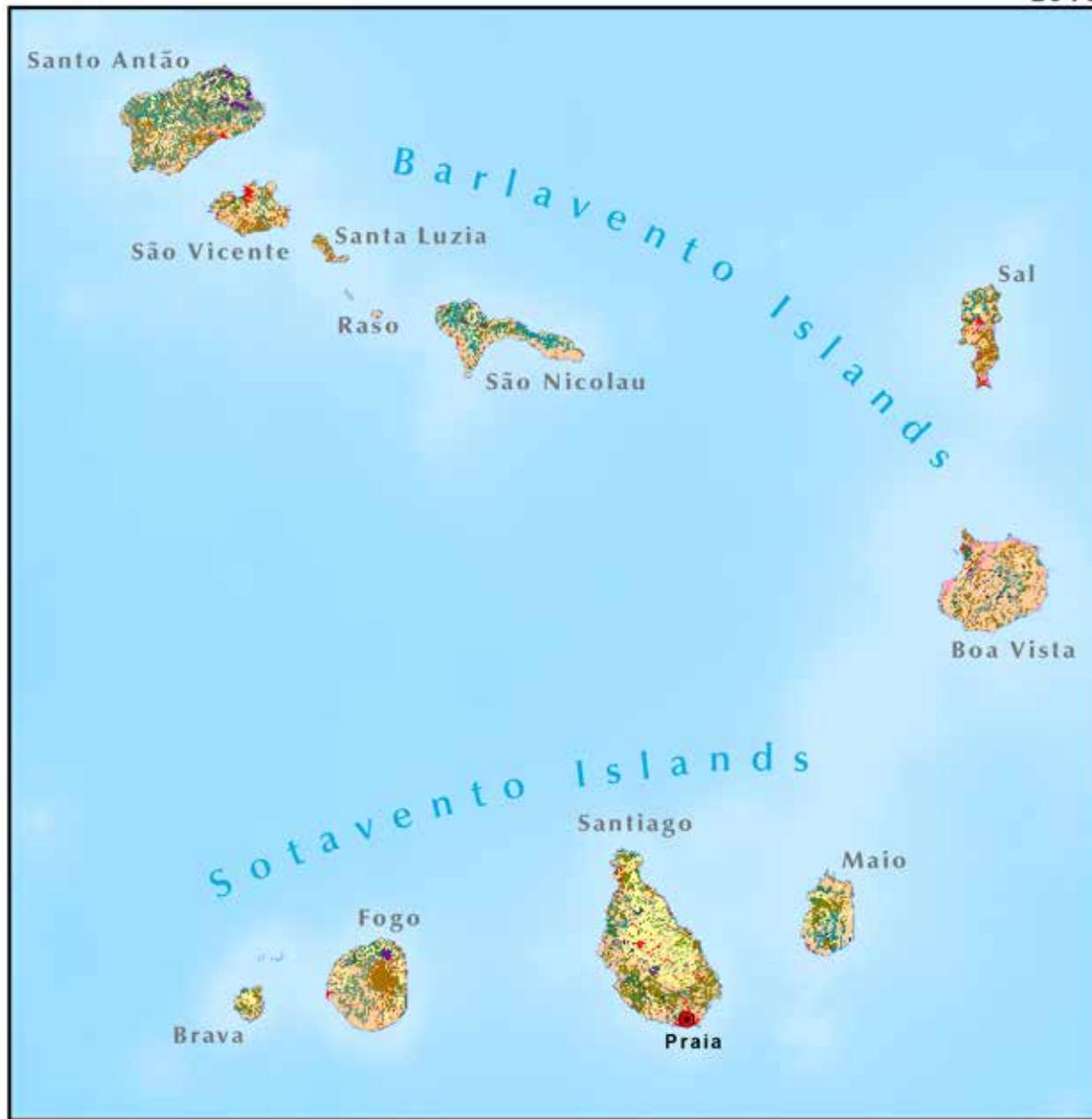
The land use and land cover maps characterize the landscapes at a resolution of 500 m. They are based on visual interpretation of Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) and high-

resolution images, from 2000 and 2013. No comparable sources of imagery were available to complete a map for the 1975 period.



