UGANDA

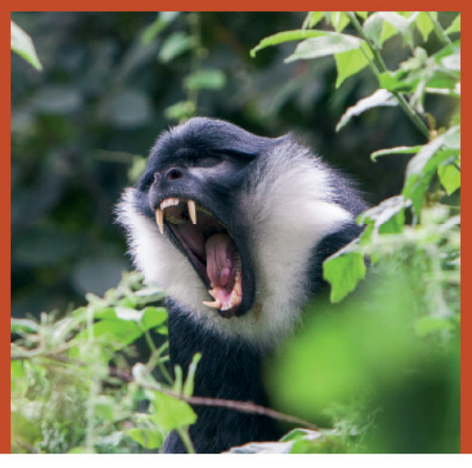
The Measure of a Land

VITAL SIGNS

Uganda:
The Measure of a Land

Tony Robertson, John Mendelsohn & Alice Jarvis





VITAL SIGNS

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VITAL SIGNS IS AN INTEGRATED MONITORING SYSTEM FOR ECOSYSTEM SERVICES IN AGRICULTURAL LANDSCAPES

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Uganda

The Measure of a Land

Foreword

The land we know as Uganda sits on the equator, located in the heart of Africa. Its fertile soils, rich biodiversity, and cool climate have long supported farming communities and growing cities, and these natural resources have positioned it to emerge as a central breadbasket for East Africa. Astonished by the beauty of the land, in 1908 Sir Winston Churchill described Uganda as the Pearl of Africa. Today the Ugandan landscape continues to be an example of natural richness, with ecosystem services that help support its rapidly growing population.

Though Ugandans depend a great deal on healthy ecosystems to support their livelihoods, many of these landscapes are now being degraded or used unsustainably. Several major drivers of degradation include land use conversion, the loss of soil nutrients, and increasing demand for food, water and energy. In addition, poorly planned agricultural development can have detrimental impacts on ecosystems and their services. This in turn disproportionally affects the poorest populations, those who depend most directly on natural resources for their livelihoods.

These issues are major challenges to Uganda, and they highlight the need for better information and more sustainable methods of harnessing agricultural resources and ecosystem services. The future of Uganda will be measured in part by how it manages the above challenges, and its ability to remain resilient in the face of disturbances and shocks like climate change, and its increasing population.

The Government and the people of Uganda are aware of these challenges and the need to preserve the wealth and richness of the land. Through its Ministries, the Government is beginning to pursue sustainable management and development of Uganda's resources and the ecosystem services that support its people.

Uganda - The Measure of a Land will help leaders achieve these goals, providing them with integrated information on the landscape, climate, demography, ecosystem services and livelihoods of Uganda. It describes in detail the current status of ecosystems and livelihoods, and sets a benchmark against which we can be held accountable by future generations for the preservation of our soils, water, forests and biodiversity.

The drum is therefore sounded to ensure the sustainability and beauty of our land. I commend *Uganda - The Measure of a Land* for describing in detail the richness of Uganda's ecosystems and the livelihoods of those who depend on them. I recommend careful study of this atlas to all those working towards sustainability in Uganda. It is an important baseline, and a source of knowledge and inspiration.

Professor G.W. Otim-Nape

Chairman, Africa Innovations Institute, Kampala, Uganda

Preface

Feeding the growing world population will require an estimated 70 - 100% increase in food production, but agricultural activities are degrading ecosystems – and the benefits they provide for people – faster now than ever before. There is an urgent need for better data and risk management approaches to guide sustainable agricultural intensification and ensure healthy and resilient livelihoods and ecosystems.

Launched in 2012 with a US$10 million grant from the Bill & Melinda Gates Foundation to Conservation International, the Vital Signs monitoring system is co-led by Conservation International, the Council for Scientific and Industrial Research in South Africa and the Earth Institute, Columbia University. Vital Signs addresses the need for open access data and for consistent, quantitative, multi-scale, co-located metrics on agriculture, ecosystem services and human well-being. A key objective is to provide a small set of relevant, scientifically valid indicators to assess and manage risk and to support policy.

Vital Signs Uganda is a partnership with the Africa Innovations Institute. Vital Signs field teams collect data on agricultural management and productivity, ecosystems and human well-being. Field data are integrated with data from satellites and are analysed to provide diagnostic tools for leaders in Africa and around the world.

This book, together with an online atlas with downloadable data (uganda.vitalsigns.org/atlas), provides a baseline of available environmental, demographic and agricultural information for Uganda.

Sandy Andelman PhD, Cheryl Palm PhD & Bob Scholes PhD

Vital Signs Technical Council

A note on sources: Brief notes on the sources of data are provided on each double-page spread. These should be read in conjunction with the Endnotes on page 44 which give full details of all sources, together with citations and additional useful information.

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Introduction

THE REPUBLIC OF UGANDA IN BRIEF

Geographical extent	Covers 241,550 square kilometres of which 17%, or 41,100 square kilometres, is open water or wetland, principally Lakes Victoria, Kyoga, Albert and Edward. Of the remaining 200,500 square kilometres of land area, about 50% is cleared for crops, 24% is forest and woodland, 18% is savanna grassland and 8% is swamps and flooded grasslands.
Frontiers with	Democratic Republic of the Congo (west), South Sudan (north), Kenya (east) and Rwanda and Tanzania (south).
Recent history	Previously a British colony; became independent in 1962. Coups in 1971 and 1985, stable government under one President since 1986.
Administration	Multi-party democracy since 2005, with a single parliamentary house responsible for legislation. The President is the head of state, government and armed forces. In 2011 there were 4 regions and 112 districts. Each district is administered by an elected council and chairperson. Kampala is the capital.
Population	24.2 million in 2002, 34.9 million in 2014. 82% in rural and 18% in urban areas in 2014, population growth rate 3.2% between 1995 and 2014. Total fertility rate 6.2 children per woman in 2011, infant mortality rate 54 deaths per 1,000 live births, and under 5 mortality rate 90 deaths per 1,000 live births in 2011.
Gross Domestic Product	US$54.37 billion in 2013, and US$1,500 per capita in 2013; growth of 5.1% in 2012/2013.
Contribution to GDP	In 2013/2014: services 45.4%; industry 26.3%; agriculture 22.2%; other 6.1%.
Exports	US$2.408 billion in 2013. Main exports: coffee, petroleum products, fish and fish products, tobacco, cement, tea, animal and vegetable fats and oils. Main export partners: Kenya, Democratic Republic of the Congo, South Sudan, European Union.
Imports	US$5.871 billion in 2013. Main imports: capital equipment, vehicles, petroleum, medical supplies, cereals. Main import partners: India, European Union, China, Kenya.

Regions

Districts

Sources: *Maps - https://gistdata.itos.uga.edu*
Text: Uganda Bureau of Statistics; Encyclopaedia Britannica, World Fact Book

SOUTH SUDAN

ETHIOPIA

DEMOCRATIC REPUBLIC OF CONGO

KENYA

RWANDA

TANZANIA

Nimule
Koboko
Atiak
Kitgum
Kidepo Valley NP
Kaabong
Arua
Kotido
Gulu
Abim
Moroto
Pakwach
Murchison Falls NP
Lira
Iriri
Lake Albert
Namalu
Masindi
Soroti
Lake Kyoga
Lake Bisina
Lake Opeta
Hoima
Nakasangola
Bukungu
Mount Elgon NP
Mbale
Kiboga
Kamuli
Semuliki NP
Luwero
Fort Portal
Tororo
Mubende
Iganga
Rwenzori Mountains NP
Kibale NP
Jinja
Busia
Mityana
Kampala
Kasese
Entebbe
Lake Edward
Lake George
Lyantonde
Masaka
Lake Victoria
Queen Elizabeth NP
Mbarara
Lake Mburo NP
Ishasha
Bwindi Impenetrable NP
Mgahinga Gorilla NP
Kabale

Regional capital
Town
Major road
National Park
Forest Reserve
Other Protected Area

N

0 100 km

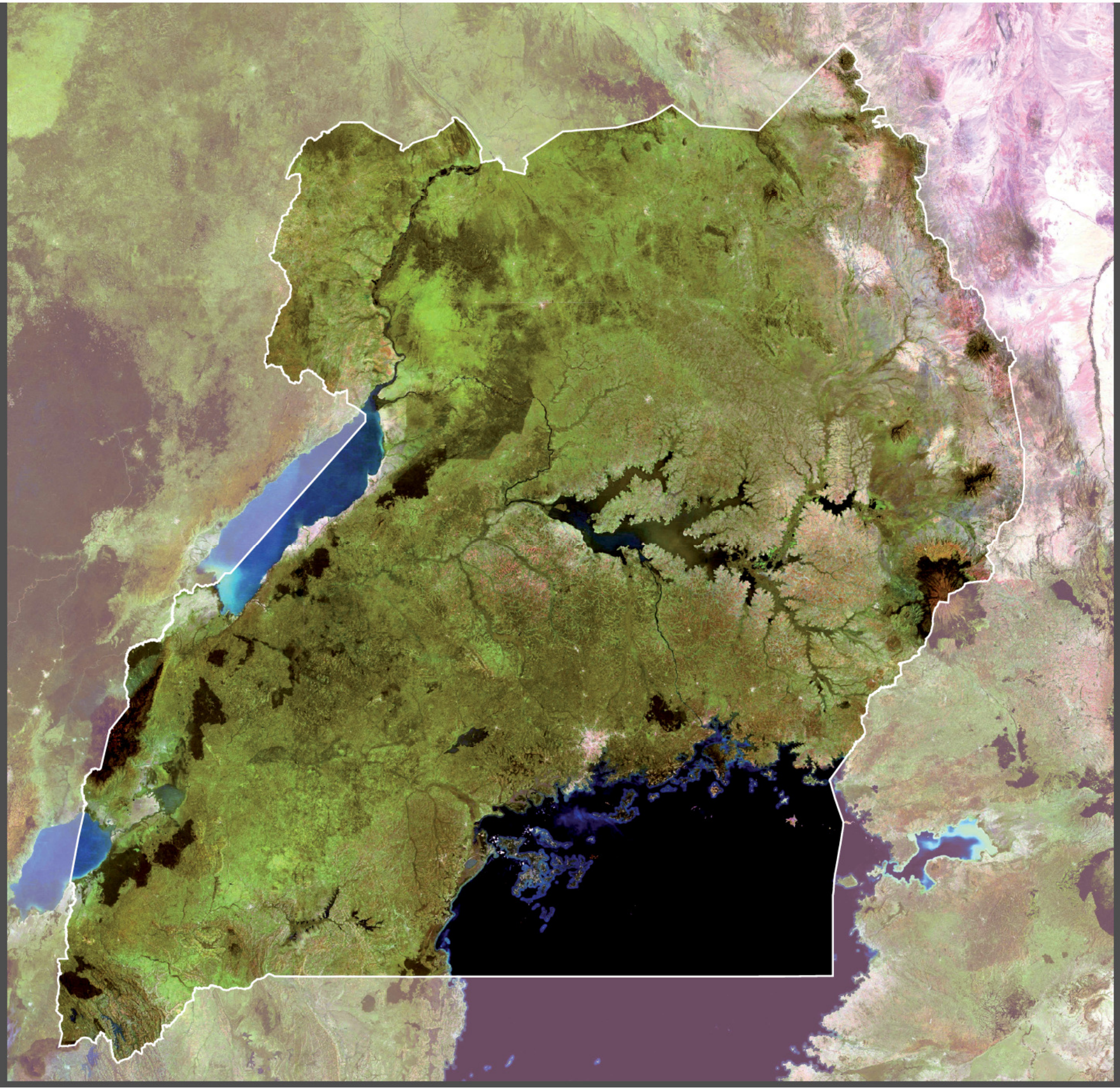
Physical landscape

TOPOGRAPHY

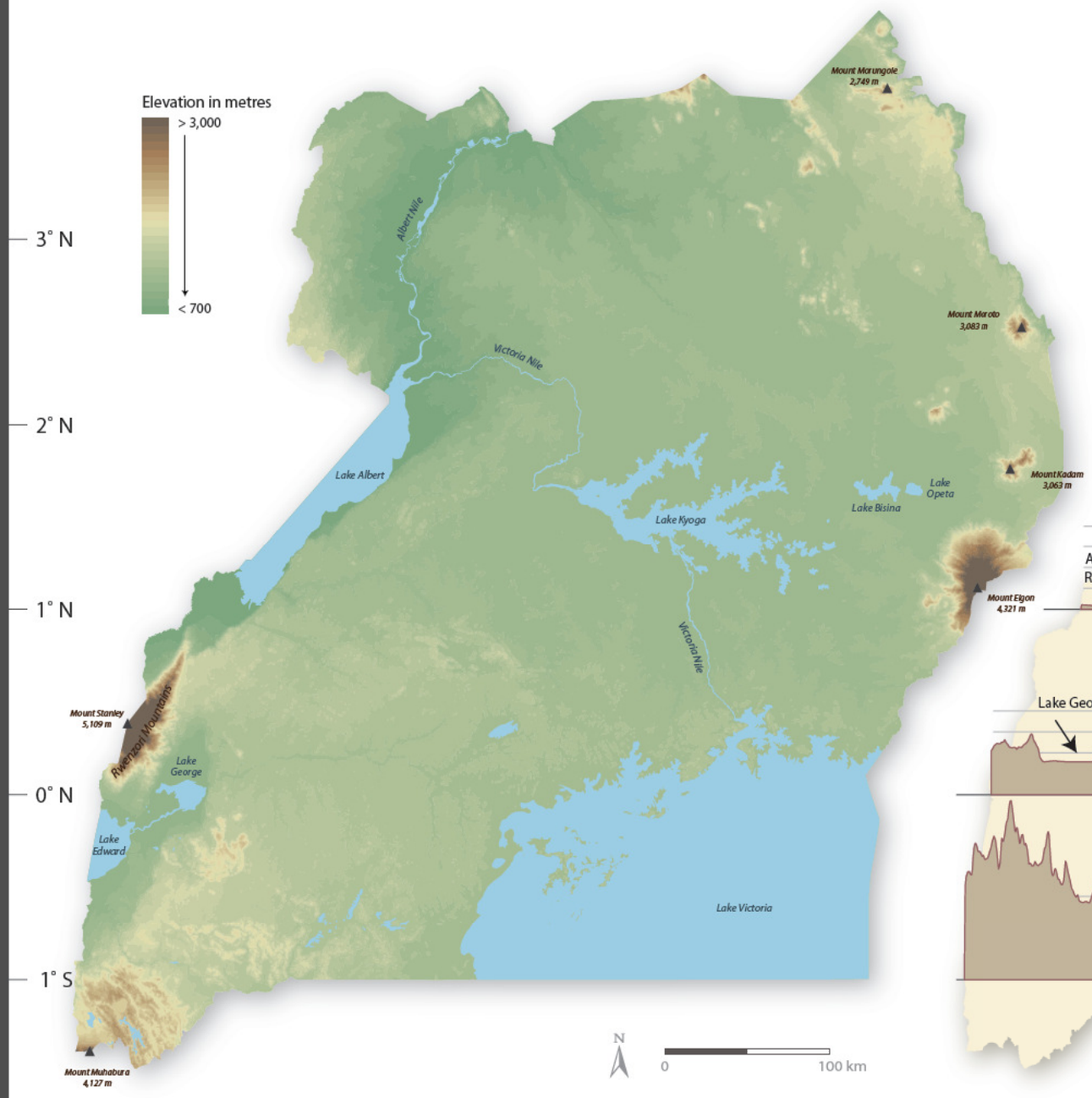
Despite its equatorial position, much of Uganda enjoys moderate temperatures throughout the year. This pleasant climate is a consequence of elevation, with most of the country being between 1,000 and 1,200 metres above sea level.

The lowest areas are in the Albertine Rift. Lakes Edward and George lie 913 metres above sea level, while Lake Albert and the Nile (as it leaves Uganda into South Sudan) are about 615 metres above sea level. By contrast, Lake Victoria is at 1,135 and Lake Kyoga at 1,035 metres above sea level.

