Landscapes of West Africa

A Window on a Changing World

Back of cover

Landscapes of West Africa

A Window on a Changing World

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USGS 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.

Source: NASA, Lunar Reconnaissance Orbiter

Dr. Djimé Adoum

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

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

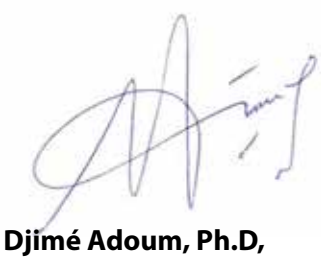
The West Africa Land Use Dynamics (LULC) Project is emblematic of this cooperation. Initiated in 1999, the LULC project has had several phases including training national experts to extract pertinent information from satellite images to characterize vegetation cover and producing tools and supporting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

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

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

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

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



Djimé Adoum, Ph.D,
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USAID | WEST AFRICA

FROM THE AMERICAN PEOPLE

Alex Deprez

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

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

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

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

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

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

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

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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:

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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

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)!

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

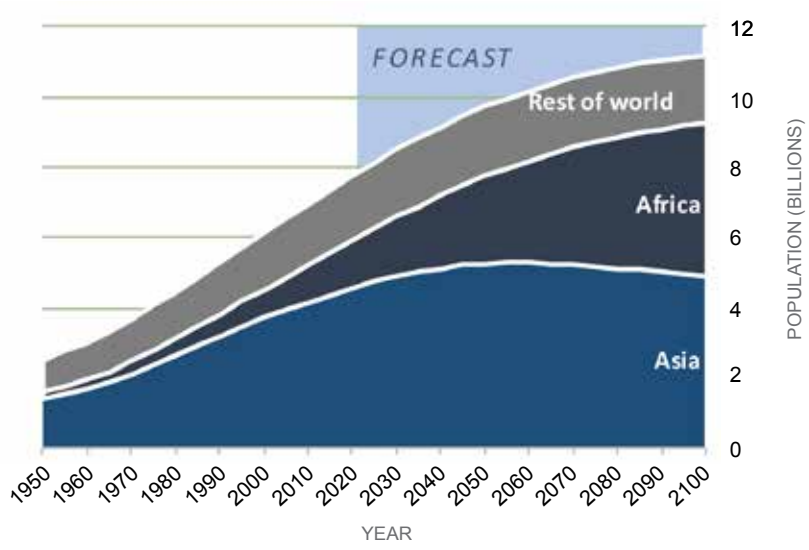


PHOTO (OPPOSITE PAGE): SUZANNE COTILLON / SGT

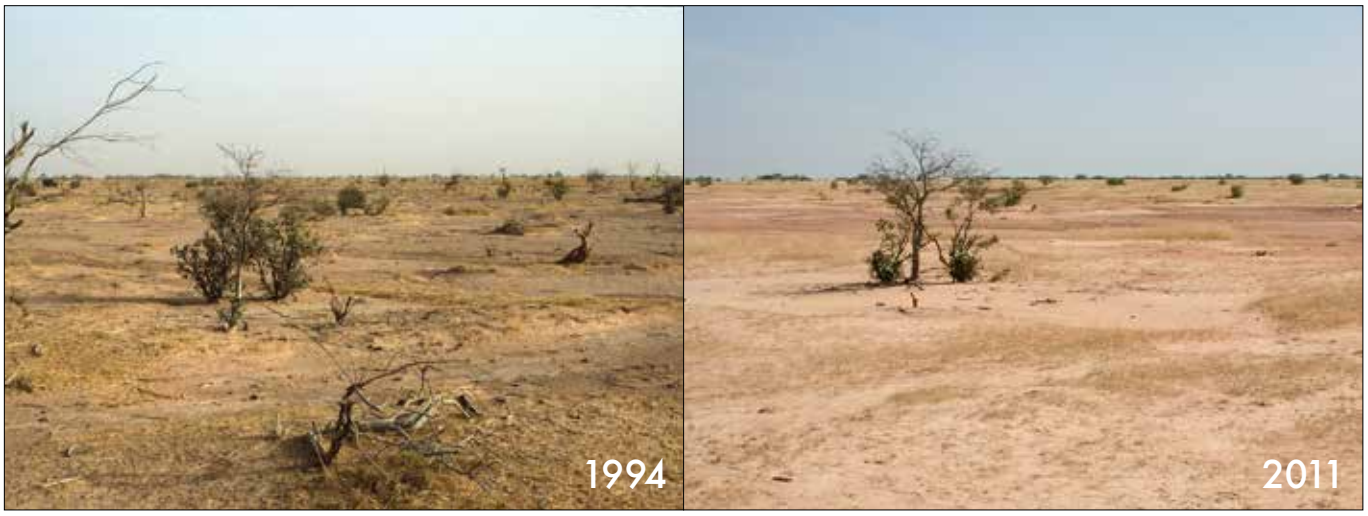
Wooded landscape fragmented by agriculture expansion in western Burkina Faso

JAMES ROWLAND / USGS

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

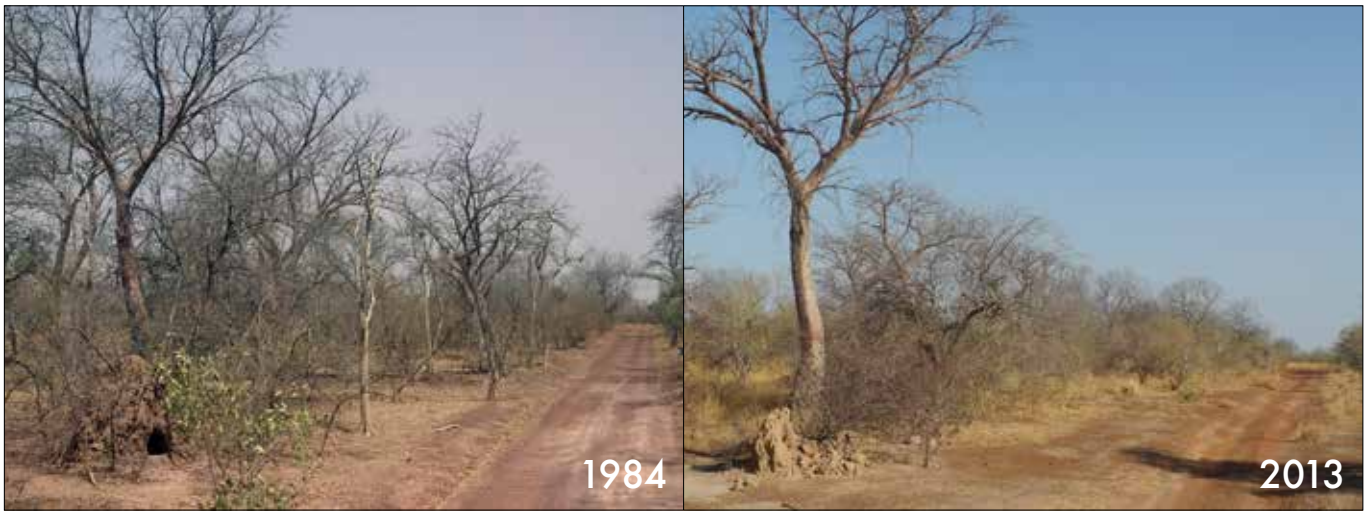
Conversion of the natural landscapes of West Africa to agriculture greatly reduces the natural biodiversity, and exposes the soil to wind and water erosion. The savanna, woodland, forest, and wetland ecosystems that are lost have some relatively tangible impacts such as the loss of natural ecosystem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