Agriculture in the ribeiras, Santiago

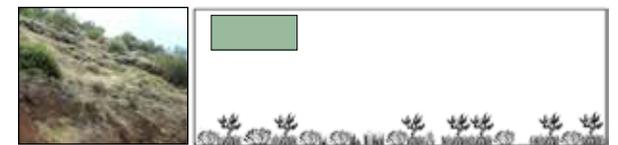
2013



Occupation des Terres / Land Cover

- Forêt / Forest
- Forêt galerie & formation ripicole / Gallery forest & riparian forest
- Forêt claire / Woodland
- Zone arbustive / Shrubland
- Savane herbacée / Herbaceous savanna
- Steppe
- Zone de culture / Agriculture
- Cultures irriguées / Irrigated agriculture
- 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

Cabo Verde has a semiarid shrubland land cover class that is unique to these islands. It is characterized by shrubs and bushes scattered on discontinuous grassland cover (shrubs and bush cover between 25 and 50 percent). Shrublands are mostly located on the more humid northern slopes of the mountainous islands or along the ribeiras.

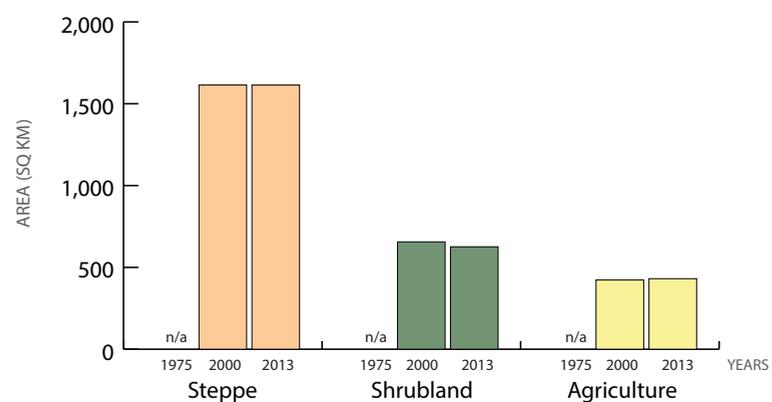


slightly to 243 sq km in 2013. As the young trees matured and their canopies coalesced, the plantations take on a woodland appearance. The succession of some plantations into woodlands accounts for the decrease in plantation area.

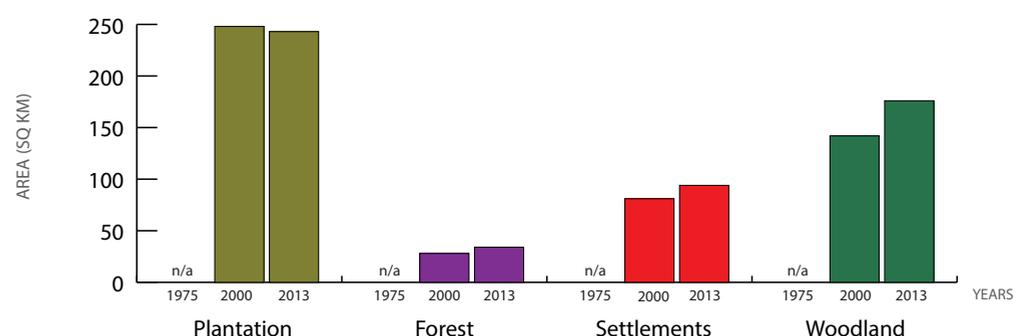
The arid zones of the lower elevations — all the flat islands such as Sal, Boa Vista, and Maio, and the pediments of the mountainous islands — account for over half the Cabo Verde’s land area. These areas, predominantly bare, steppe, or shrubland, remained largely stable from 2000 to 2013. Suitability for agriculture is very low but better suited to pastoral or silvo-pastoral use. However, steppe and shrubland areas decreased 2 and 5 percent, respectively, between 2000 and 2013, mostly because of restoration projects that converted certain areas to plantation or woodland.