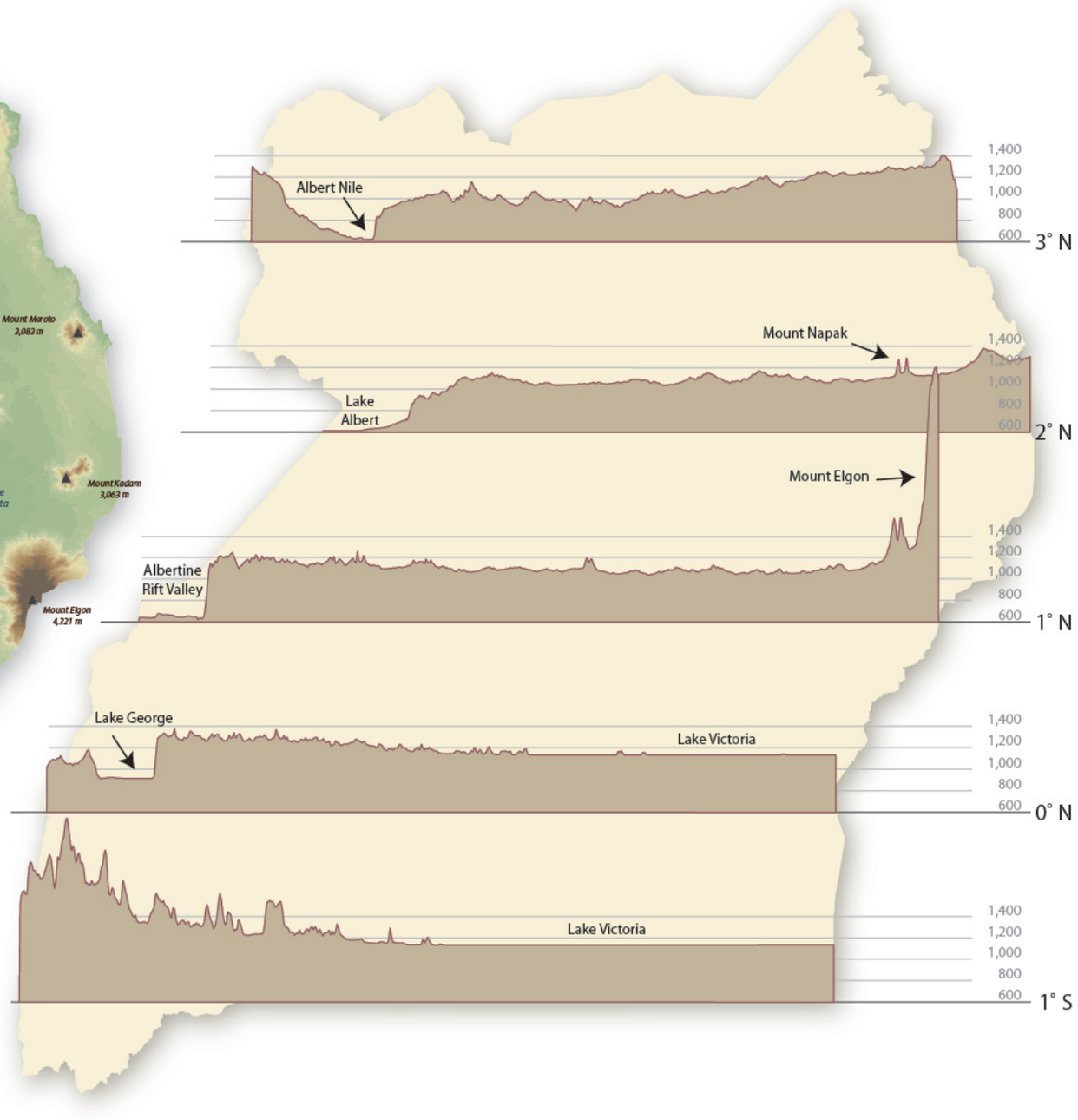
Most landscapes consist of gently rolling hills, as reflected in the elevation profiles along five lines of latitude. Those along the Equator and 1°N show how the steep eastern walls of the Albertine Rift rise several hundred metres. The only noteworthy mountains are along the country's borders: the Rwenzori Mountains in the west, the Ugandan section of the Virunga Mountains in the south-west, and Mount Elgon, Mount Kadam, Mount Moroto and Mount Morungole in the east.



Elevation



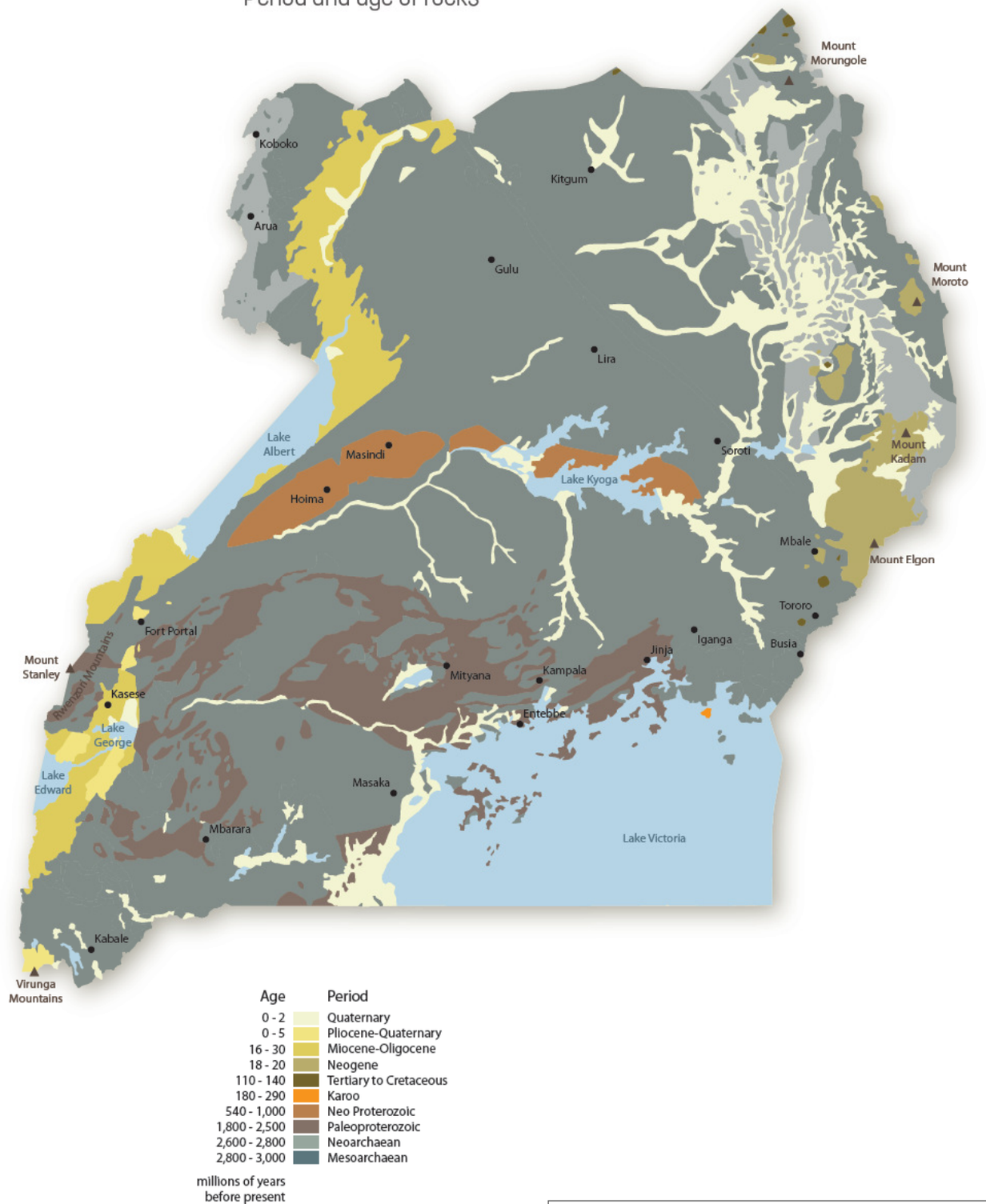
Elevation profiles along five lines of latitude



Source: Map of elevation: SRTM - National Aeronautics and Space Administration

GEOLOGY

Period and age of rocks



Source: Map and text compiled by RAISON from various sources

Uganda's geological foundation was assembled over the last 3 billion years. The oldest rock formations cover most of the country, largely as a basement of metamorphic gneisses formed when rocks were compressed and folded by extensive movements of the earth's crust which occurred several times between 2.2 billion and 540 million years ago.

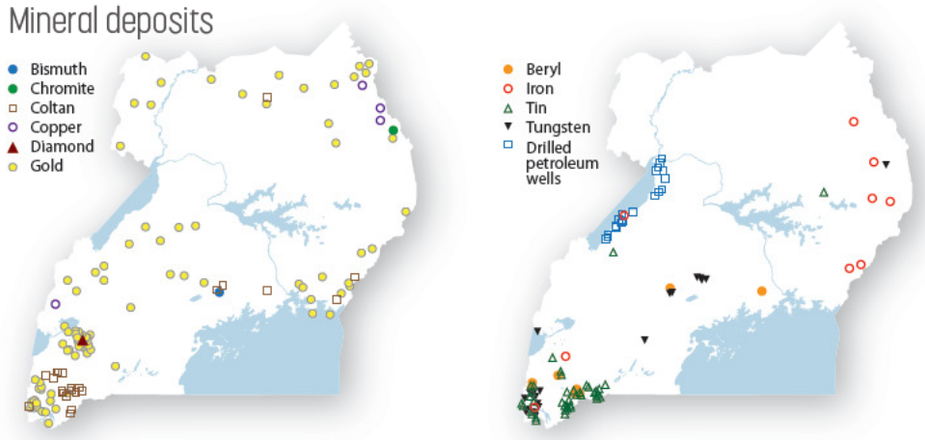
Granites from intrusive flows of magma remain between the large expanses of metamorphic rocks, particularly in the districts of Busia in the east and Kyenjojo and Kibaale in the west. These granites date from between 2.8 and 3 billion years ago.

Little was added to Uganda's geological base between 540 and up to about 30 million years ago. Other than very small areas of Karoo age shales, the only other notable features are localised carbonatites formed from volcanos that erupted between 140 and 110 million years ago.

That volcanic activity was followed by enormous eruptions and rifting caused by the development of the East African Rift Systems. Mounts Elgon, Kadam, Moroto and Napak erupted between 20 and 18 million years ago as a result. Rifting of the earth's crust along Uganda's western border led to the slumping of the great Albertine Rift as well as the uplifting of the massive Rwenzori Mountains. Many small volcanic cones and crater lakes were formed from eruptions during this era of instability. Some of the smaller cones erupted within the last 10,000 years.

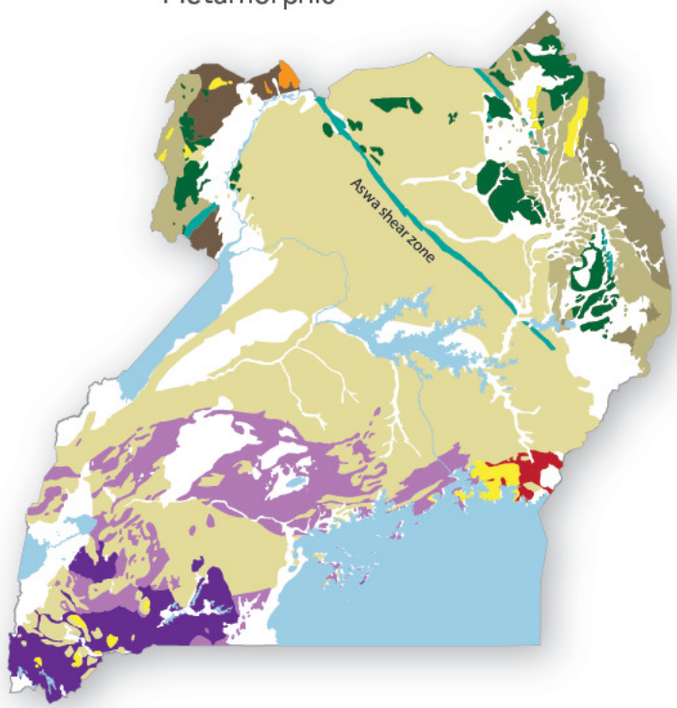
While the country has a rich variety of minerals, they contribute little to the formal economy. However, hundreds of thousands of people make their living from artisanal mining. Revenue from recent discoveries of petroleum resources in deep sediments in the Albertine Rift is expected to change Uganda's economy radically.

Mineral deposits



Rock type

Metamorphic



- Argillites and arenites
- Cataclasites
- Gneiss
- Banded gneiss
- Gneiss, amphibolites, quartzites and marbles
- Undifferentiated gneiss
- Granitoids
- Granulites
- Metavolcanics
- Phylites, schists, quartzites and amphibolites
- Schist
- Water

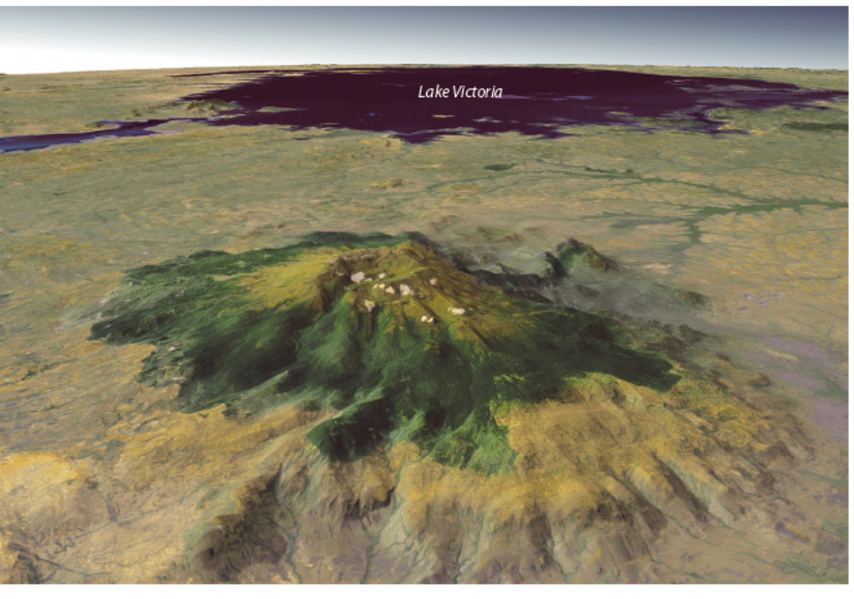
Sedimentary

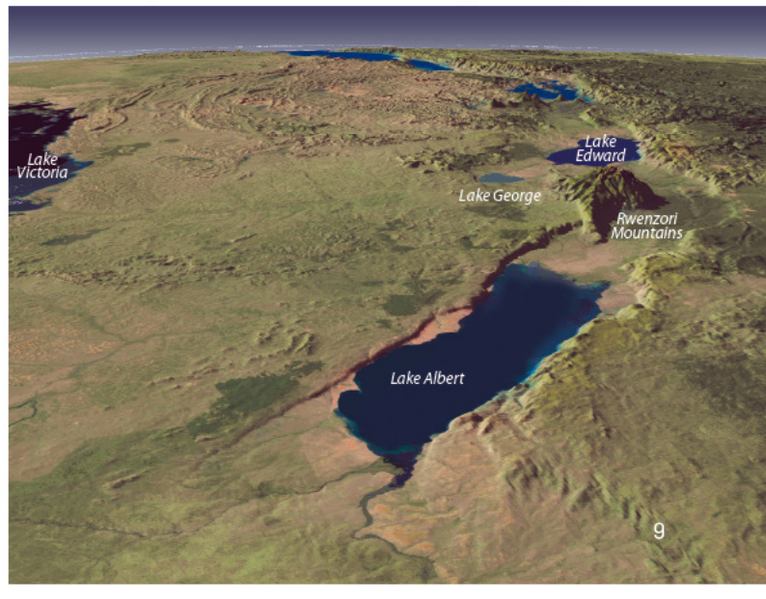
- Alluvial sediment
- Conglomerates
- Rift valley sediments
- Sandstones
- Shales
- Water

Igneous

- Granites
- Volcanic basalt
- Carbonatites
- Water

Left to right: Mount Elgon looking towards Lake Victoria; the rift wall at Lake Albert; the Albertine Rift valley looking south.