Expansion of degraded land in the Ferlo region of Senegal



GRAY TAPPAN / USGS

Decline in vegetation cover and biodiversity in east-central Senegal



GRAY TAPPAN / USGS

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

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

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

Chapter II

Country Profiles, Land Use and Land Cover, and Trends

Republic of

Ghana

Total Surface Area: 238,533 km²
Estimated Population in 2013: 26,164,000

Ghana is situated in the center of the Gold Coast of Africa and has a 535-km-long shoreline that includes lagoons and mangrove forests. The country's tropical climate varies from a Sudanian type climate in the north with a short rainy season, to the high rainfall regime of the forested Guinean and Guineo-Congolian Regions in the southwest. The export of cocoa has traditionally dominated the economy of Ghana, and today it is one of the world's largest exporters of cocoa. Agriculture remains a major economic sector, providing income for nearly half of Ghanaians. The country is endowed with rich natural resources. Timber, gold, diamonds, bauxite, manganese, and oil contribute to making Ghana among the wealthier nations in West Africa. While its economy is one of the most successful in the region, it remains heavily dependent on international finance. Ghana, like most West African countries, has daunting environmental challenges since its economic development depends directly on natural resources. Large tracts of forest have been cleared to support increasing cocoa production. Mining is causing localized land degradation and water pollution. A quarter of its people are concentrated along the narrow coastal zone.

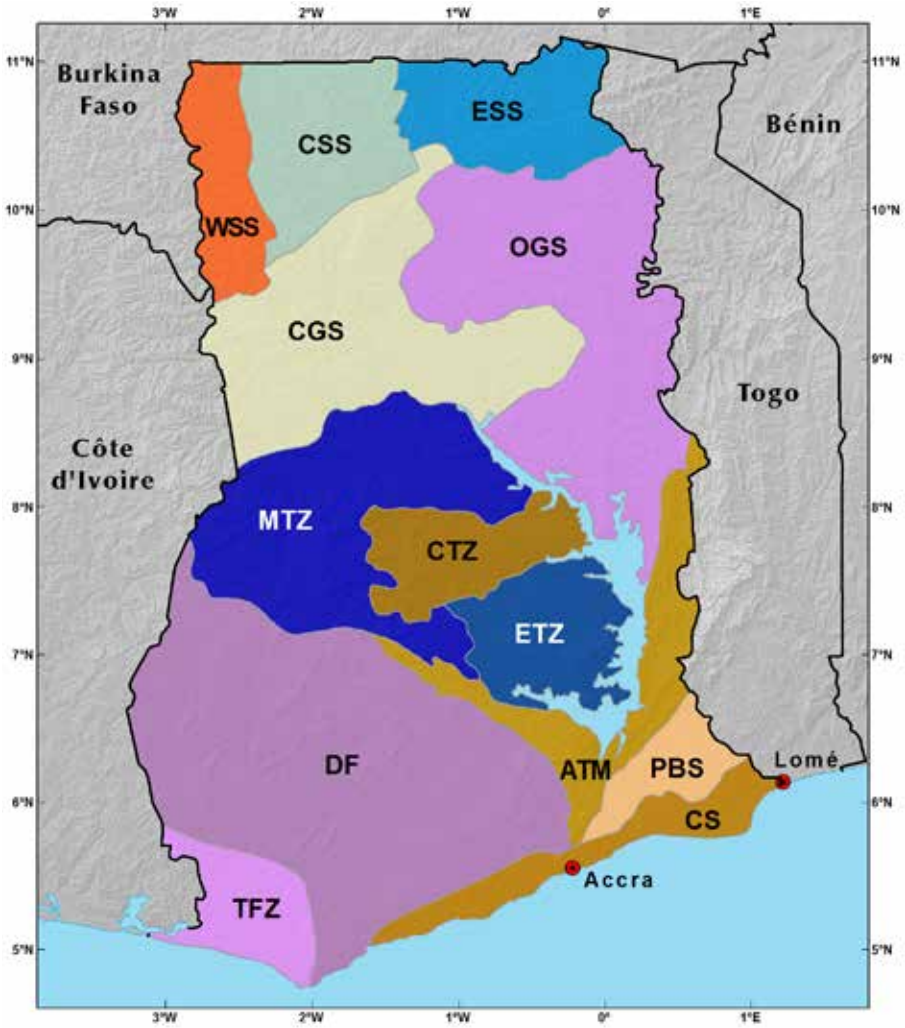
NASA BLUE MARBLE NEXT GENERATION

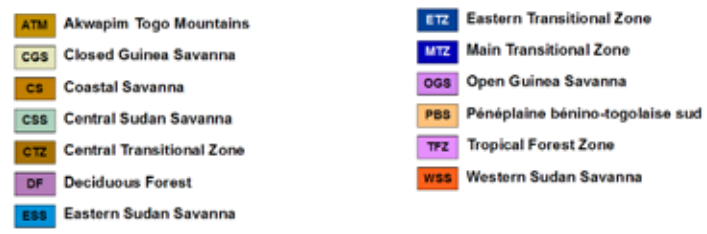
Environmental Highlights:

- Significant inventory of Upper Guinean biodiversity
- Largest artificial lake (by area) in the world
- Ecotourism
- Deforestation
- Pollution from mining