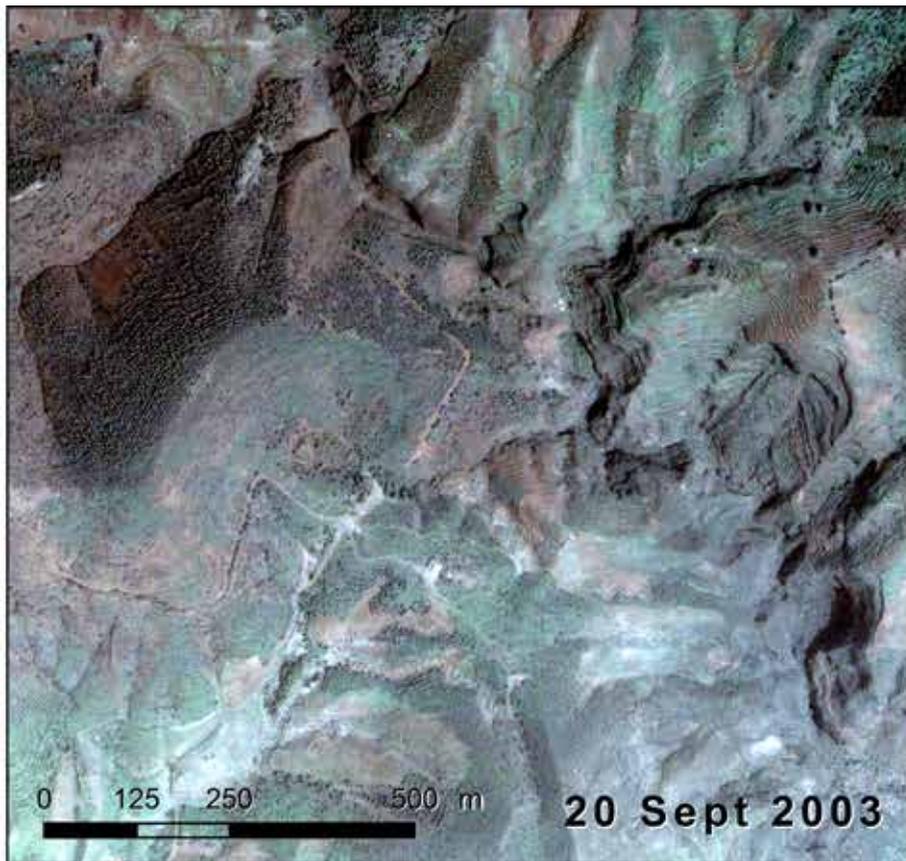
In 2000, agriculture covered 423 sq km over the whole archipelago, about 10 percent of the country area. Cropland increased by only 8 sq km from 2000 to 2013. Cultivated areas, however, are not evenly distributed among the islands. Santo Antão and Santiago are the most cultivated islands, with more than 70 percent of the total farmed land of Cabo Verde. Irrigated agriculture was mostly found on Santiago island in the *ribeiras* — valleys where ephemeral streams have created steep hillsides, at times with nearly vertical walls. In spite of climatic hazards and rugged terrain, agriculture is the main activity in the archipelago, occupying more than half of the workforce.

Large area classes



Small area classes





A comparison of two satellite images showing the dramatic afforestation on the slopes of Santo Antão Island.



The successful large-scale afforestation of Santo Antão and Santiago Islands

Santo Antão and Santiago are the two largest islands of the archipelago of Cabo Verde (991 sq km and 754 sq km, respectively). Following the colonization of the islands in the late 1400s, the fragile environment of these relatively recent volcanic mountains, associated with the arid and semiarid sahelian climate, underwent severe deterioration (Spaak, 1990). The land degradation problems led to large afforestation programs after independence in 1975, which restored more than 800 sq km of land and drastically changed the landscape of Cabo Verde.