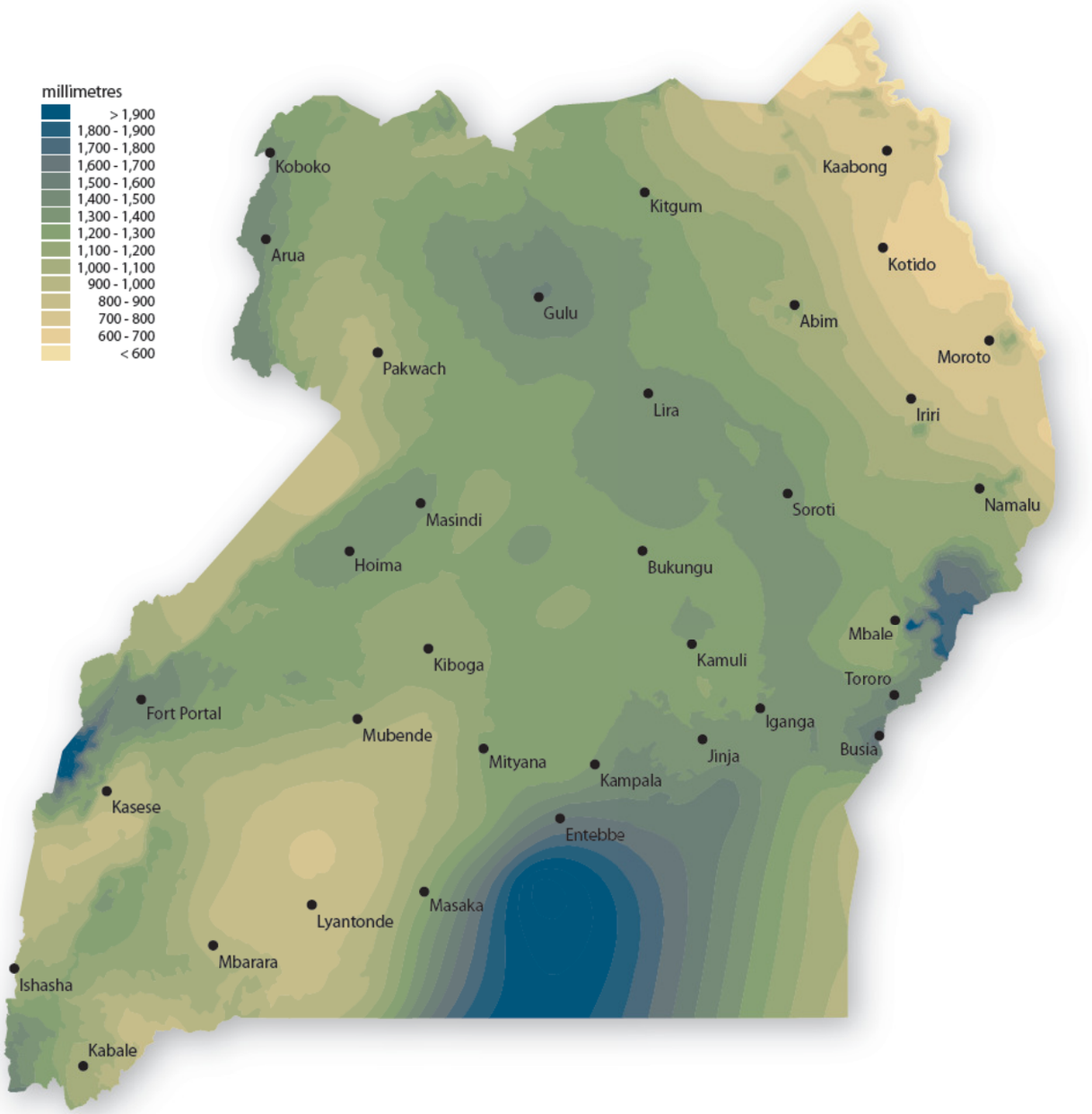
Climate

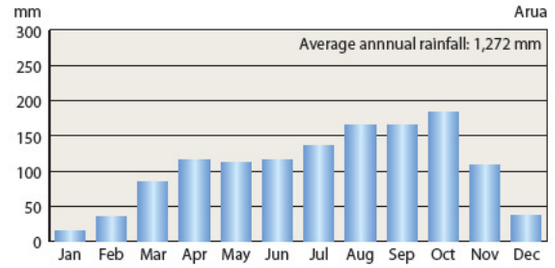
RAINFALL

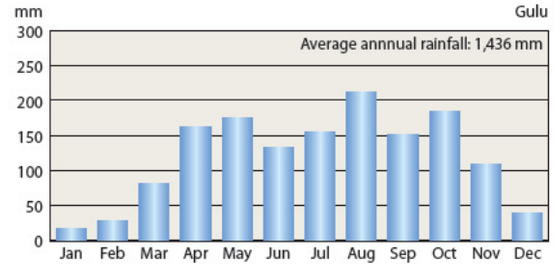
Average annual rainfall

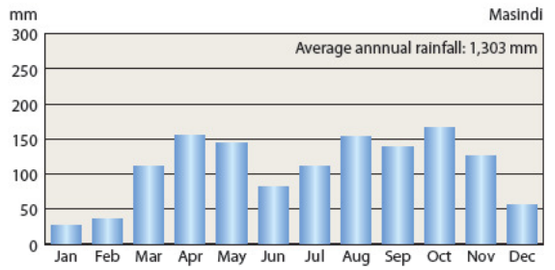
Average annual rainfall in Uganda varies over three-fold: from more than 2,000 millimetres over Lake Victoria, Mount Elgon and the Rwenzoris to less than 600 millimetres along the north-eastern border. That degree of variation over such a small area is striking.

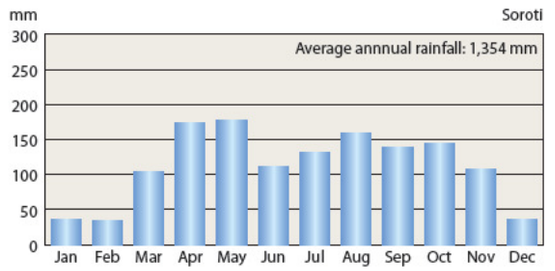
The graphs show the average rainfall per month measured at eight stations between 1961 and 2010. The average annual totals received at these stations are noted in the top right corners of the graphs. With the exception of Arua in the north-west, records show how most of the country receives rain falls during two seasons: one from March to May and the second from August to November, in some places extending into December. The duration of each season varies across the country, as does the proportion of annual rainfall received in each season. For example, similar amounts of rain fall in each season in the south-west, but in the north-west more rain falls during the August-November season than earlier in March-May.

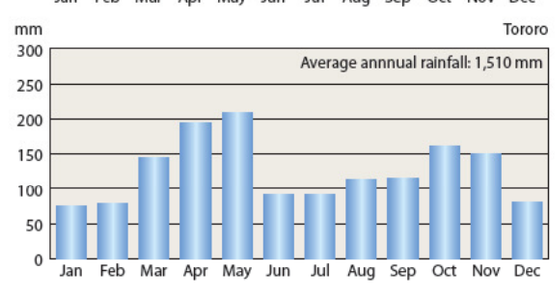


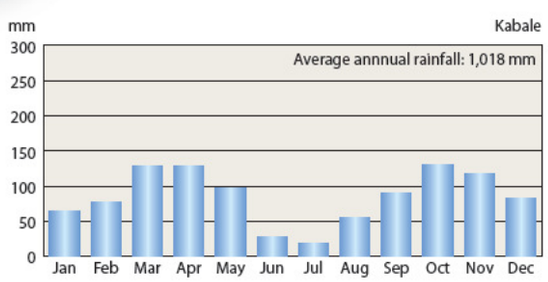


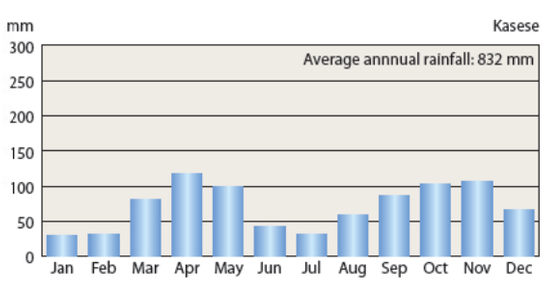


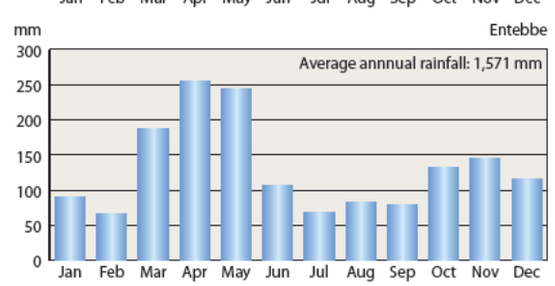




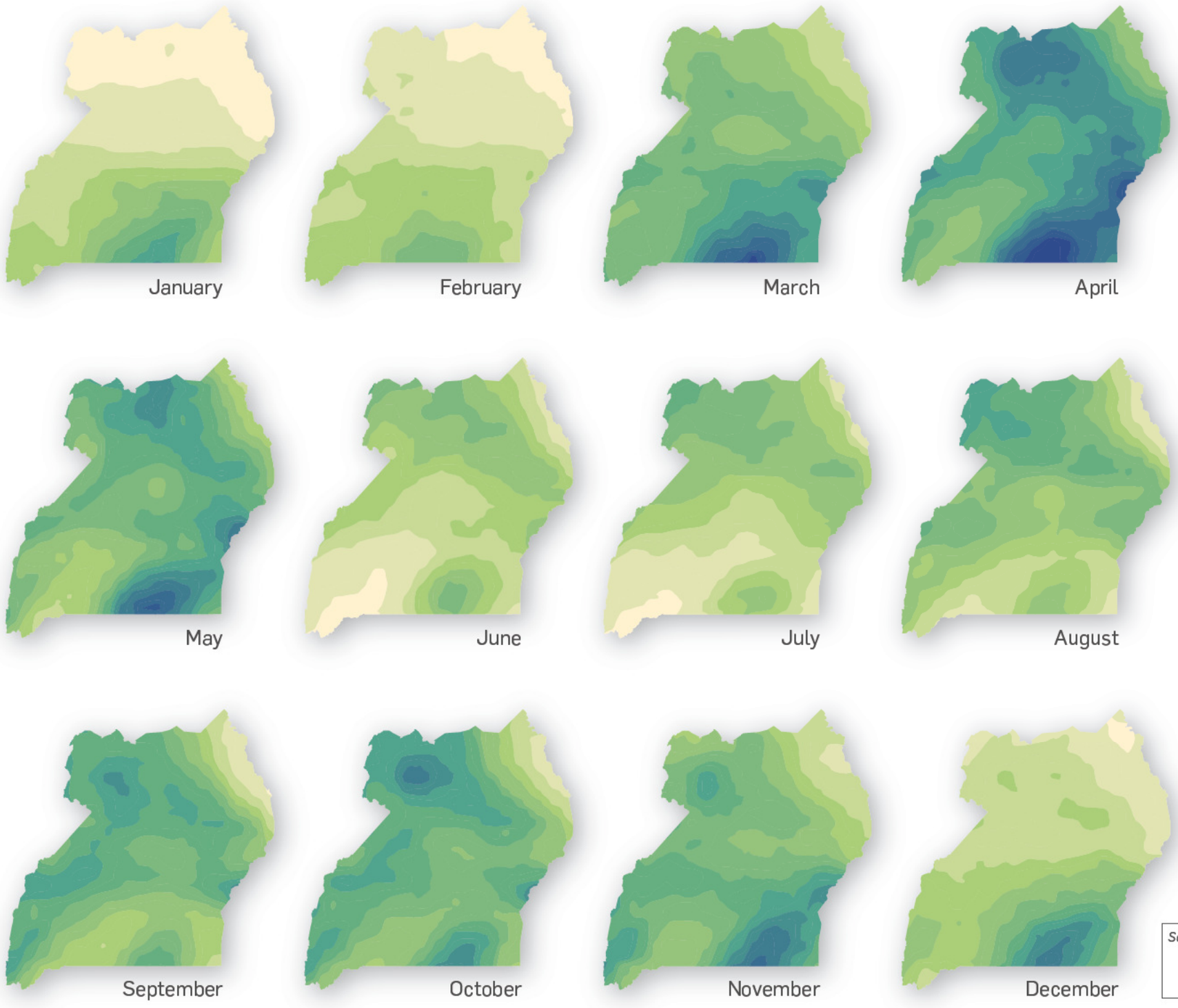








Average monthly rainfall



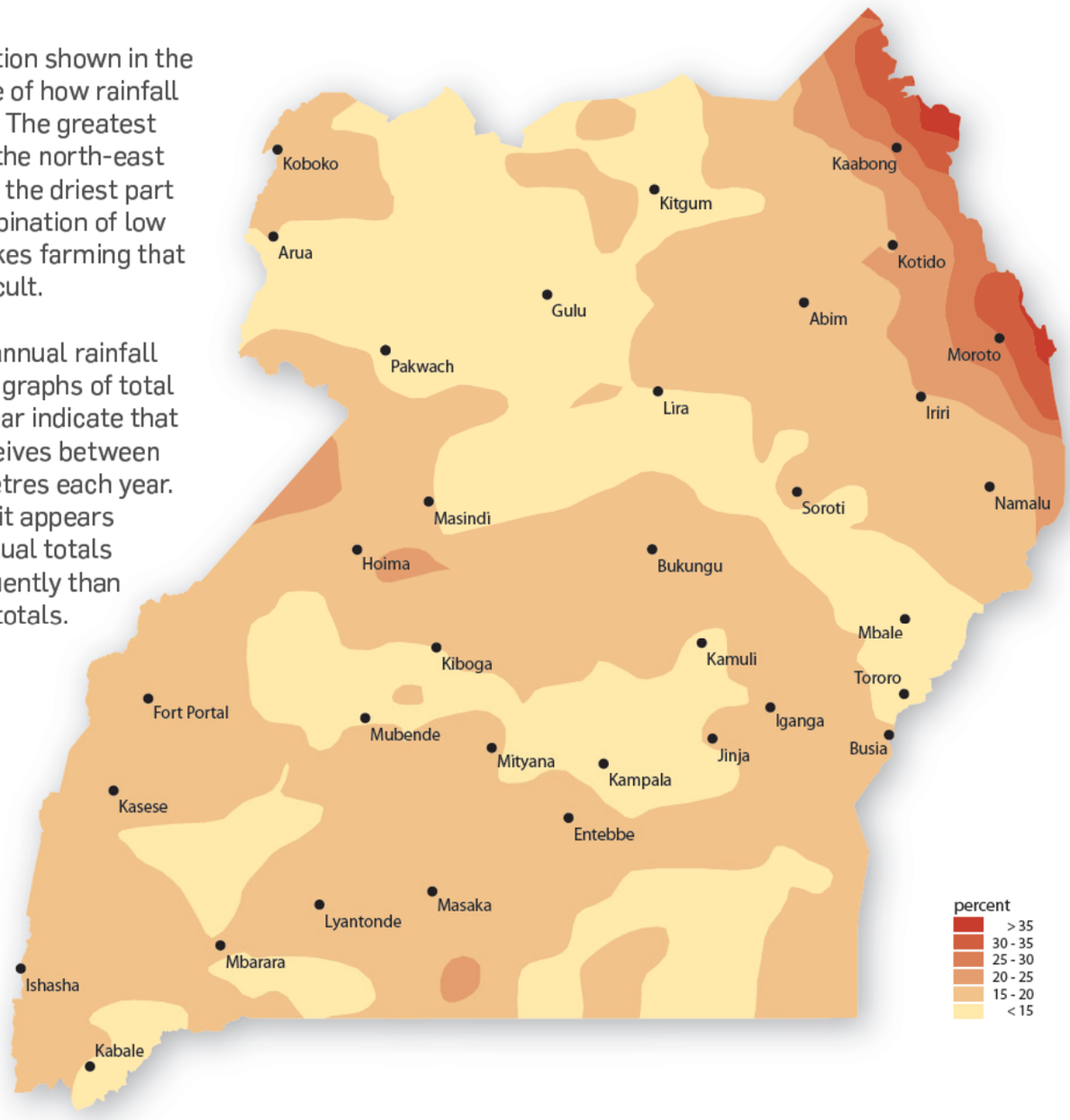
Seasonal and monthly changes in rainfall are due to shifts in the position of the Intertropical Convergence Zone (ITCZ). The ITCZ lies over, or relatively close to, Uganda during the two rainy seasons between March and May and between August and November. In June, July and August the ITCZ is north of Uganda, and that is why these are relatively dry months, especially in the southern half of the country. By contrast, December, January and February are dry months in the northern parts because much of the ITCZ then lies to the south of the Equator and Uganda.