Grassy coastal plain in the western region, Ghana

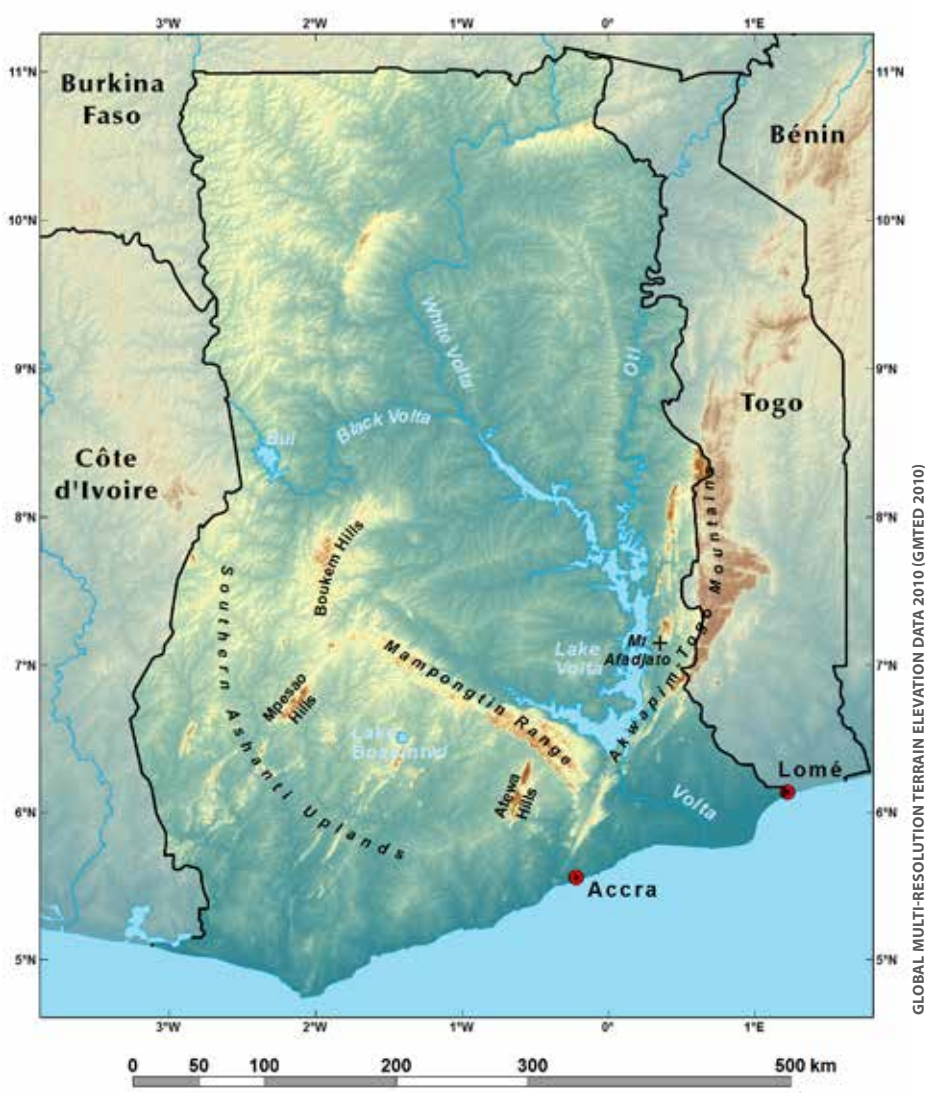
Ecoregions





With elevations that range from sea level to 885 m on Mount Afadjato, Ghana's physical terrain is composed primarily of low plains, punctuated with several uplands and a major plateau in the south-central part of the country. Ghana is home to Lake Volta, the world's largest artificial lake by area (8,482 sq km). In the north, the three Sudan Savanna ecoregions (WSS, CSS, and ESS) characterize the relatively dry northern climate with its single rainy season, open tree savannas, and scattered rainfed croplands. Moving south, the Closed Guinea Savanna (CGS) has extensive wooded savannas characteristic of the Guinean Region. In the adjacent Open Guinea Savanna (OGS) ecoregion, farmlands are expanding rapidly into the wooded savannas. In central Ghana, the Main, Eastern, and Central Transitional Zones (MTZ, CTZ, and ETZ) share common elements of a transitional climate with two rainy seasons and transitional forest-savanna vegetation. To the southeast, the Akwapim Togo Mountains (ATM) make up Ghana's highland ecoregion. It derives its main character from the rugged mountain chain and lush forested vegetation cover. This region still harbors much wildlife and offers great potential for ecotourism. The Deciduous Forest (DF) ecoregion in the southwest is Ghana's largest ecoregion, with deciduous tropical forests scattered among a number of biological reserves. In the south, the Tropical Forest Zone (TFZ) is Ghana's wettest ecoregion, with remnants of its biologically diverse evergreen rain forest. Finally, the Coastal Savanna (CS) ecoregion is highly distinguished by its relatively low rainfall in two seasons, high population density, grassland savanna vegetation, and coastal geomorphology that includes tidal flats and lagoons.

Shaded Relief

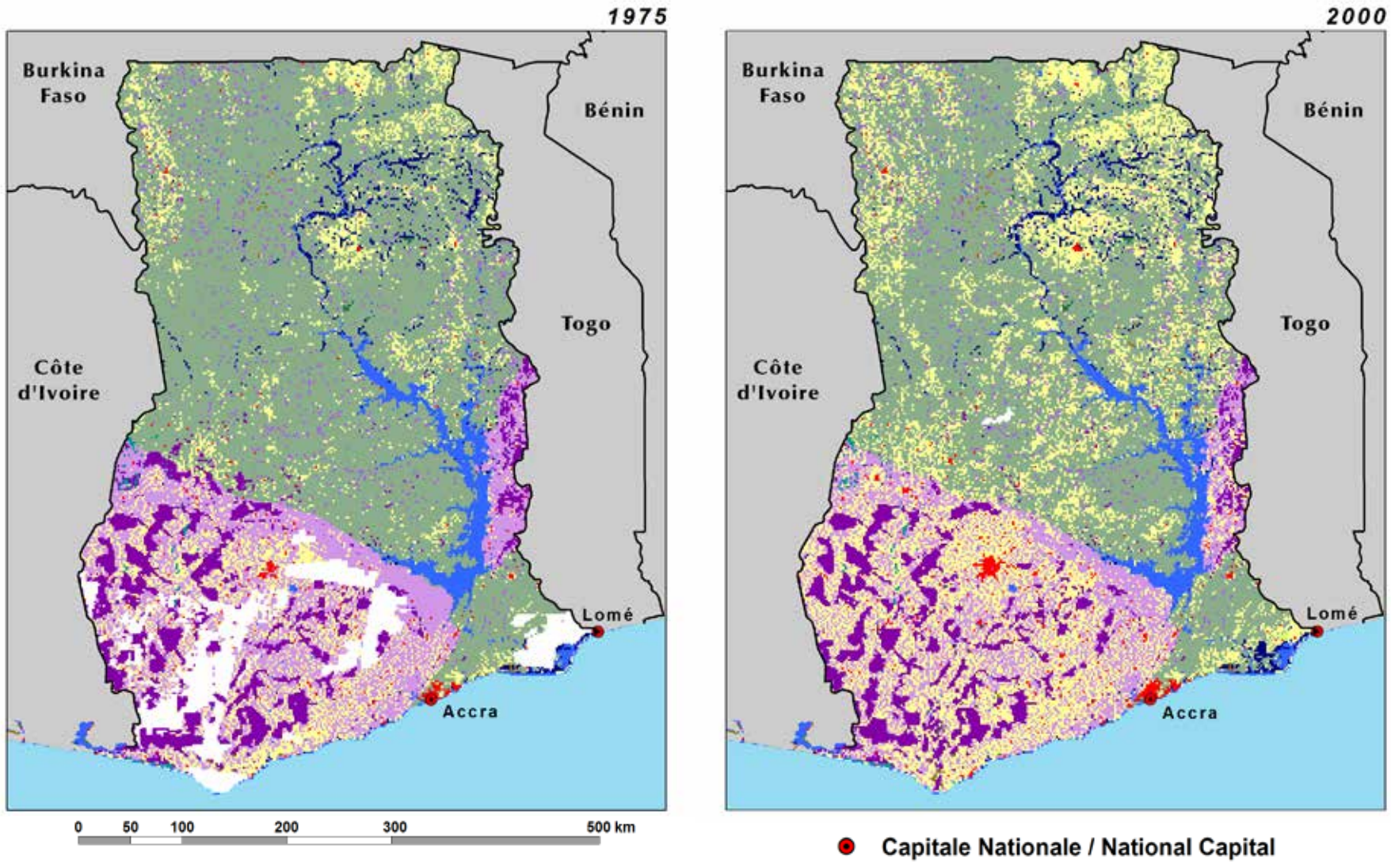


GLOBAL MULTI-RESOLUTION TERRAIN ELEVATION DATA 2010 (GMTED 2010)