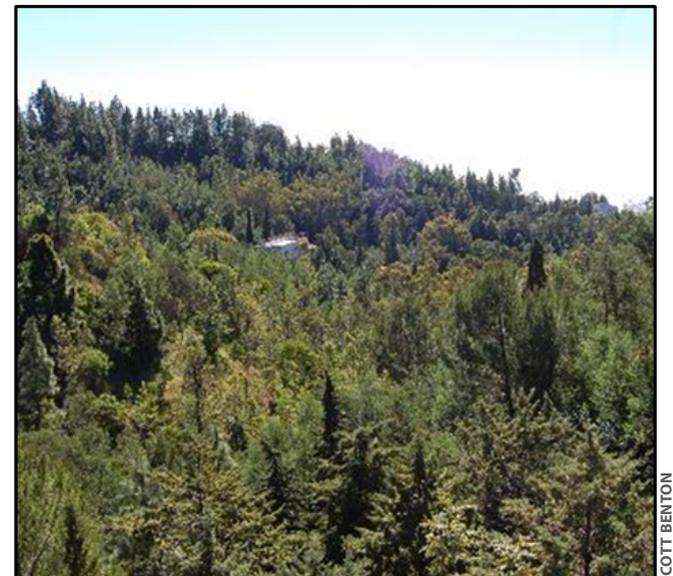
Santo Antão and Santiago islands are characterized by a dramatic landscape with steep slopes, associated with a strong orographic effect. Their soils are generally young, shallow, and very susceptible to erosion. The climate varies from humid to arid, with a short rainy season from August to October and periodic multi-year droughts. Rainfall varies widely from place to place and year to year, ranging anywhere from 50 to 1400 mm (Eklund and Kronhamn, 2002).

Since the 1980s, afforestation has focused mainly on the arid zones of Santiago and Santo Antão, where the annual rate of afforestation was 57 sq km (Santiago received about 80 percent, or 45 sq km). This was a big step toward land restoration (Eklund and Kronhamn, 2002). The goals of all afforestation efforts were to 1) provide soil erosion control by mechanical and vegetative methods; 2) increase infiltration, fog capture, and water availability; 3) increase biodiversity and vegetative cover; and 4) increase economic aspects of forests such as firewood, employment,

Ground pictures showing the afforestation on Santo Antão island between 1950 (left) and 2012 (right) (Agua das Caldeiras).



ANONYMOUS, 1960



SCOTT BENTON



A comparison of two satellite images showing the afforestation on the drylands of Santiago Island.

or timber (Benton, 2013). Over the past 40 years, this afforestation has contributed to a general rehabilitation of vegetation cover, combating desertification, meeting energy needs, forage production and development of agrosilvopastoral systems, while at the same time contributing to a significant increase in the diversity of the landscape in Cabo Verde (Lopes and Santos, 2010). The former degraded areas of Santiago and Santo Antão islands are now covered by a dense forest in the mountainous parts, and woodland in the drier areas.

The first image pair (see opposite page) shows an example of afforestation on a humid highland in Santo Antão. In 2003 (left), forest and woodland already existed on some of the slopes and highland areas, resulting from earlier afforestation projects in the 1970–1980s. In the early 2000s, new plantations were implemented on slopes but the trees were not visible yet in 2003. In 2014, however, the forest became denser and new woodland and growing plantations appeared on the lower slopes. Afforestation continues and several programs have been implemented in the late 2000s, especially in Santiago and Maio, but not to the same extent as before.

In the second image pair (above), high-resolution images show the afforestation on arid land in Santiago (8 km northwest of Praia). In 2002, an afforestation project had just started to restore the degraded steppe. The trees might have been planted but are not visible in the imagery. In 2014, the whole area was covered by dense plantations. Today, 67 percent of the total reforested area in Cabo Verde is located in Santo Antão or Santiago, and represents 7 percent¹ of the country area (about 300 sq km). The afforestation also had a great impact on the local population. Forests are perceived to provide numerous benefits to communities, especially to the poorer rural interior of the island. Since the beginning of the afforestation program, major positive changes in vegetation, land use, and infrastructure can be observed.

Afforestation is one of the key technologies to address the fragility of ecosystems. It provides better protection against erosion and makes better use of rainfall in order to maintain the sustainability of agricultural systems (WOCAT, 2015). The forests of Cabo Verde present an enduring example of positive land use change in West Africa. They are heavily utilized by the local population to meet many needs and are viewed favorably. Simple changes in forest management practices can improve biodiversity conservation and increase economic activity. Many valuable lessons learned in Santo Antão and Santiago can be applied in other West African afforestation projects.



GRAY TAPPAN / USGS

¹ This number represents the area that successfully was reforested and is now covered by forest, woodland, or new plantations. It does not take into account the agroforestry plantations in areas of agricultural potential.