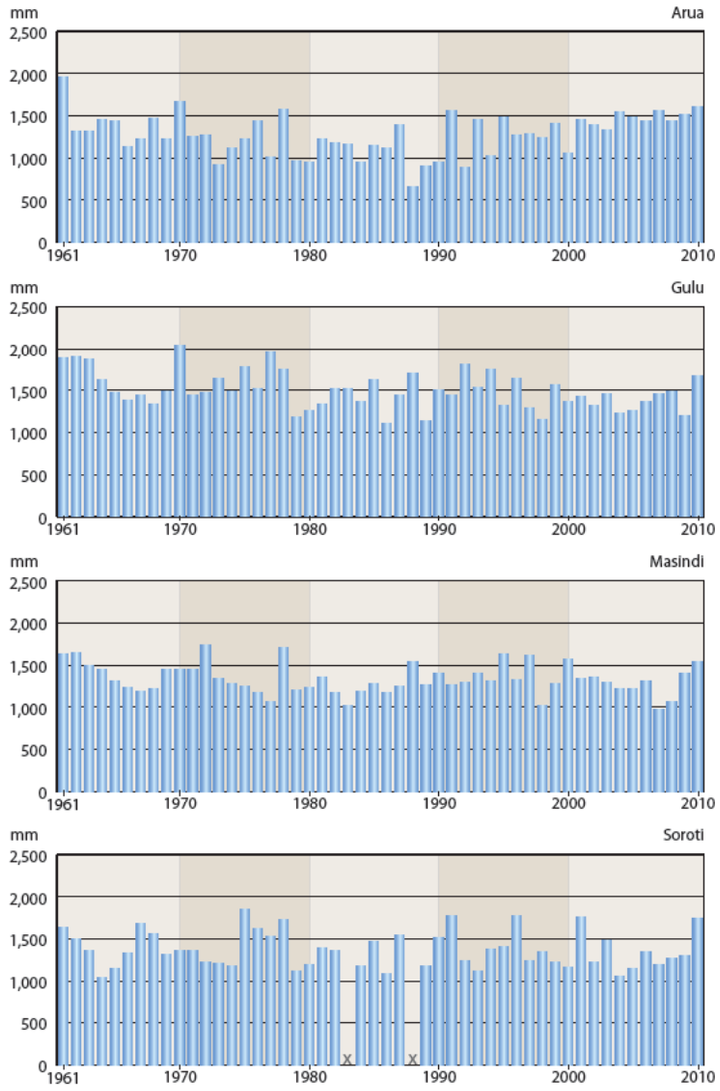
Sources: *Annual map - WorldClim representation of 1950 - 2000*
Monthly maps - Famine Early Warning System Network, 1996 - 2013
Graphs - Uganda Meteorological Agency

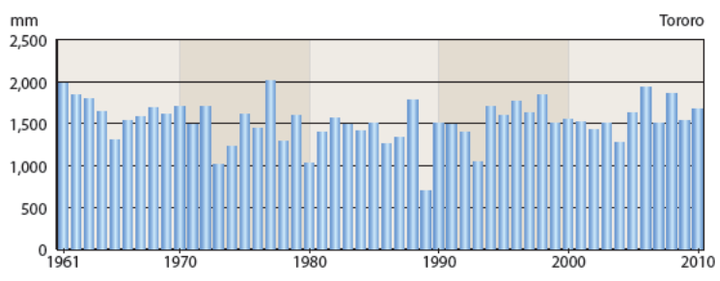
Rainfall variability

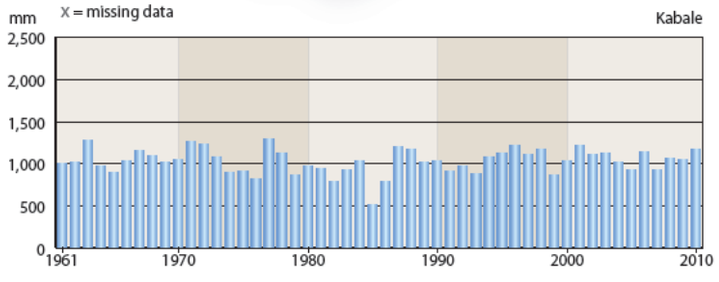
The co-efficient of variation shown in the map provides a measure of how rainfall varies from year to year. The greatest degree of variation is in the north-east of Uganda, which is also the driest part of the country. The combination of low and variable rainfall makes farming that depends on rainfall difficult.

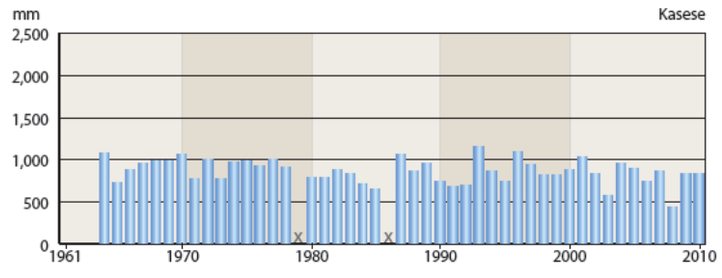
Elsewhere, variation in annual rainfall is rather similar and the graphs of total rainfall received each year indicate that most of the country receives between 1,000 and 1,500 millimetres each year. At most of the stations, it appears that occasional high annual totals are recorded more frequently than particularly low annual totals.

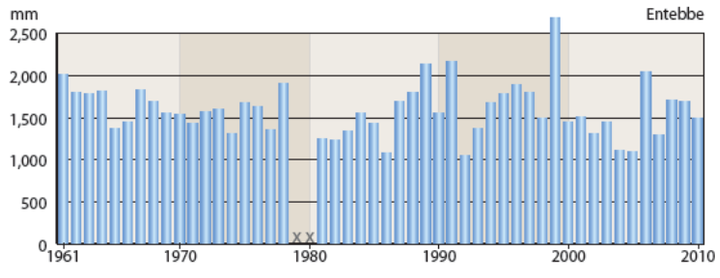










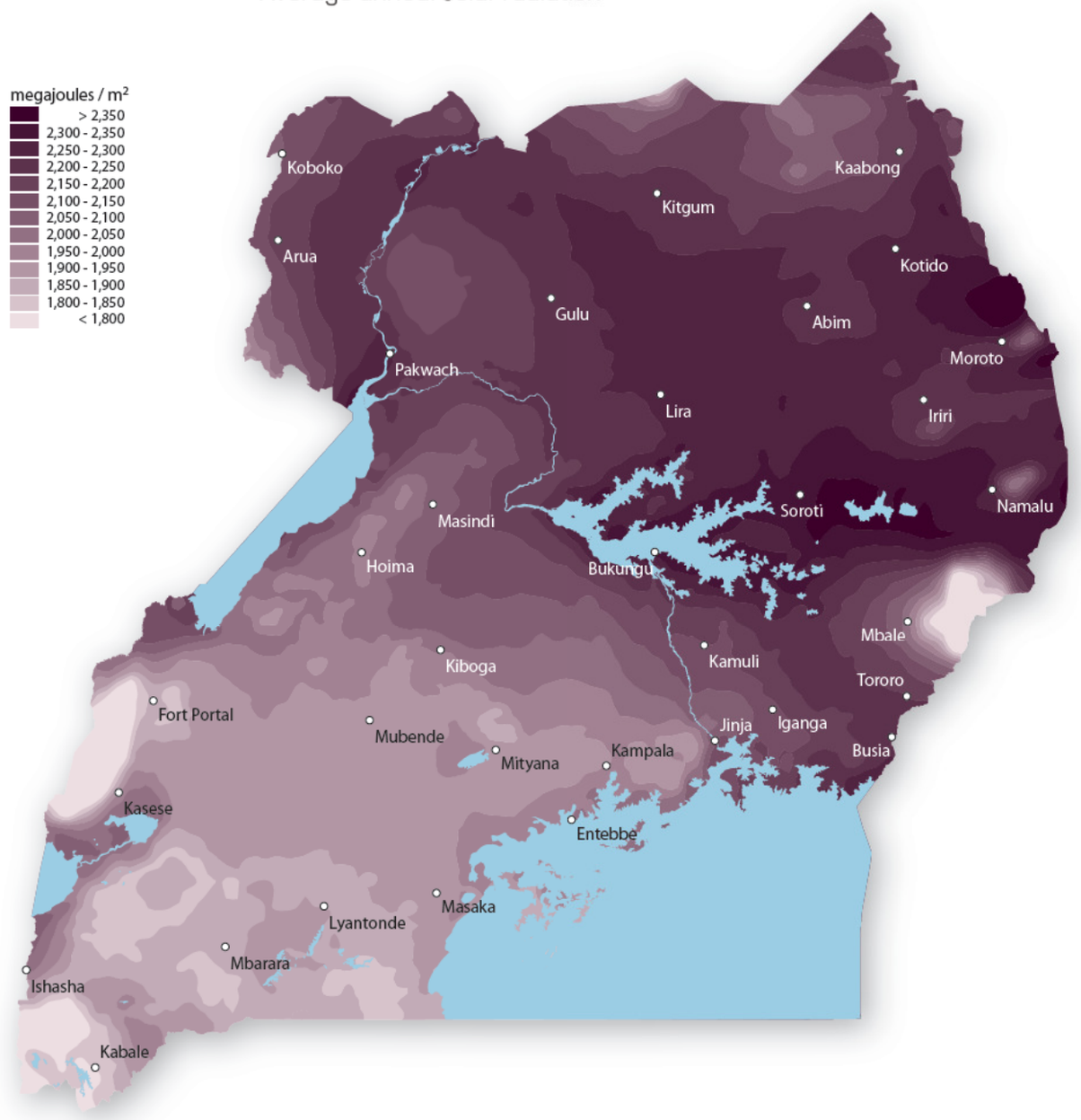


RADIATION AND SUNSHINE

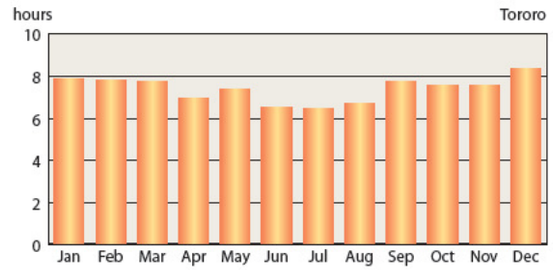
As a result of frequent cloud cover, most of Uganda sees much less sun than would be possible in an average 12 hours between an equatorial sunrise and sunset. This is particularly true in the south where about six hours of sunshine is normally recorded each day. The average duration of sunshine in the southern areas also varies little from month to month.

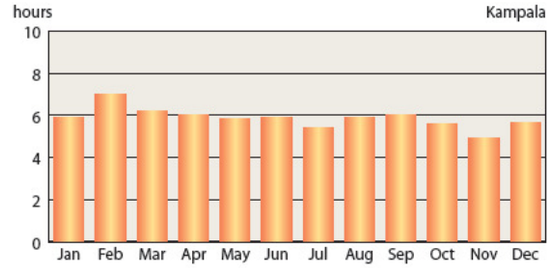
The northern half of Uganda is much sunnier. It therefore receives more solar radiation than the south, as shown in this map of solar radiation. This is measured by the average number of megajoules reaching a square metre of ground each year. Persistent cloud cover over the Rwenzori Mountains and Mount Elgon limits solar radiation over these and other highlands, an effect which is clearly visible in the map.

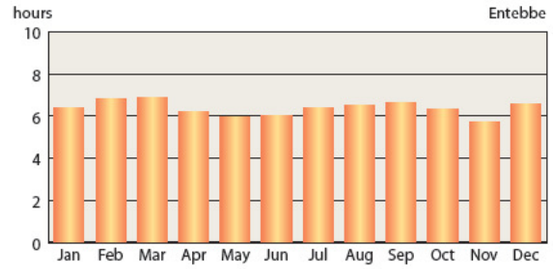
Average annual solar radiation

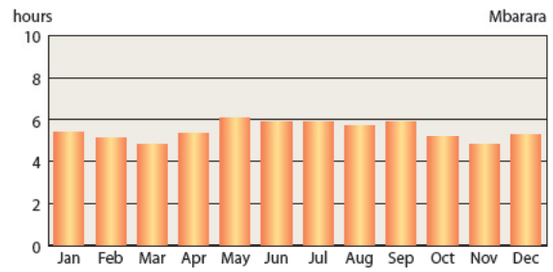


Average hours of sunshine per day









Sources: *Map of variability - Famine Early Warning System Network, 1996 - 2012*
Rainfall graphs - Uganda Meteorological Agency, 1961- 2010
Radiation - Joint Research Centre, European Union, 1998 - 2011
Sunshine graphs - Karume et al *2007, data from 1990 - 2005*

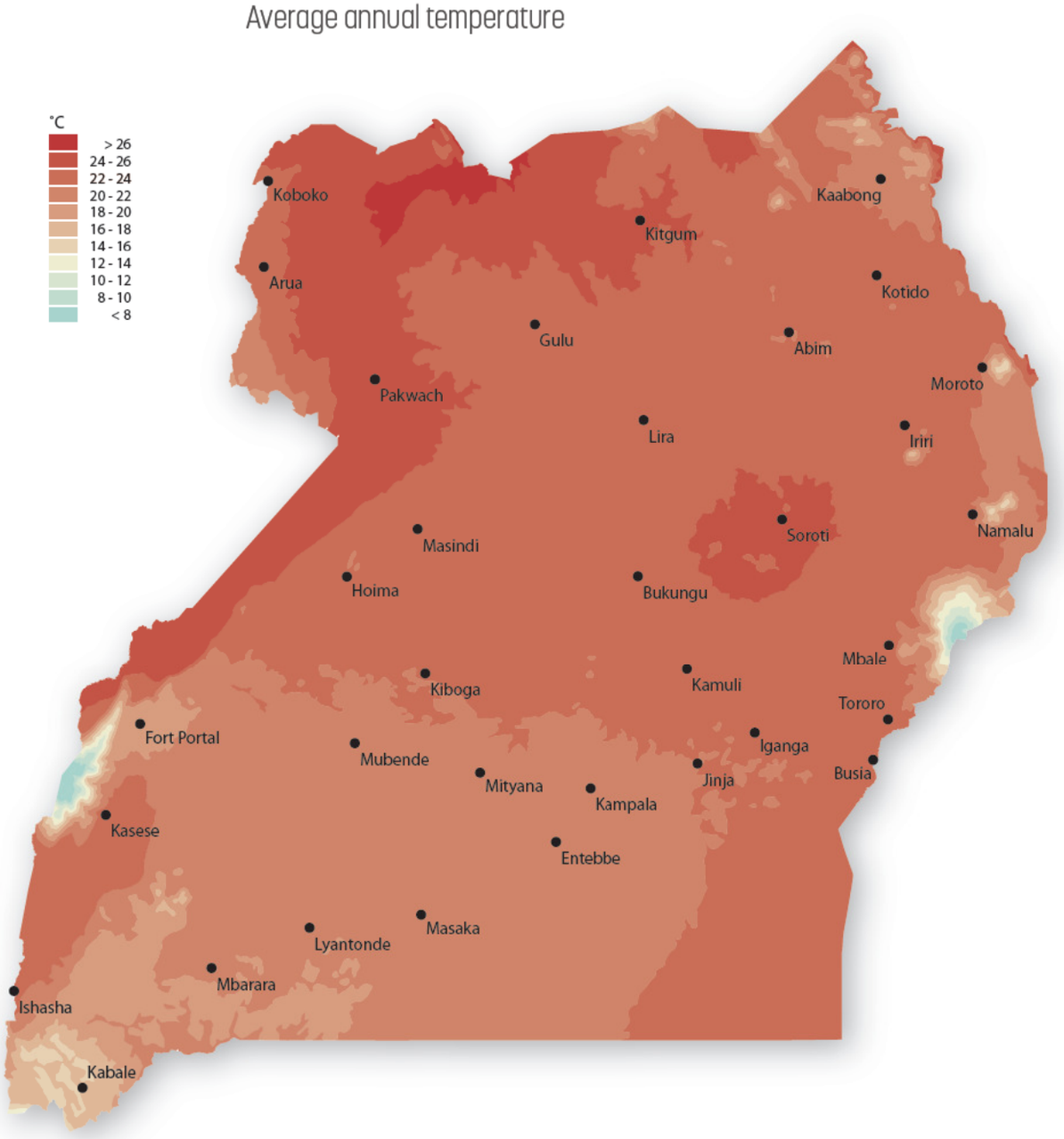
TEMPERATURE

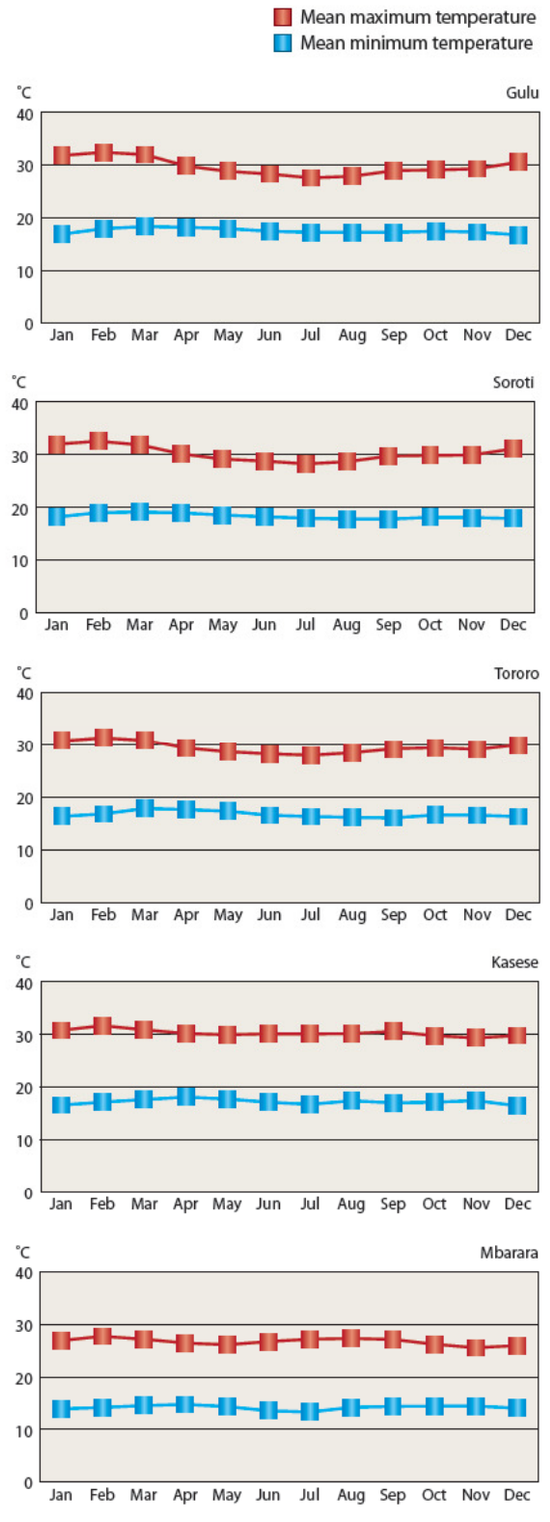
The most important determinant of temperature in Uganda is elevation: highlands are cool and lowlands warm. Overall, temperatures are mild and the only extremes are the sub-zero temperatures recorded on the tops of the highest mountains: Mount Elgon and the Rwenzoris. As shown in the graphs of readings from five stations, maximum temperatures are on average just below or above 30°C, while minimum temperatures range between about 15 and 20°C each day.