ERIC LANDWEHR/SDSU

Canopy walk at Kakum National Park

PHOTO (OPPOSITE PAGE): GRAY TAPPAN /USGS



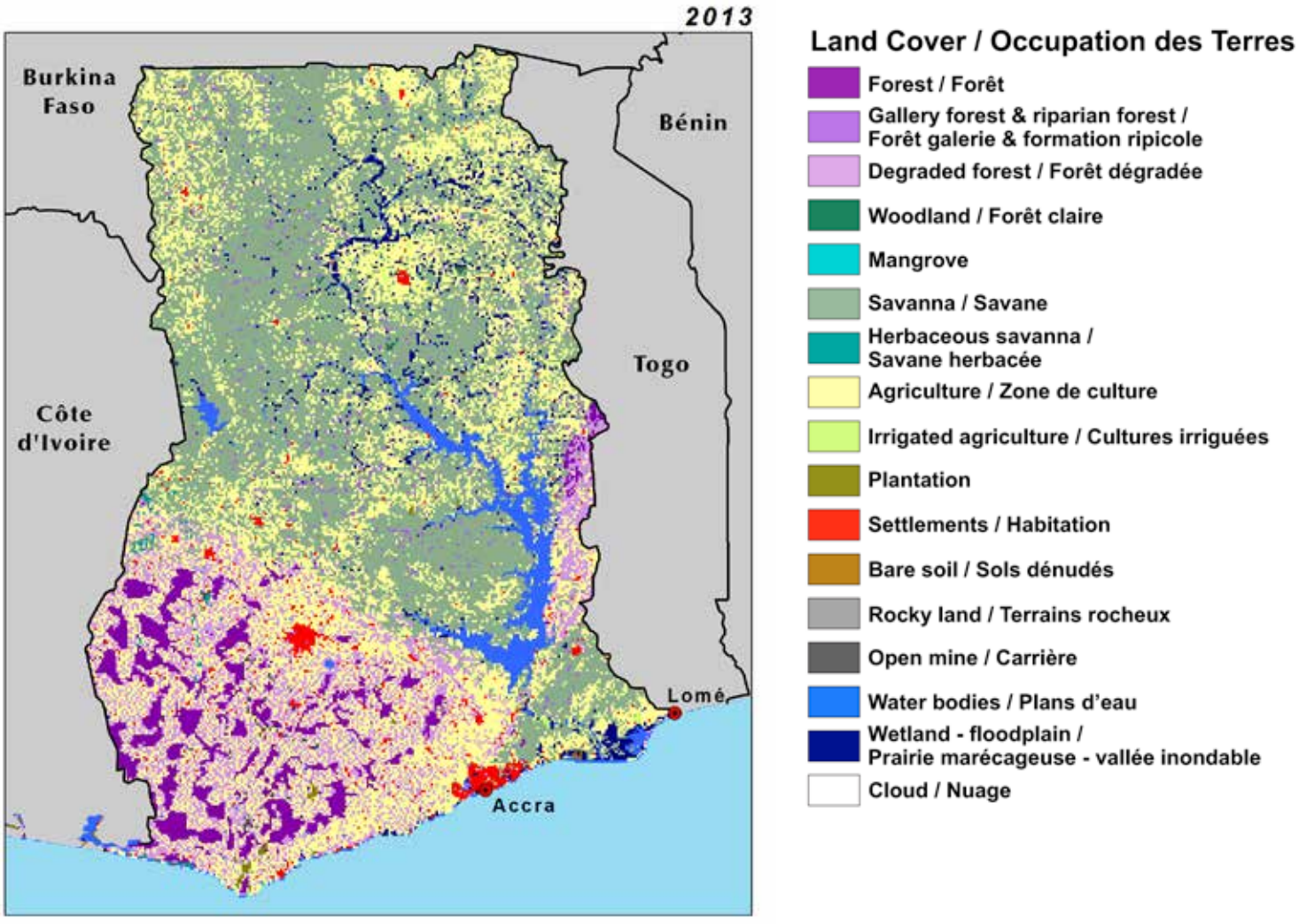
White areas in the 1975 map represent data gaps caused by persistent cloud cover.

Fishermen boats on the beach

ROBERT WATREL/SDSU

The most obvious land cover change in Ghana is the major increase in agricultural land in all regions of the country. However, the largest increases can be seen in the northeast, east-central, and southwestern regions of Ghana. This rate of agricultural expansion is unprecedented in the country's history, overrunning many of the other land cover types, including Ghana's savannas, woodlands, and forests. From 1975 to 2000, agricultural lands expanded from 13 to 28 percent of Ghana's total area and continued to extend rapidly, reaching 32 percent of Ghana's land area in 2013. This expansion has significance beyond the simple area numbers. Agricultural lands often represent a radical transformation from a diverse variety of vegetation types and natural habitats to crop-dominated landscapes. In Ghana, savannas experienced a large loss, from about 51 to 40 percent of the total land area from 1975 to 2013. The formerly uninterrupted savanna landscapes of the Central Sudan Savanna, Main Transitional Zone, and Central Transitional Zone are now highly fragmented, with large tracts of natural habitat broken into myriad patches of farmland, reducing habitat suitability for many types of wildlife.

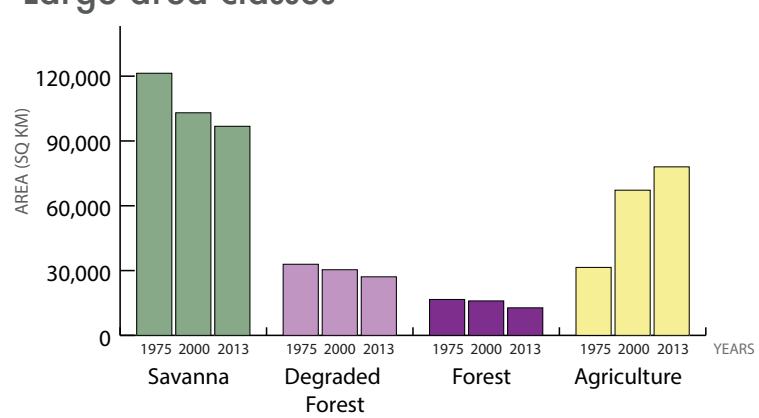
Another important land cover change in Ghana is the degradation of forest. The forest class (represented primarily by Ghana's dense evergreen rain forest and moist deciduous forest) shows a small decline in area from about 16,400 sq km in 1975 to 15,500 sq km in 2000, a reduction of 5 percent. This decline accelerated rapidly between 2000 and 2013, as forests were reduced by an additional 20 percent, to 12,400 sq km in 2013. The degraded forest, which occurs mainly in the off-reserve areas, represents a vegetation type that was derived from the dense and deciduous forests, modified by human activity. The traditional slash-and-burn method of agriculture, logging, annual wildfires, and recently commissioned open cast mining are the major disturbing factors that have diminished vegetation extent and composition in the southern ecoregions. Degraded forests continued to decrease in area, losing 17 percent of their cover between 1975 and 2013. The expansion of cocoa farms,



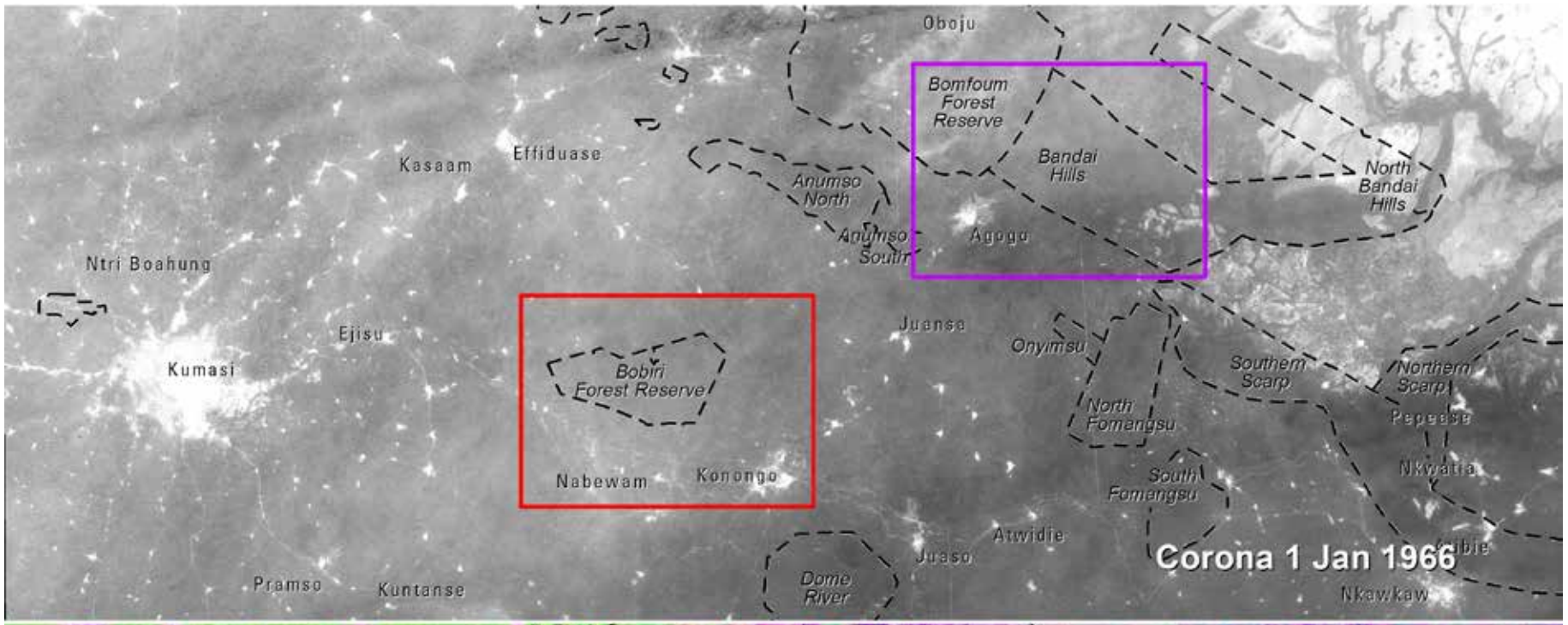
other crops, and fallow lands was the primary driver of the decline in degraded forest area. The gallery forest, which represents the most biologically rich habitat in the savanna zones of central and northern Ghana, also experienced a decline that has accelerated, mainly because of clear-cutting for agriculture, from 6,200 sq km in 1975 to 3,750 sq km in 2013. If we add all forest classes together, we see a significant decline of 25 percent of forests over the 38-year period. However, historical imagery confirms that a much larger loss of forest occurred during the 1960s. What remains today is primarily contained in the biological reserves. Ghana continues to lose its forest resources at an unsustainable rate.

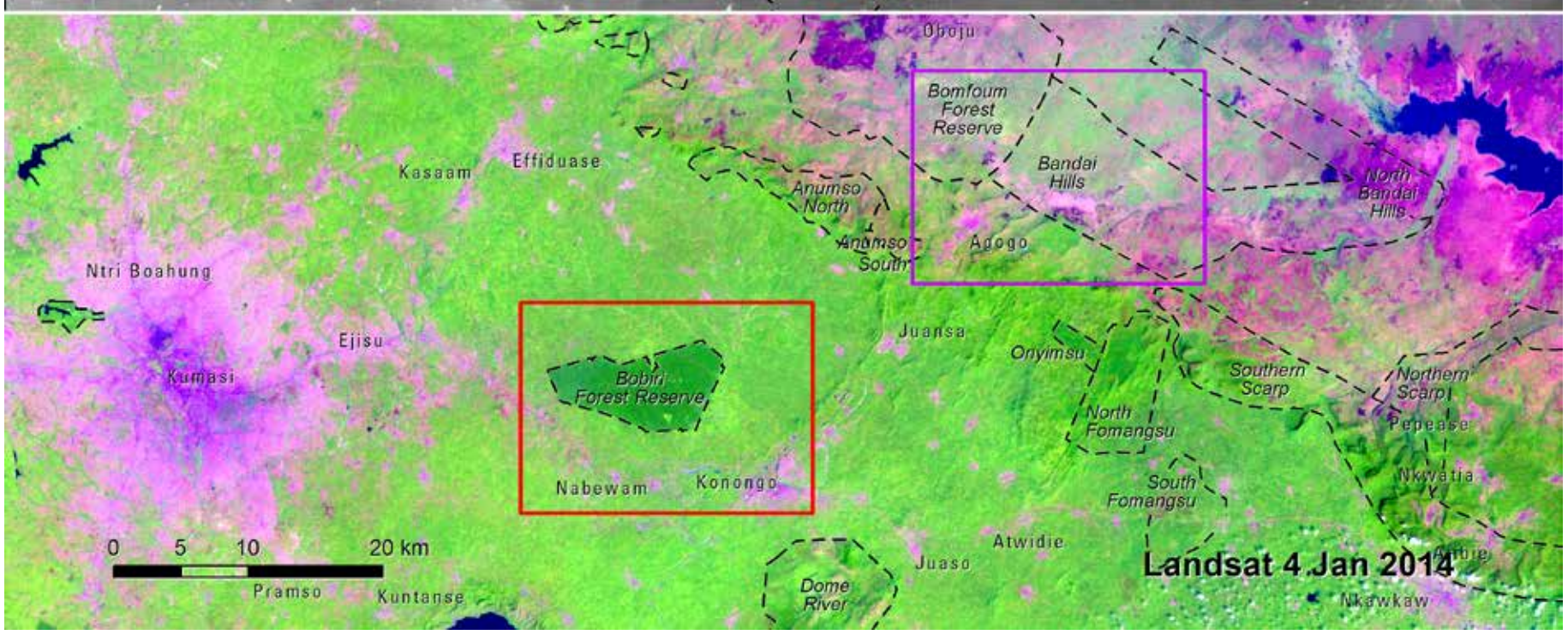
Ghana's rapid population growth is reflected in the rapid expansion of the Settlements land cover class. From 1,460 sq km in 1975, urban areas expanded to 2,560 sq km in 2000 and 3,830 sq km in 2013, a 161 percent increase over 38 years. The greater Accra metropolitan area has about 4 million people, Kumasi just over 2 million, and Tamale about 370,000 (GSS, 2013).