Throughout the country average minimum temperatures hardly change during the year. The same is true for maximum temperatures in the south, but the period between December and March tends to be the hottest further north. June, July and August have the lowest maximum temperatures in these northern regions.

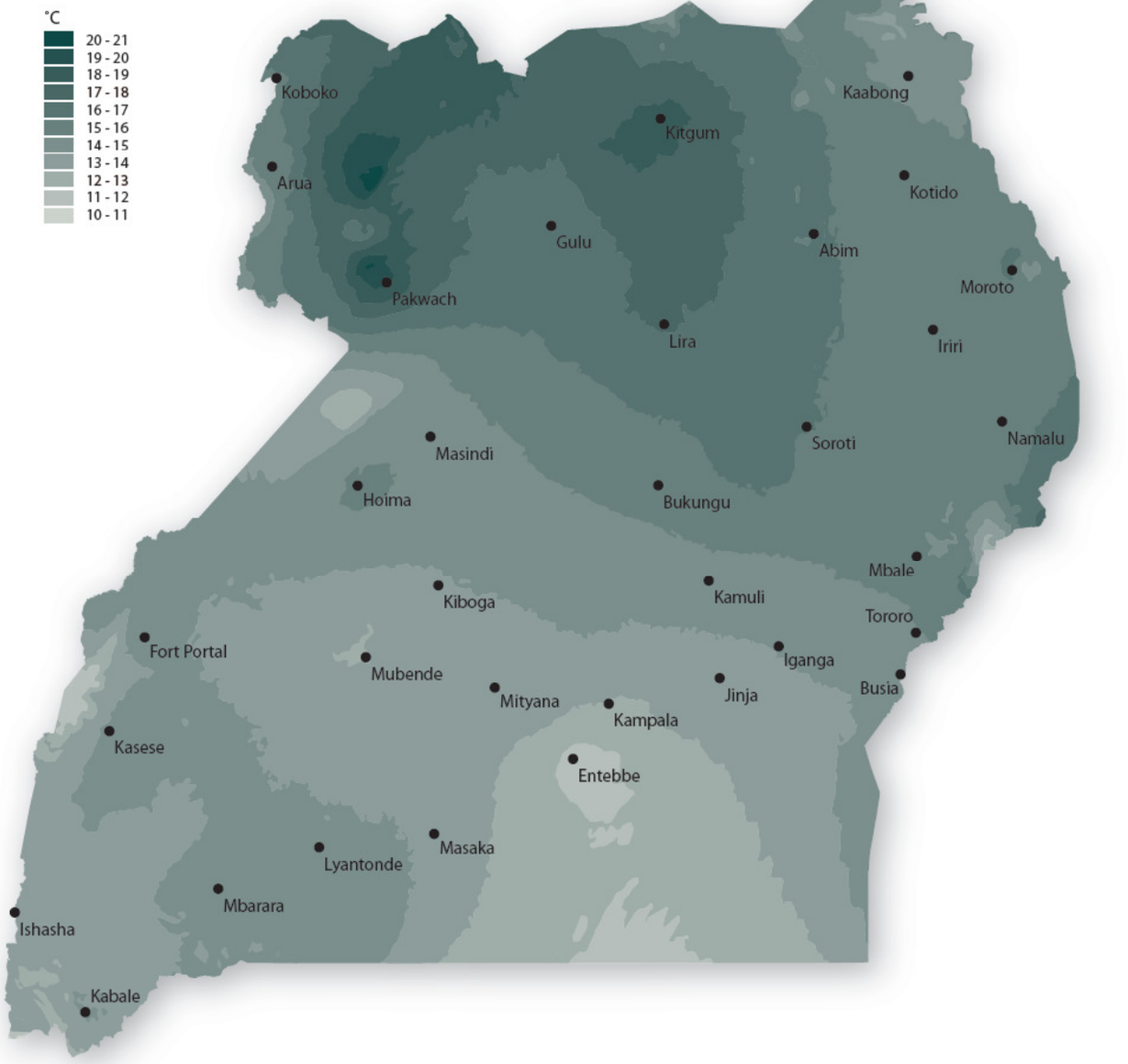
Maps of minimum and maximum temperature on the facing page are of the average lowest and highest temperature during the coldest and warmest months, respectively. The map of annual range shows the difference in average temperature between the warmest and coldest months of the year.

Average annual temperature

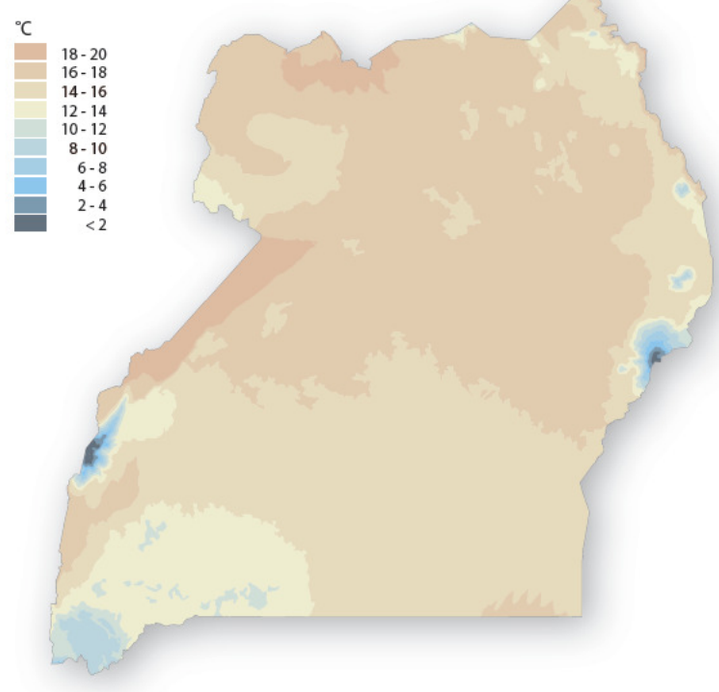




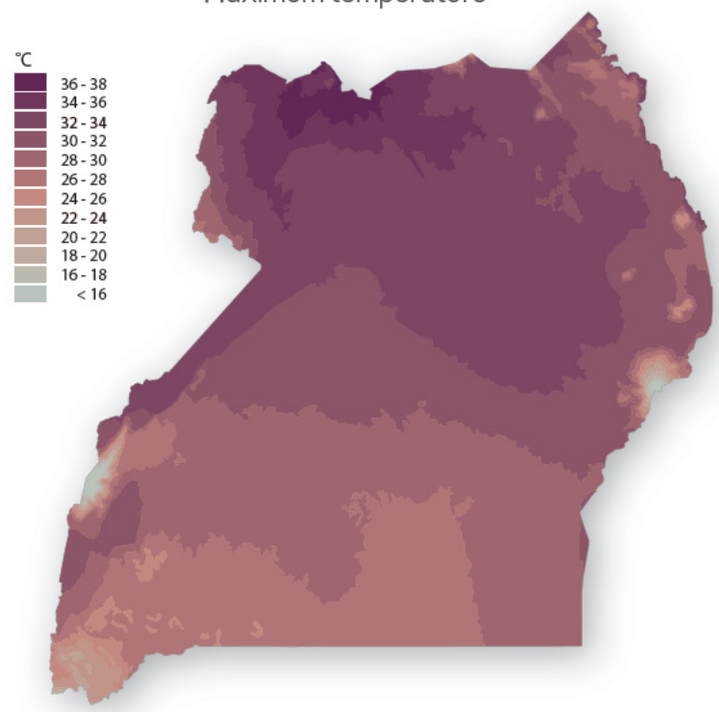
Annual temperature range



Minimum temperature



Maximum temperature



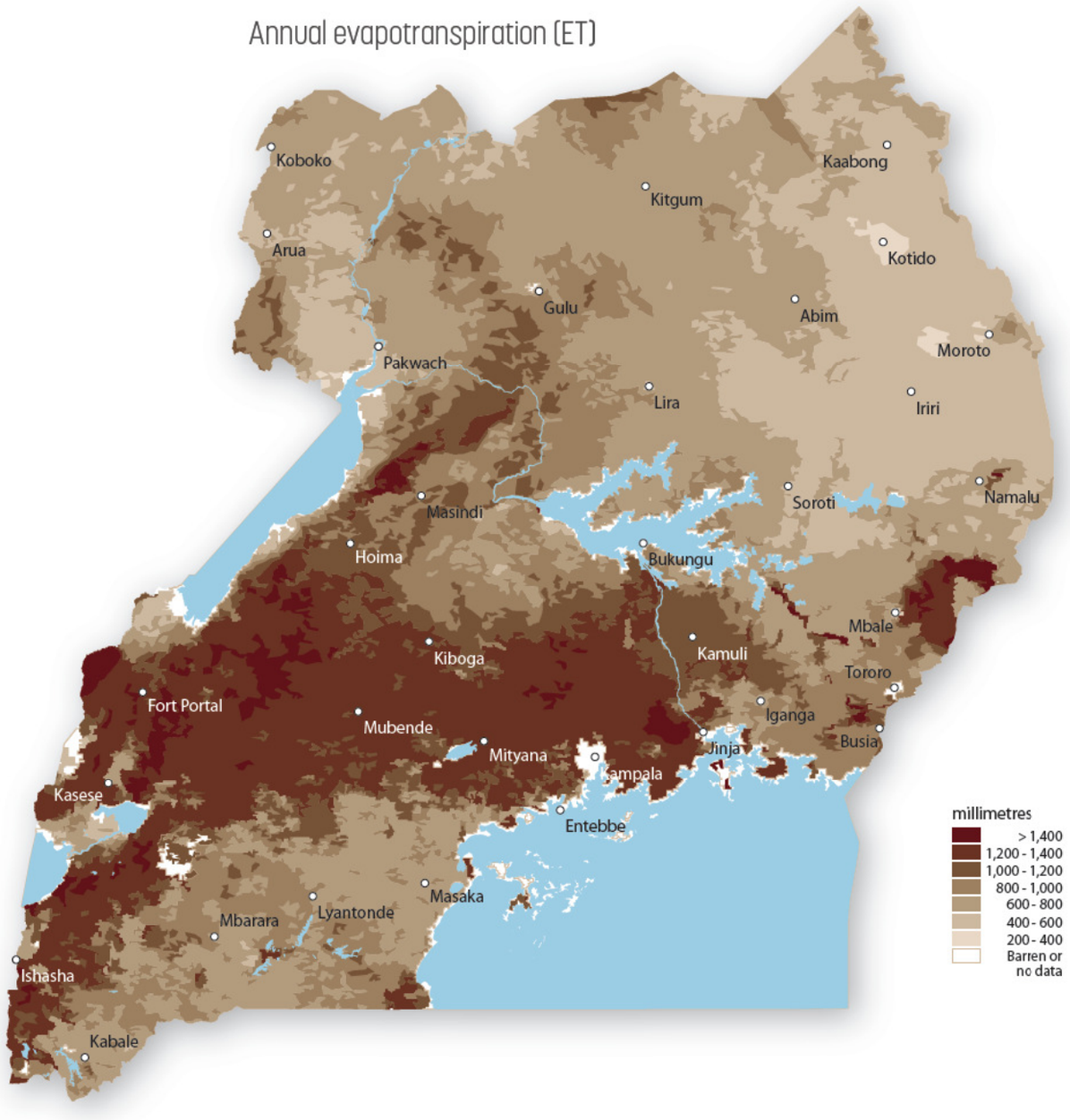
Sources: Maps of temperature - WorldClim, 1950 - 2000
Graphs of temperature - Uganda Meteorological Agency, 1961 - 2010

EVAPOTRANSPIRATION

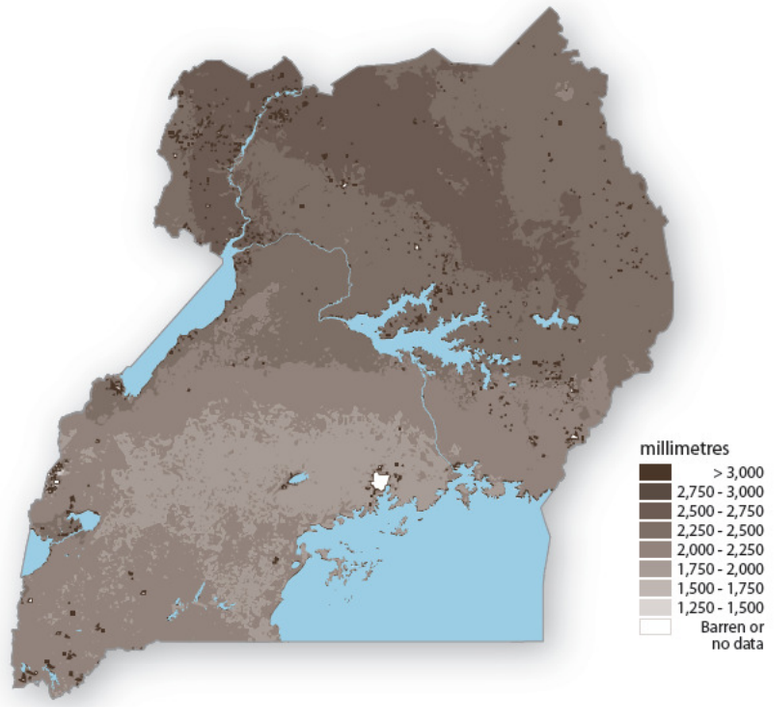
Evapotranspiration (below) is the amount of water lost to the atmosphere each year through evaporation and transpiration by plants. The large map shows how much water is lost in this way in an average year. Potential evapotranspiration (top right) is a measure of how much water would be lost per year if sufficient water was available to evaporate or be transpired.

This is largely determined by the extent of solar radiation. The difference between actual and potential evapotranspiration (bottom right) is a measure of the water stress experienced by plants. Broadly, the degree of water stress is low in the southern half of Uganda, allowing year-round crop production, and higher in the north, where there is a distinct growing season.