Large area classes



Small area classes





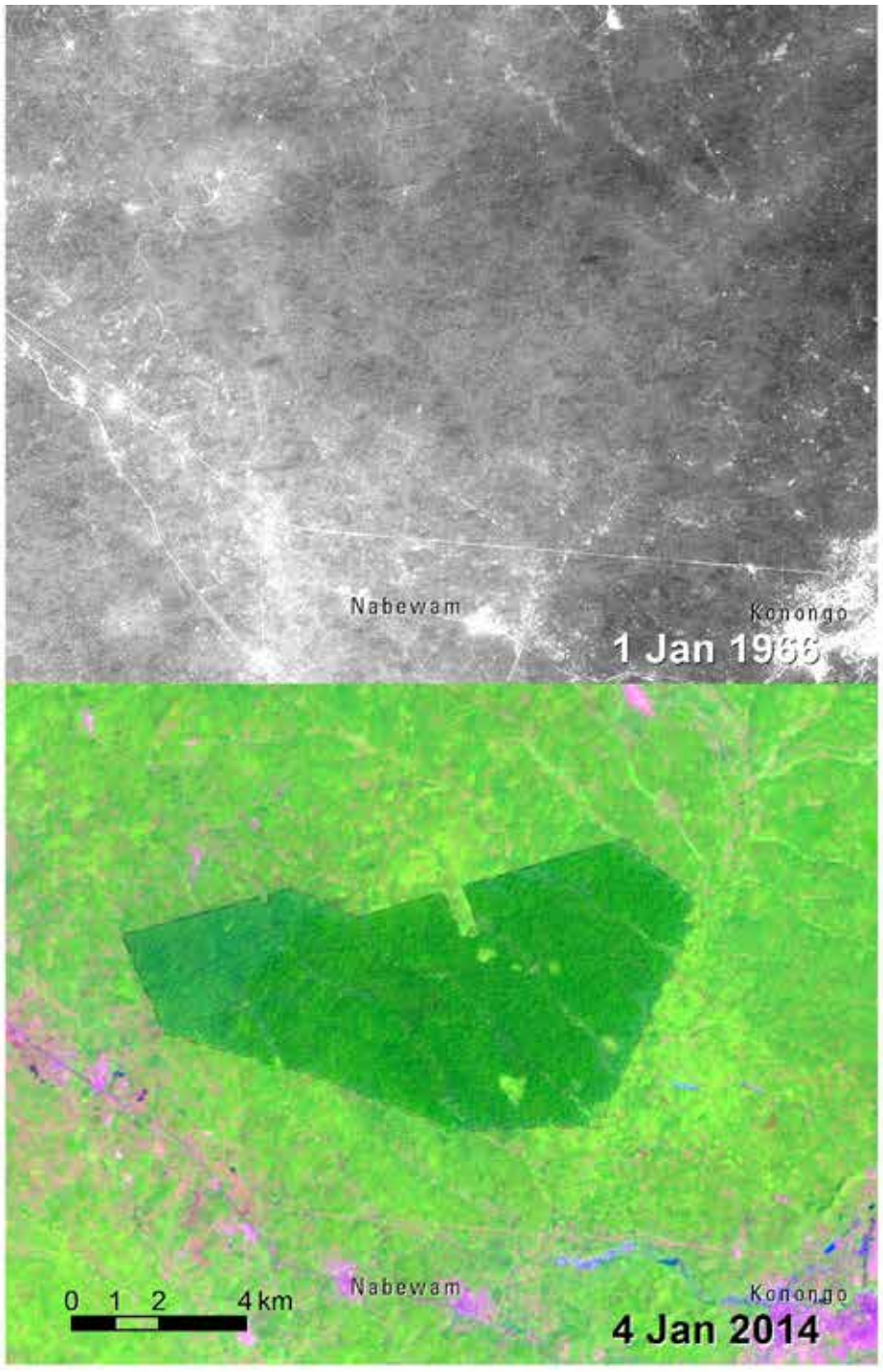
Urbanization and deforestation in the Greater Kumasi area

Kumasi is the second largest city in Ghana, after the capital Accra, and functions as the administrative, commercial, industrial, and cultural center of the Ashanti region. Owing to considerable rural-urban migration driven by the growth of industries and commercial activities in and around the city, the population of Kumasi has increased sharply over the past four decades. The census of 1970 reported 346,000 inhabitants, surpassing 1 million by 2000 and over 2 million in 2013 (GSS, 2013).