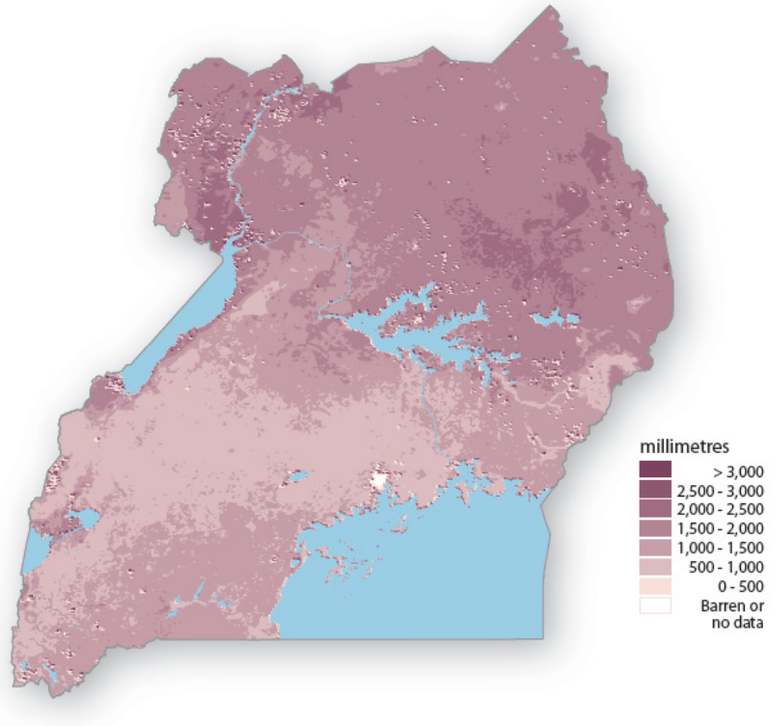
Annual evapotranspiration (ET)



Potential evapotranspiration (PET)



Difference between ET and PET

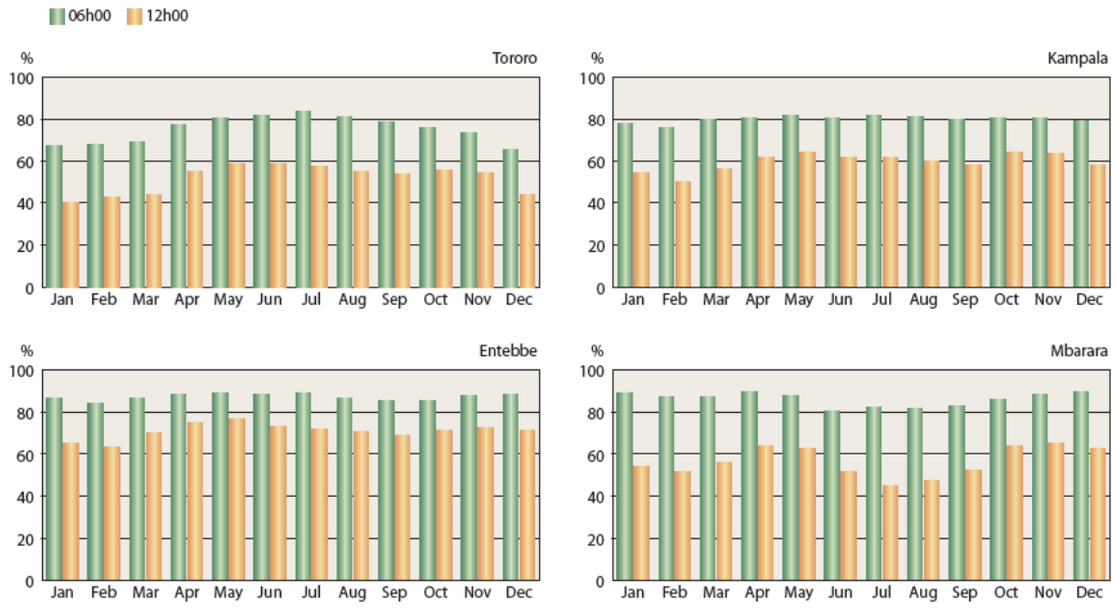


HUMIDITY

Relative humidity measures the amount of water vapour in the air relative to its saturation point which is influenced by temperature. As a consequence, relative humidity is high in the early morning when it is cool, and it then drops as the day heats up. Standardised measurements at weather stations are therefore typically taken at 06h00 and at 12h00.

The graphs show that relative humidity remains relatively constant during the year at these stations in southern Uganda. Greater fluctuations occur in the north of the country where seasonal changes in rainfall are also greater.

Entebbe is on the shores of Lake Victoria, while Kampala is just 30 kilometres away from the main body of lake water. That small distance makes a difference to the climate, with Entebbe being noticeably more humid than Kampala.

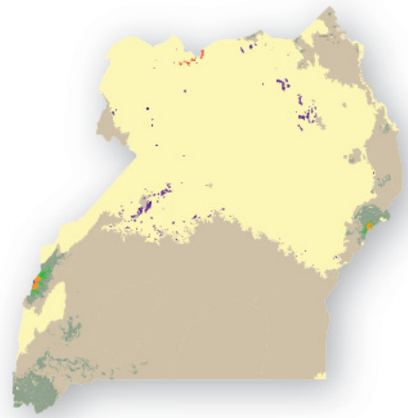


Sources: *Maps of evapotranspiration - MODIS Global Evapotranspiration Project, 2000 - 2010*
Graphs of humidity - Karume et al 2007, 1990 - 2005
Bioclimate maps - United States Geological Survey
Map of agroclimatic zones - Food and Agriculture Organisation of the United Nations

BIOCLIMATE

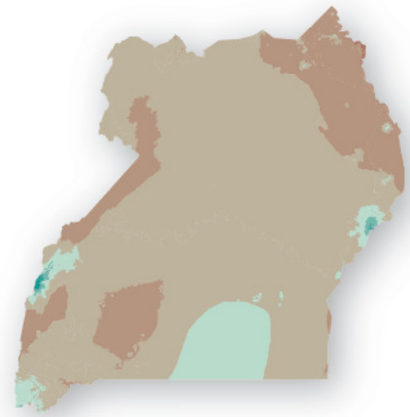
Natural vegetation and crops are strongly affected by both temperature and rainfall. The top two maps depict areas that share similar thermal and moisture conditions, respectively called thermotypes and ombrotypes. As shown in the bottom map, thermal and moisture conditions can be organised into agro-climatic zones, which are simple aggregations that are particularly relevant to growing crops.

Thermotype



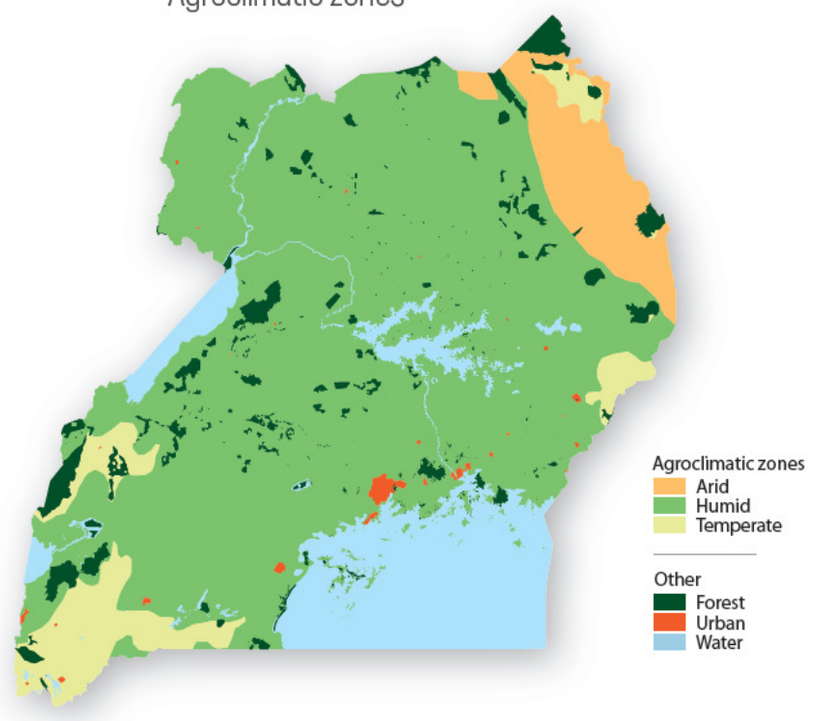
- Cryorotropical
- Orotropical
- Supratropical
- Mesotropical
- Lower thermotropical
- Upper thermotropical
- Infratropical

Ombrotype



- Semi-Arid
- Dry
- Subhumid
- Humid
- Hyperhumid
- Ultrahyperhumid

Agroclimatic zones



CLIMATE CHANGE

The earth is becoming warmer. This heating influences the patterns of air circulation around the globe which, in turn, may alter rainfall and other aspects of the earth's climate. These changes are likely to have implications for agriculture and ecosystems.

The maps show projected changes in rainfall and temperature by 2040 - 2060 and by 2080 - 2100. The two scenarios used for the projections are based on assumed levels of greenhouse gas emissions associated with differences in radiant energy received by, and radiated from, the earth. The RCP 8.5 scenario makes the assumption that the current rate of increase of emissions will continue throughout the 21st century. By contrast, RCP 4.5 scenario assumes that emission levels will remain relatively stable up to 2050 and then decline to below current levels. Under the 4.5 scenario, emissions in 2100 could be several times lower than those projected by the 8.5 scenario.

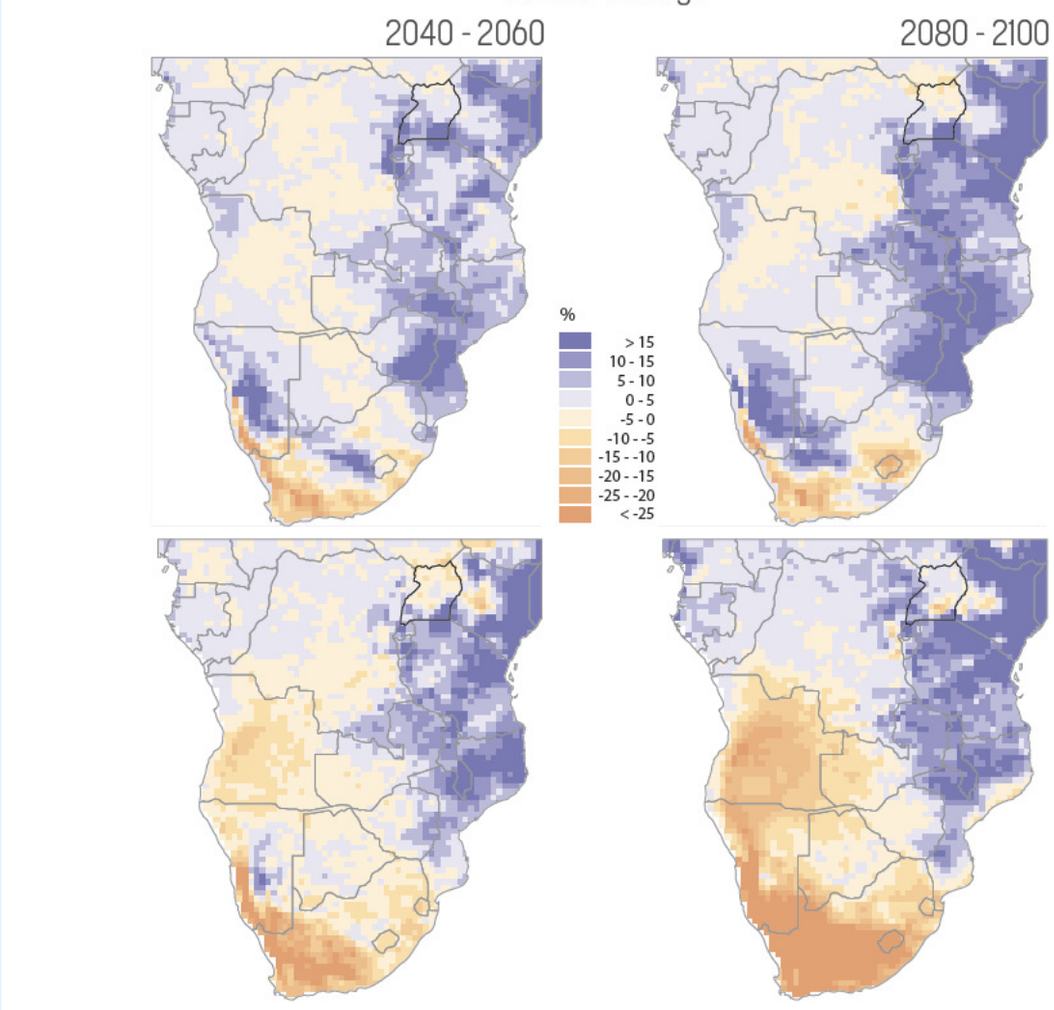
The rainfall maps show the percentage change between current annual totals and those projected in 2040 - 2060 and in 2080 - 2100. Rainfall is projected to decrease in northern Uganda but increase in the southern regions according to the RCP4.5 scenario. The RCP8.5 scenario projects that rainfall will decline over a greater part of the country. All the projected changes are relatively modest, at about 10% or less than current average precipitation in most areas.

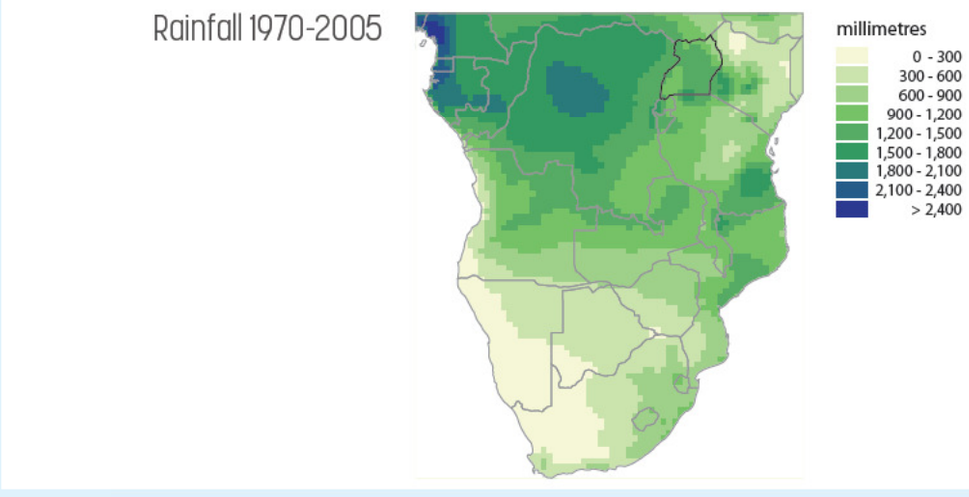
Projected temperature changes are shown for the period February - April, the warmest months of the year, and July - September, the coolest months. Further temperature rises are projected by both scenarios, but to higher levels in February - April than July - September. Greater increases are projected by the RCP8.5 model.

For reference, the three maps at the bottom show annual average rainfall and average temperatures between 1970 and 2005 during the selected months.

RCP4.5

RCP8.5



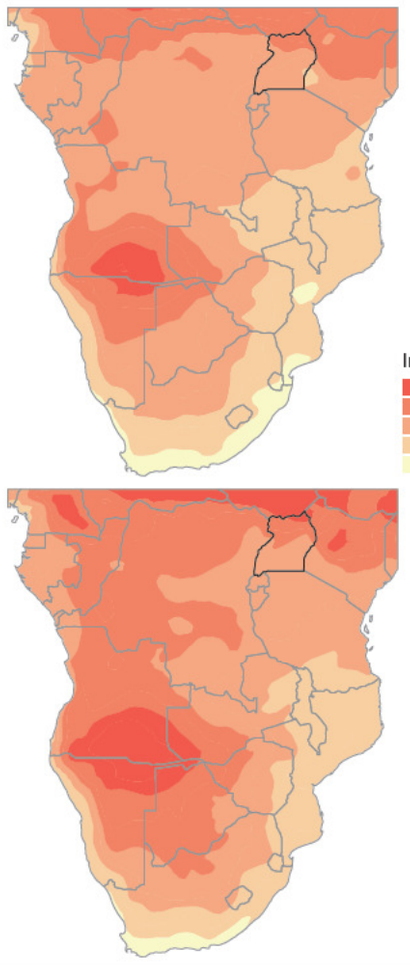


Source: Modelled by CSIR South Africa, baseline data 1970 - 2005

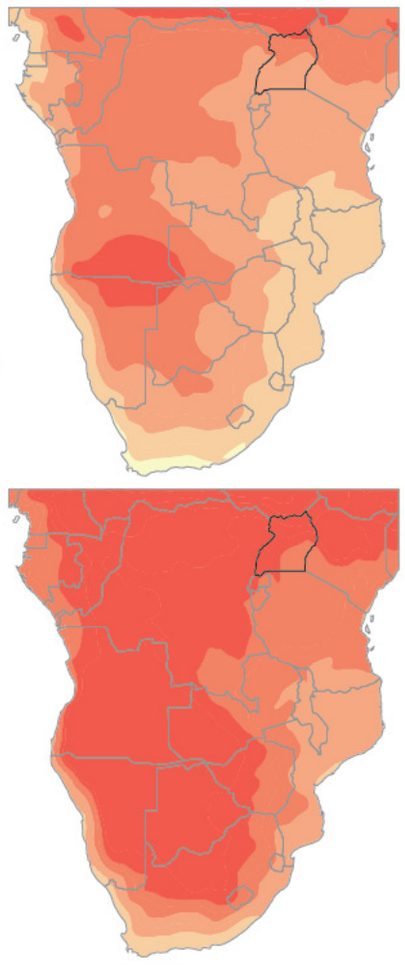
Temperature change relative to 1970-2005

February to April

2040 - 2060



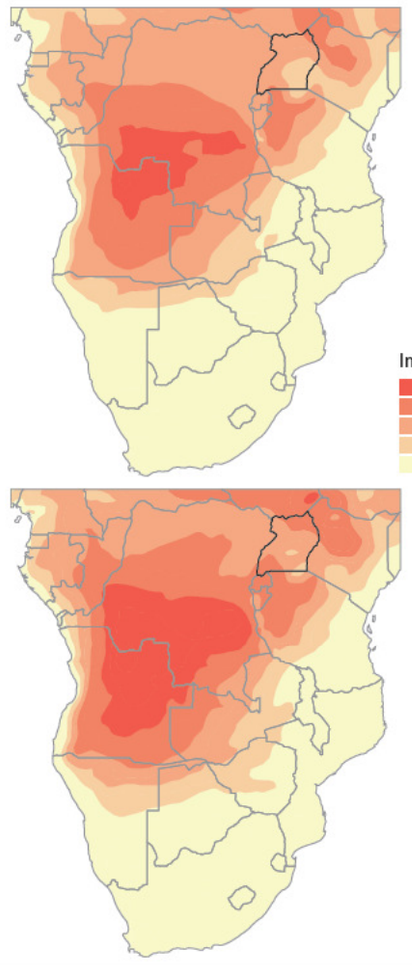
2080 - 2100



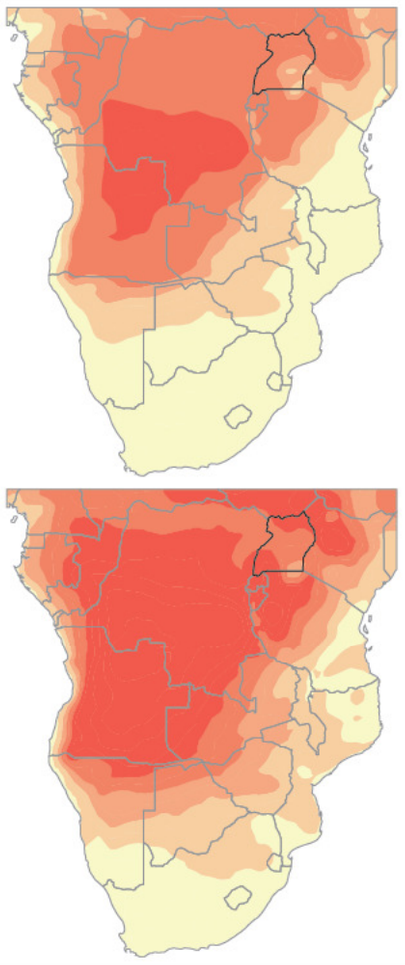
Increase (°C)
- >7
- 5 - 7
- 3 - 5
- 1 - 3
- <1

July to September

2040 - 2060

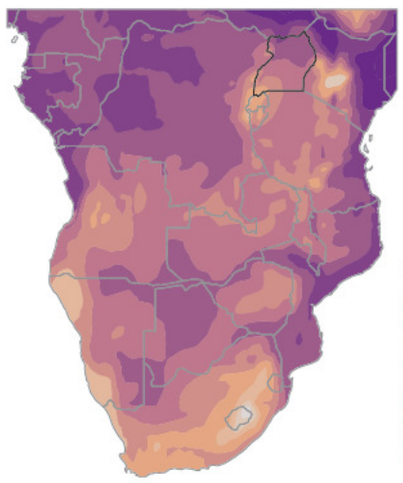


2080 - 2100



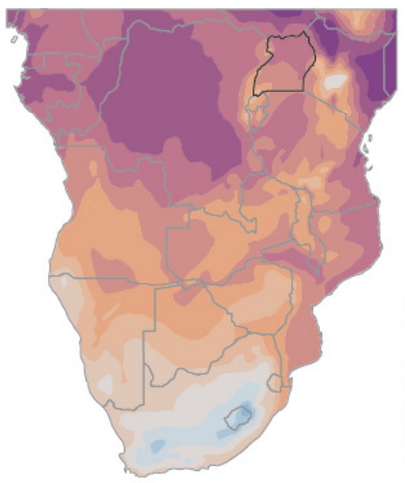
Increase (°C)
- >7
- 5 - 7
- 3 - 5
- 1 - 3
- <1

Temperature
1970-2005



°C
- < 10
- 10 - 12
- 12 - 14
- 14 - 16
- 16 - 18
- 18 - 20
- 20 - 22
- 22 - 24
- 24 - 26

Temperature
1970-2005



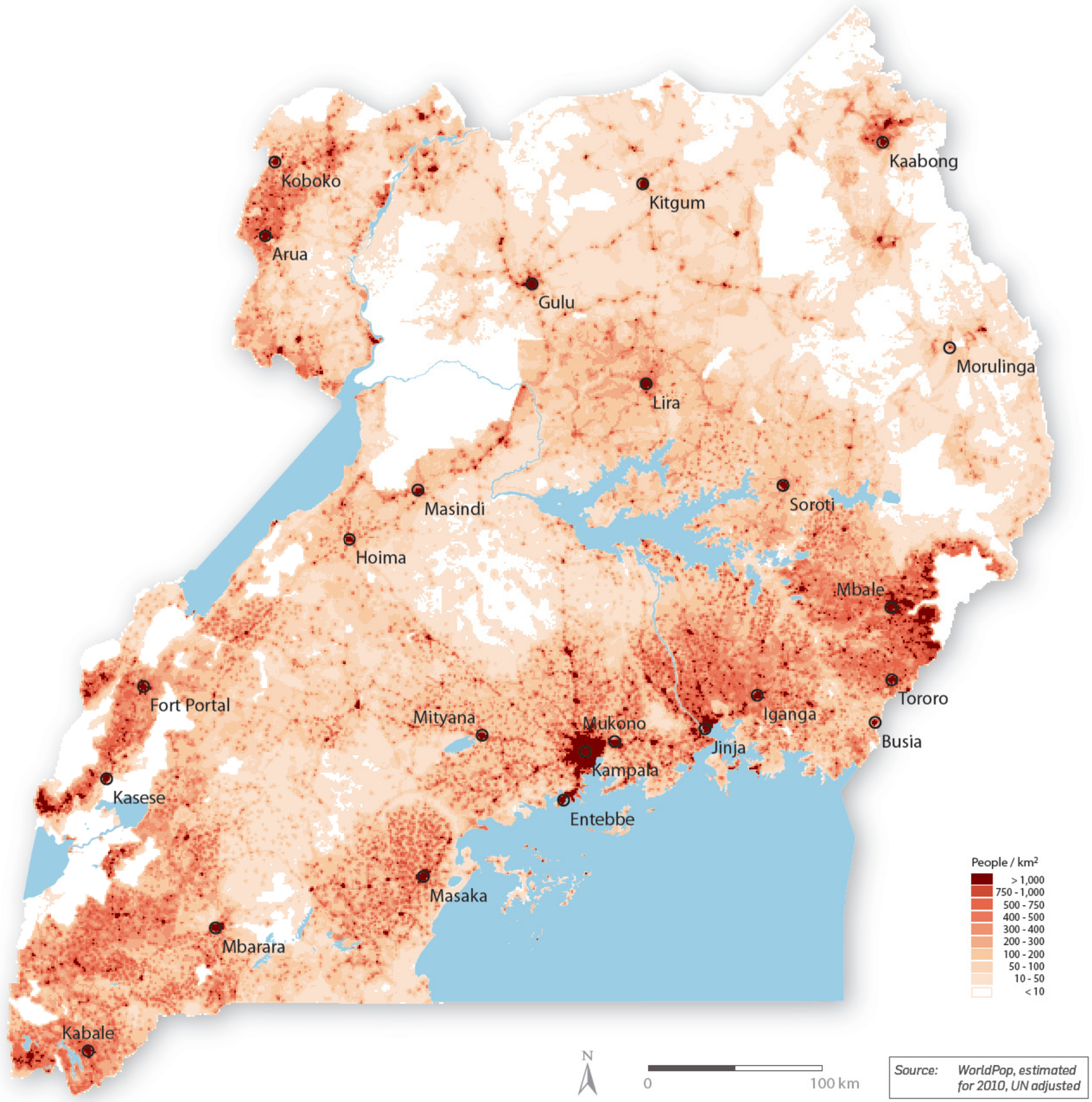
°C
- < 10
- 10 - 12
- 12 - 14
- 14 - 16
- 16 - 18
- 18 - 20
- 20 - 22
- 22 - 24
- 24 - 26

Demography

POPULATION DISTRIBUTION

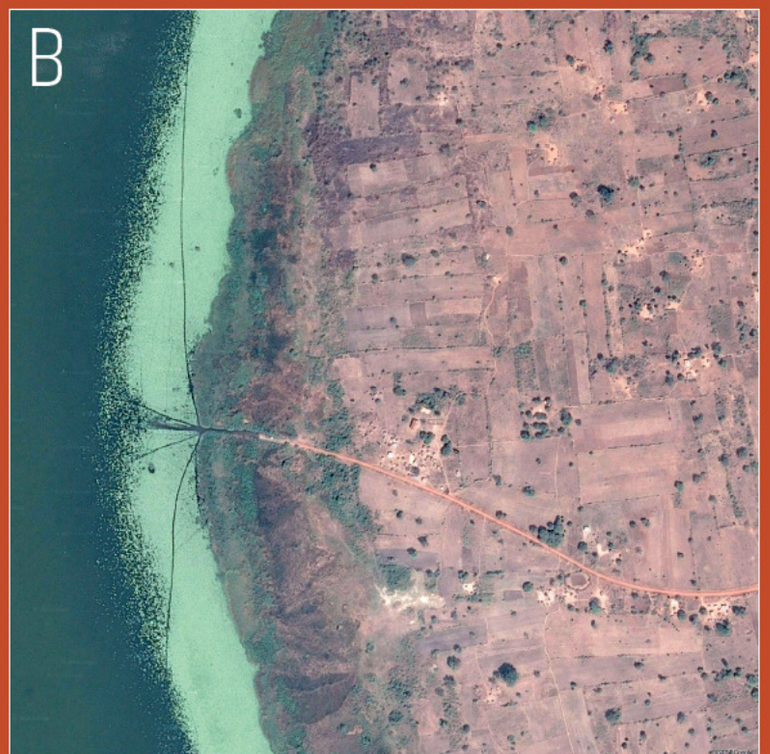
Uganda's population in 2014 was 34.9 million people. They live on 200,500 square kilometres of land, at an average density of 174 people per square kilometre. This is one of the highest population densities in sub-Saharan Africa. However, population density varies enormously across the country, as this map shows. The highest densities in informal urban areas may exceed tens of thousands of people per square kilometre, while the highest rural densities reach over 1,000 people or 200 households per square kilometre. The average number of people in a household in 2014 was 4.7, but urban households were smaller (4.2 people) than those in rural areas (4.8 people).

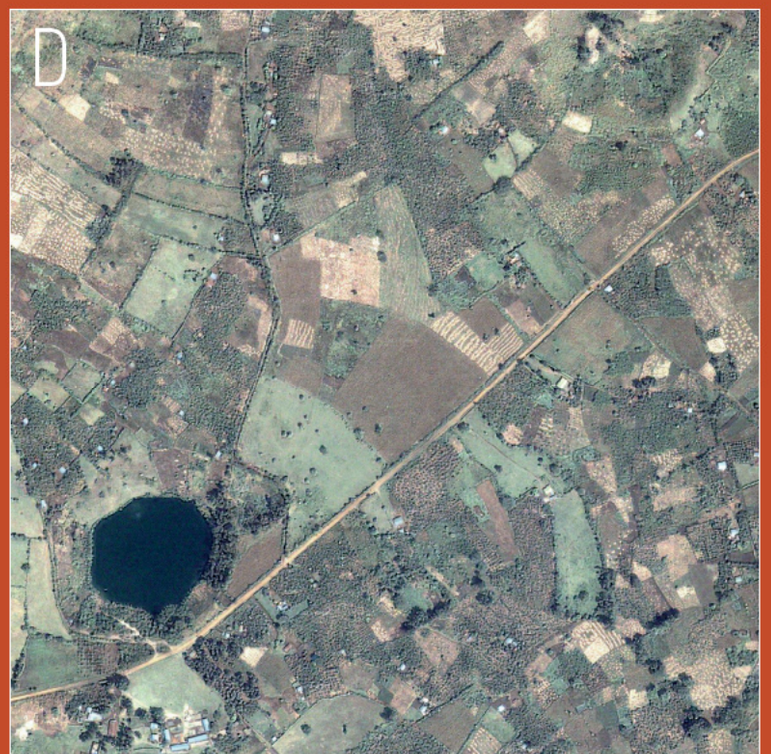
The drier northern regions of Uganda have always supported fewer rural people than the southern areas. Furthermore, up to 1.6 million people were displaced and 100,000 killed in the north during the civil war between 1988 and 2008. Large areas that had been farmed remain unoccupied, and some of these areas have now become large private farms or mineral concessions.



These images provide some perspectives on how differently houses, farmland and other land uses are arranged locally. Each image covers one square kilometre.

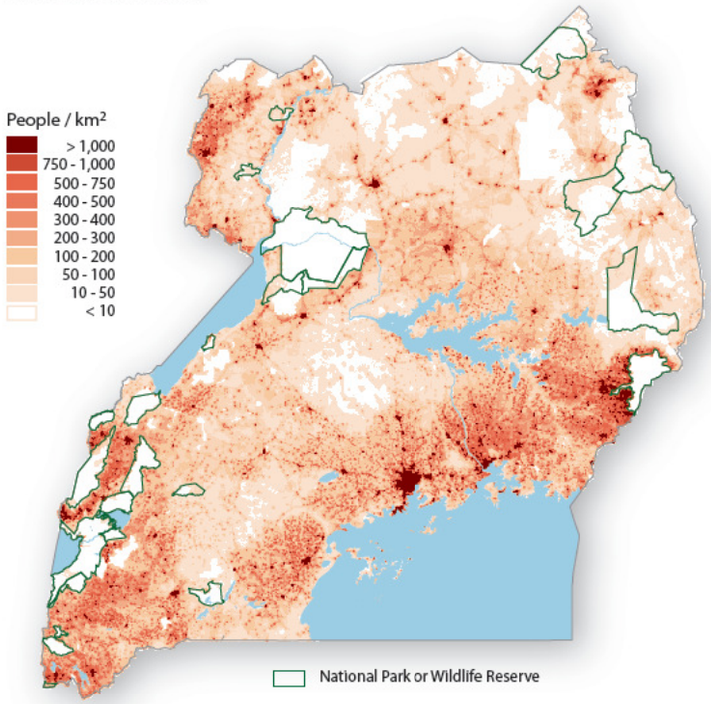
Households are often clustered in high densities in towns where people make a living from trade and services (as in A) or from fishing in nearby Lake Kyoga (B). Population densities are very low in pastoral areas where households may be far apart (C). This is in sharp contrast to the high density of people in many crop farming areas where soils are especially fertile, such as close to a crater lake (D) or near Bwindi Impenetrable Forest (E).