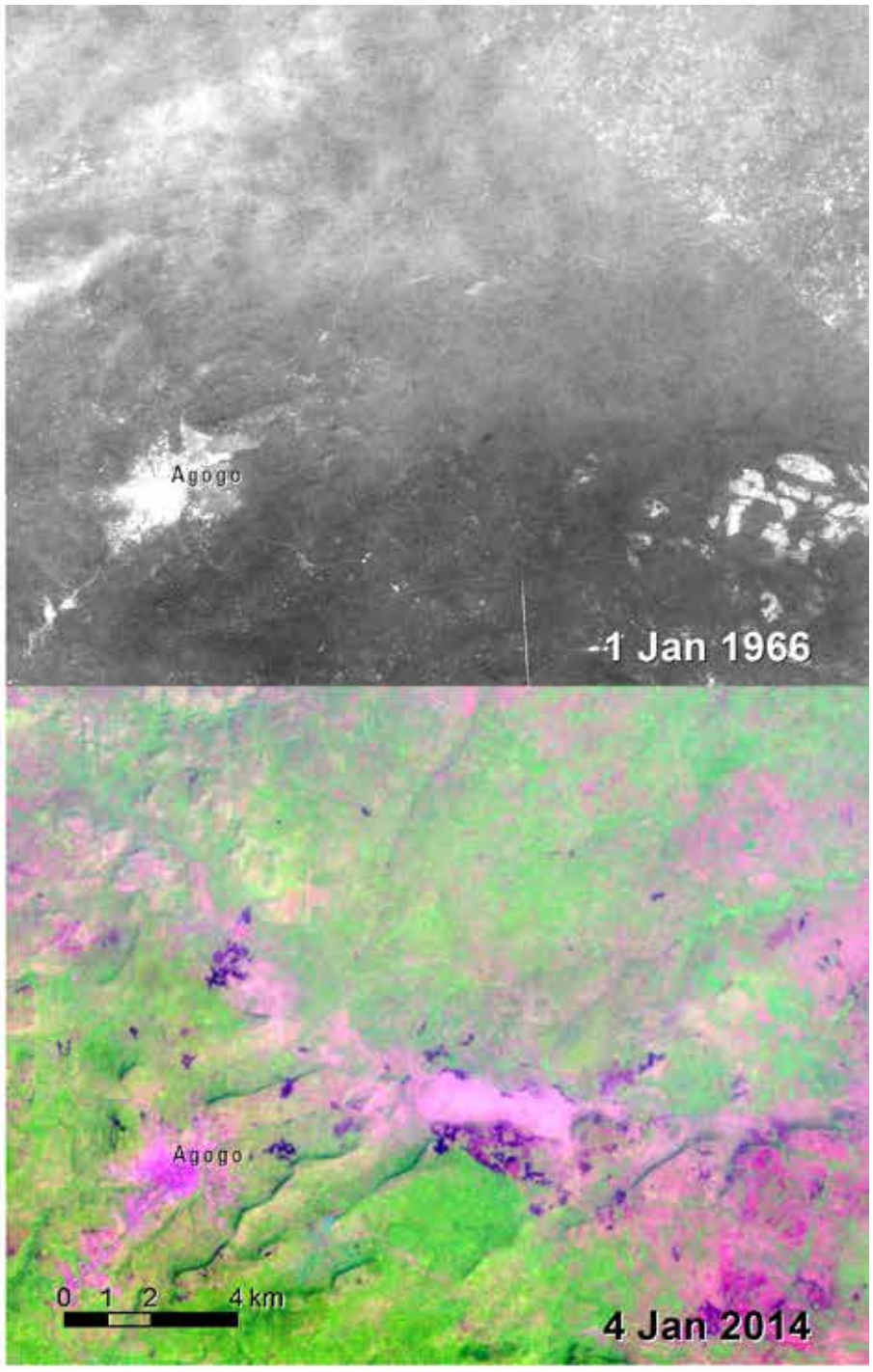
The comparison of a Corona satellite image from 1966 with a Landsat image from 2014 shows the expansion of built-up area from 60 sq km in 1966 to over 400 sq km in 2014, in parallel with the population growth in the Kumasi metropolis. The influence of the city on land cover change reaches far beyond the immediate peri-urban area. While agriculture, mostly in the form of shifting cultivation, was certainly present in greater Kumasi in 1966, by 2014 the forest and woody savanna has become considerably more fragmented within a radius of at least 50 km of the urban fringe, creating a fine mosaic of cultivated land and degraded forest.

The Bobiri Forest Reserve, 20 km east of Kumasi, illustrates the contrast between this mosaic and a continuous forest canopy. In 1966, the forest reserve completely blended in with its surroundings. Although it contains nearly 50 sq km of forest, the reserve is far from pristine. It has already been actively exploited for timber, and its more accessible parts are known to be moderately to severely degraded. By 2014, fairly large clearings for cultivation

Bobiri Forest Reserve



Bandai Hills

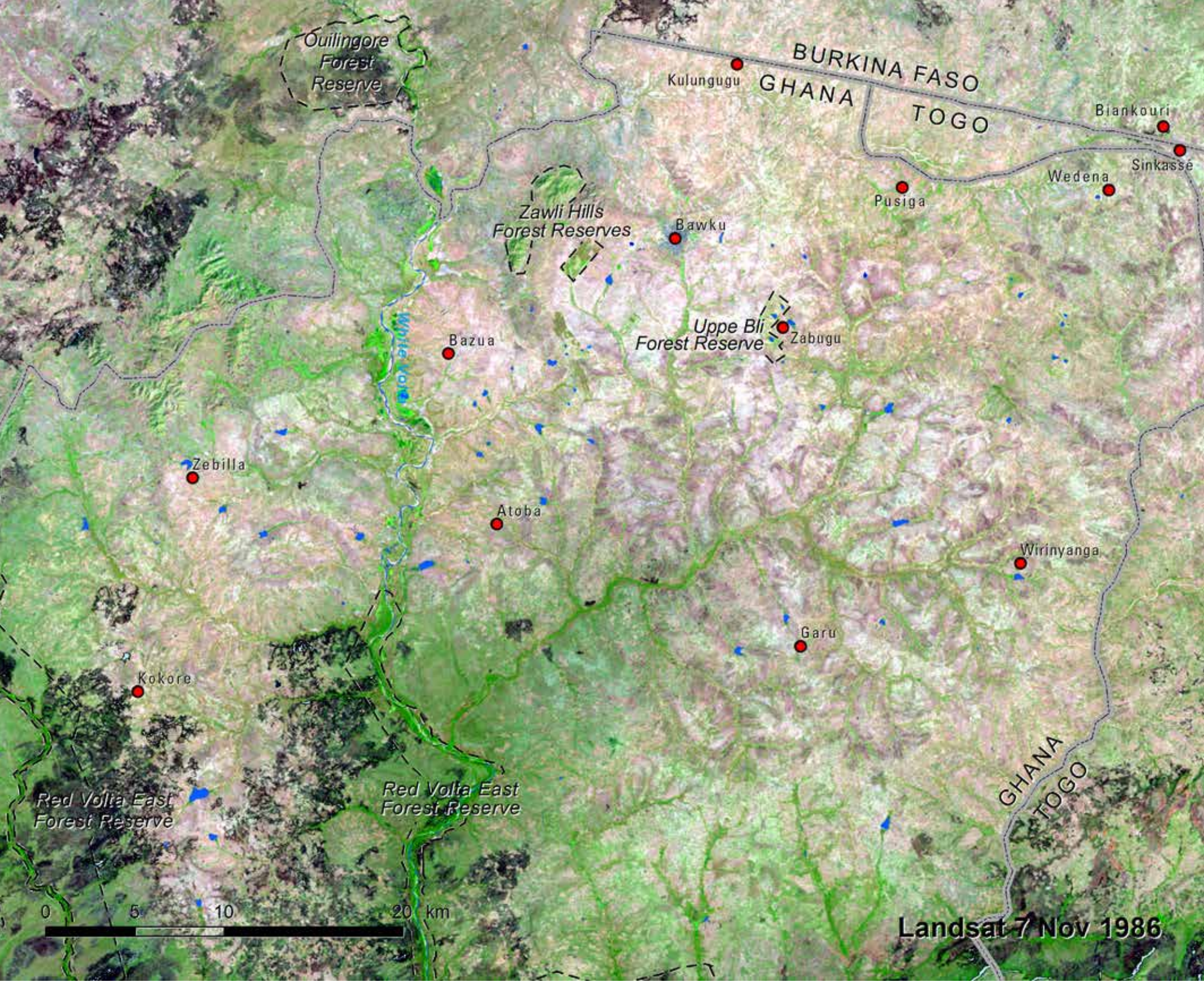


and palm wine tapper camps are visible inside the reserve. Locals collect firewood, and the felling of small trees is not uncommon. On the positive side, the reserve also includes significant sections of intact high canopy forest and hosts a forest arboretum with about 100 indigenous tree species. The reserve also has a butterfly sanctuary with 340 butterfly species, which is managed according to an ecotourism plan for the benefit of local communities.

Between 1966 and 2014 in the Bandai Hills, a contiguous area of degraded forest of 130 sq km has been cleared for cultivation to the northeast of the town of Agogo, leaving a visible footprint in the 2014 Landsat image. However, deforestation is not a new phenomenon in Ghana. Encroachment of agriculture into forest has accelerated dramatically in recent years, but historical research has shown that much of the forest inside and outside of reserves is not primary, but regenerated secondary forest on previously cultivated and depopulated lands.

ROBERT WATREL/SDSU

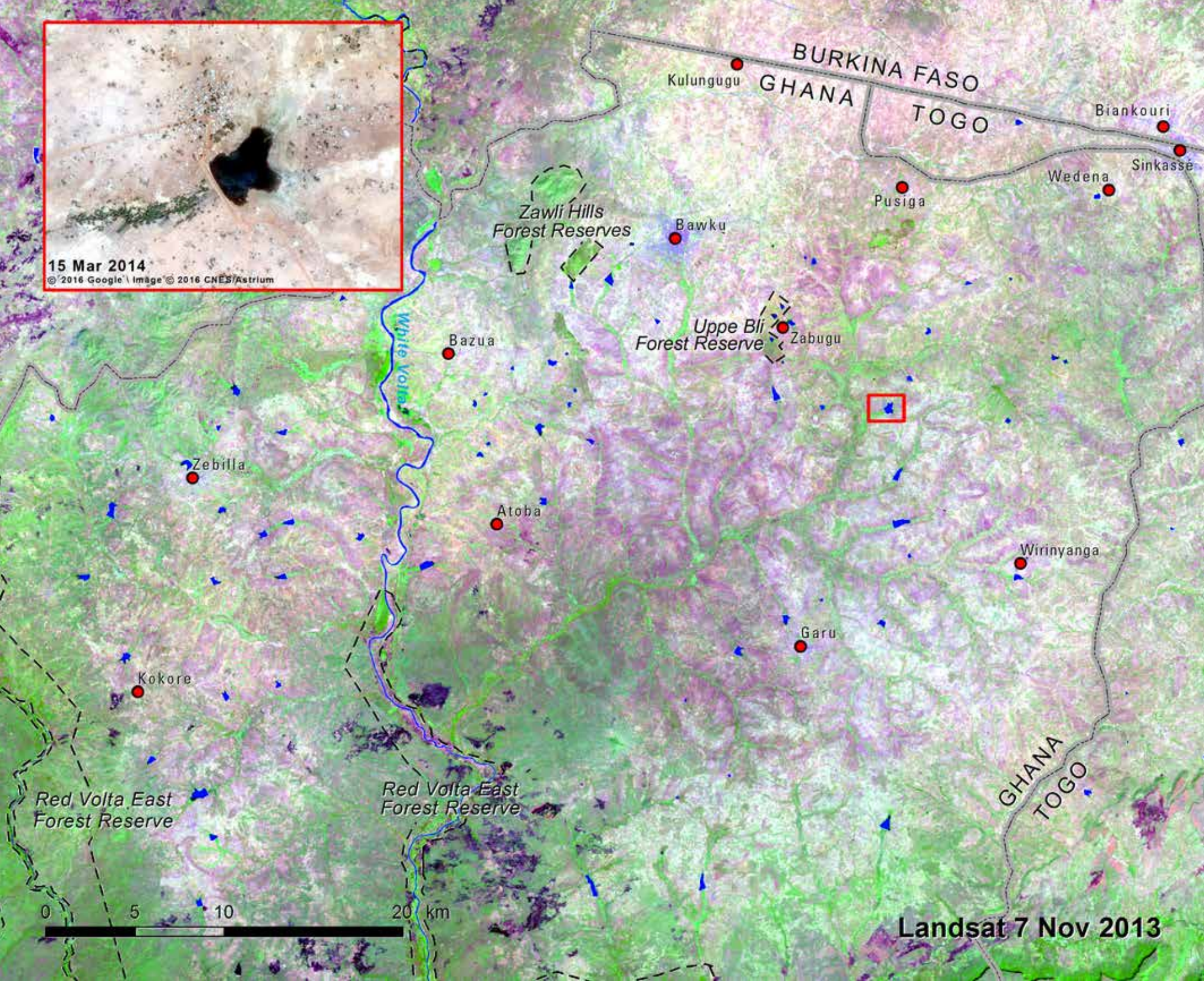
Central Kumasi



Small reservoirs as engines for local development in the Upper East region of Ghana

Northern Ghana trails the rest of the country in terms of wealth, not least because of its environmental challenges — low mean annual rainfall (about 900 mm per year), frequent droughts, and shallow soils susceptible to erosion. Given its dry climate and a high incidence of rural poverty, it is also considered the part of Ghana most vulnerable to climate change. Nonetheless, population densities are relatively high and growing, particularly in the Upper East region, where most people work in agriculture. While rates of out-migration are among the highest in Ghana at over 20 percent, birth rates are also above the national average. At the same time, northern savanna regions have served as receiving areas for Fulani migrants from Burkina Faso, Mali, and Niger. Thus, the population of the Upper East region has more than doubled from almost 500,000 in 1960 to over a million in 2010.

Due to the precarious environmental situation and high pressure on resources, the Upper East region has long been a focus of development interventions in natural resource management. Already in colonial times, protected areas had been set aside and timber plantations of local tree species established, in particular Ceiba and Anogeissus. Several small-scale water reservoirs also date from that period, when they were created to help meet the dry season water needs of the rural population. Since then, donor-funded projects have rehabilitated the old reservoirs and constructed new ones (Snyder and others, 2013). Today, 149 small reservoirs and 129 dugouts can be counted in the Upper East region. They provide a source of water for livestock, domestic use, dry season irrigation, and



fish production. A total area of nearly 9 sq km is irrigated by these systems. The water surfaces appear as small blue patches in the images, and an increase in number and size can be observed between 1986 and 2013. They are not to be confused with the larger irregular dark surfaces, which are temporary and represent areas recently burned and charred by grass fires.

A close-up view at higher resolution of the community of Bugri shows land use around the reservoir, which has a surface area of almost 10 ha and is one of the more important reservoirs (see inset). Downstream from the dam, reservoir water benefits fruit trees and allows for dry season cultivation of a variety of garden crops (onions, peppers, tomatoes). A portion of the dry season crops are sold on the market, whereas wet season crops such as maize, millet, beans and rice are mainly grown for household consumption. The ability to have two or three growing seasons per year, to keep more livestock and to sell produce on the market has made the communities with access to reservoirs more food secure and better off than neighboring communities without reservoirs (Namara, Nyamadi, and Barry, 2011). Tree densities were found to be higher and tree species more diverse in communities with reservoirs, since the availability of alternative and more sustainable sources of income has lessened the pressure on tree resources. An additional benefit that appears to have arisen from the presence of reservoirs is a strengthening of local governance and institutions, as these communal structures require collective management and have hence encouraged community organization.

STEFANIE HERRMANN / U. OF ARIZONA

Farmer watering onions and leafy winter crops using calabashes.