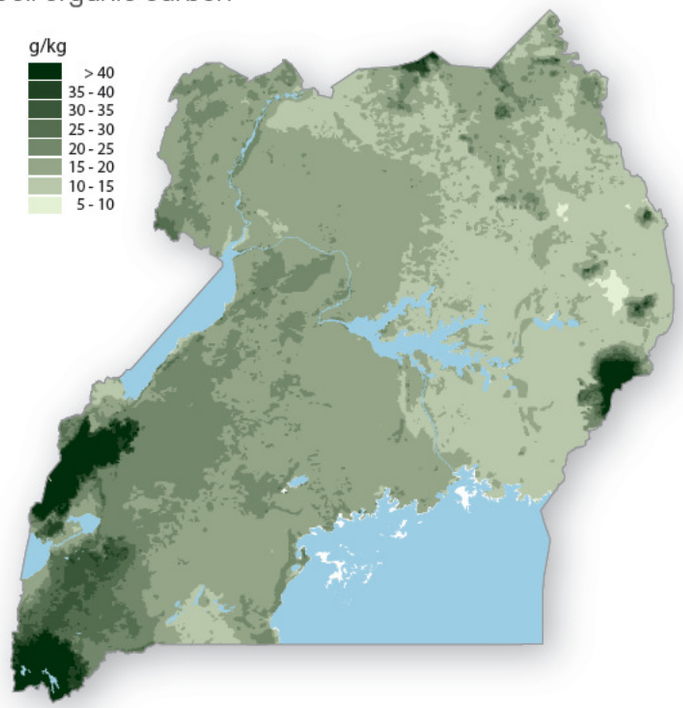


FACTORS INFLUENCING POPULATION DISTRIBUTION

Protected areas



Soil organic carbon



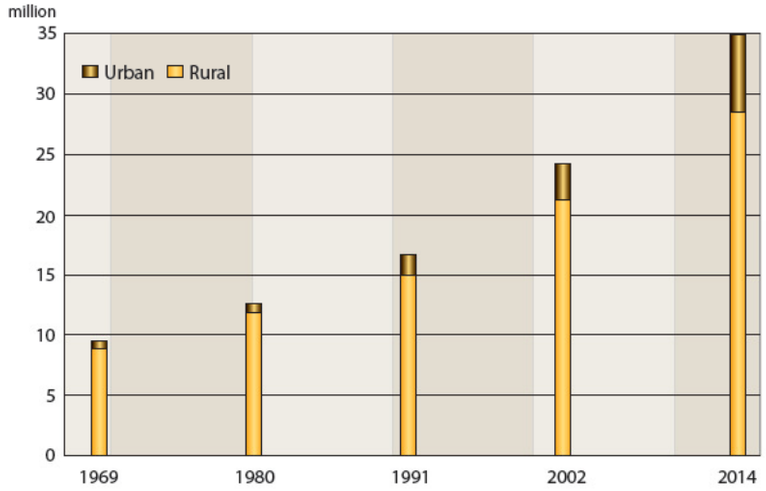
Uganda's high population density is largely a consequence of the combined influences of abundant rain and fertile soil that prevail over much of the country. The effects of soil fertility can be seen by comparing maps of population density and concentrations of organic carbon in the soil, which is a main determinant of fertility in many places (see page 25). The density map also shows where people are absent from national parks and wildlife reserves.

Large areas of Uganda consist of marshy soils. People cannot live in these areas, but some of the soils are excellent for growing crops like rice, sugar, certain vegetables and bananas. These are the green areas in the satellite image to the left. Houses are built on higher ground nearby, generally along roads where farmers can sell their produce. Drier soils on the higher ground are used for other crops such as maize, coffee and cassava. The dry higher ground is brown in the image.

The availability of land also determines where people can live, as demonstrated by the example of the tiny fishing village of Buhaguzi (right) which lies on an isolated patch of flat land between the eastern wall of the Albertine Rift and the waters of Lake Albert.

POPULATION GROWTH AND STRUCTURE

Population growth

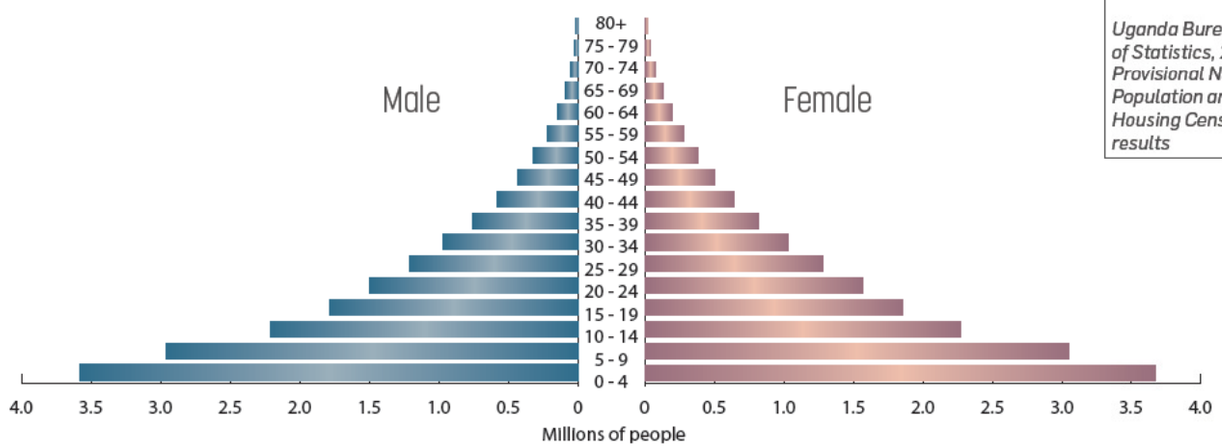


The graph to the left shows how the population in Uganda has grown, nearly quadrupling between 1969 and 2014. In fact, the population almost doubled in the 19 years between 1995 (19.3 million) and 2014 (34.9 million). The annual growth rate over that period was 3.2%. If population growth continued at that rate, it would reach 71 million by 2037.

The graph of population growth also shows how the number and proportion of people living in urban areas has increased. In 1969, 7% of the population lived in urban areas. This proportion more than doubled by 2014, with approximately 18% of the population (6.4 million people) living in urban areas, including 1.52 million people in Kampala city. Urbanisation is expected to continue to increase as more people move away from small-holder farming into trade and service sectors.

The number of males and females in the country is roughly equal among most 5-year age cohorts, as shown in the graph below. The very broad base to the age pyramids reflects the large population of young people. Uganda has one of the world's youngest populations with over 62% of its population in 2014 being 19 or younger and only 2.4% being 60 or older. Life expectancy in 2012 was estimated at 54 years, compared to 50.4 in 2002 and 48.1 years in 1991.

Population structure in 2014



Source:

Uganda Bureau of Statistics, 2014 Provisional National Population and Housing Census results

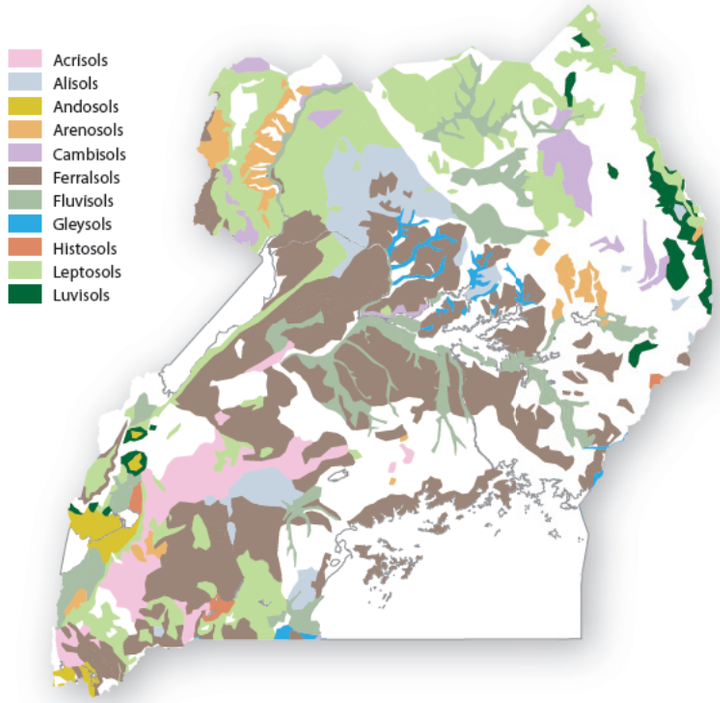
Ecosystem services

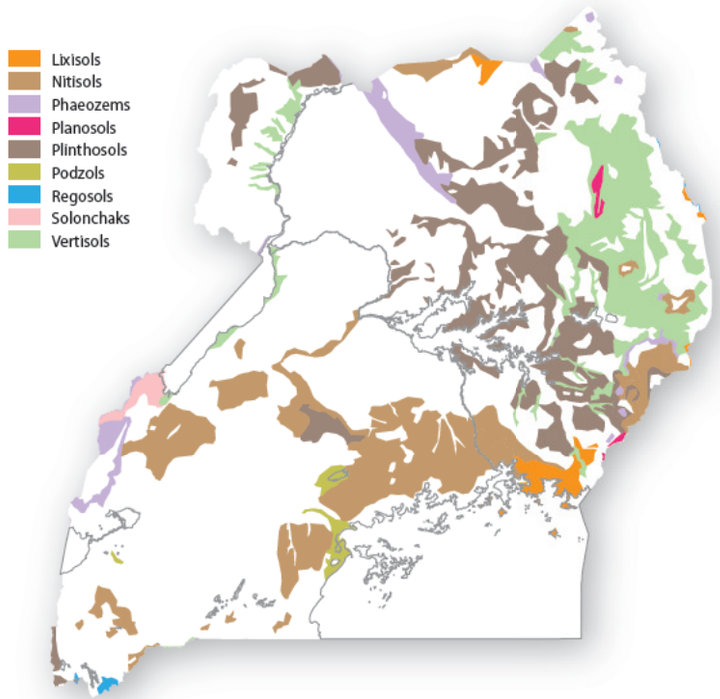
SOILS

Although rock formations give structure and stability to the surface of the earth, soils provide another key foundation layer because they play such an important role in defining vegetation. Soil affects what species grow or not, as well as the vigour of plant growth. These factors influence both crops and wild plants which, in turn, provide habitats for all animals.

For such a small area, Uganda has a great variety of soils. Many are extremely rich in nutrients, making the land among the most fertile farmland in Africa. Such qualities are especially true of andosols (derived from volcanic ash) and nitisols (developed from rocks rich in iron such as basalts). The Lake Victoria Crescent that supports so many rural families is a consequence of the fertile nitisols being cultivated. Even soils that usually offer little for plant growth elsewhere provide greater potential in Uganda. For example, ferralsols retain more organic material here because the cool climate slows the breakdown of plant material by bacteria.

These two maps show the broad distributions of soil types in Uganda. However, soils in any one area are usually heterogeneous, and farmers then use their expertise to find the best patches of soils for specific crops.





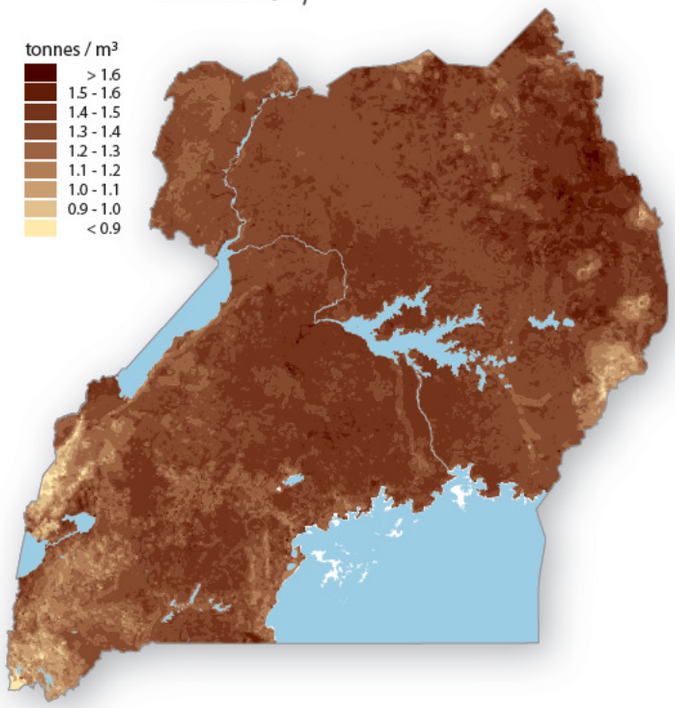
The upper layer of soil is so dark because it contains large proportions of organic material.

Plant growth is greatly influenced by the structure, moisture and nutrient content of soils. One measure of structure is bulk density, which is the weight of soil divided by its volume. Root growth may be limited by the high density of compacted soils. By contrast, roots can penetrate soils with lower densities and these soils also hold more water and allow more air to circulate.

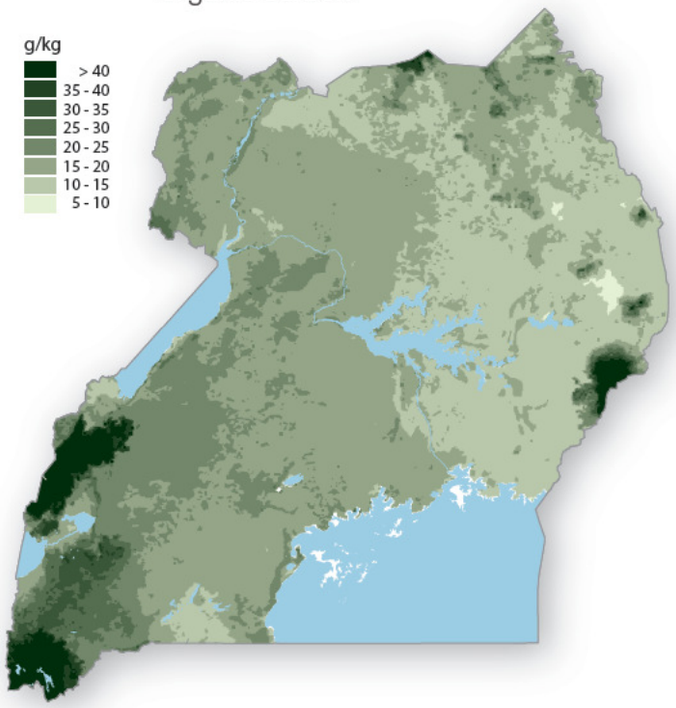
Soils with high organic carbon content are often very fertile because nutrients are released by decomposing organic material, which also helps to retain water and create tiny spaces for roots to grow. Another important measure of fertility is cation exchange capacity which reflects the ability of soils to hold certain important plant nutrients. pH is a measure of how acidic or alkaline a soil is, and this affects chemical processes that make nutrients more or less available to plants. Most plants favour soils with pH values between 7 and 5.5.

Soil particles vary in size, those of clay being smallest, followed by silt and sand. The content of clay, silt and sand in a soil affects a range of its properties. For instance, clays usually have more nutrients and moisture than sandier soils.

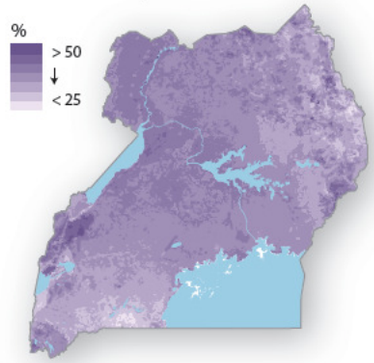
Bulk density



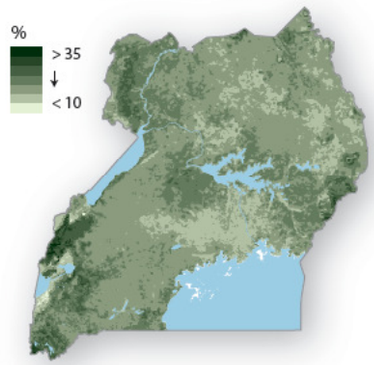
Organic carbon



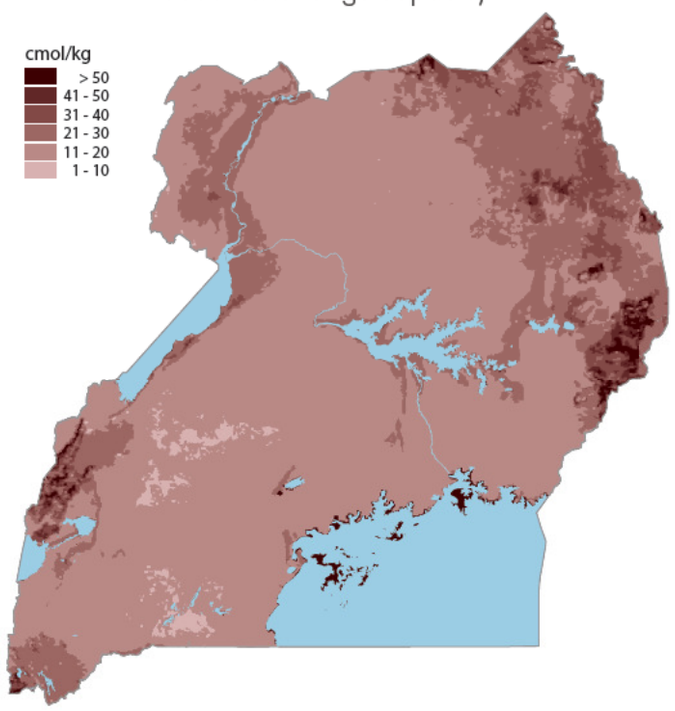
Clay content



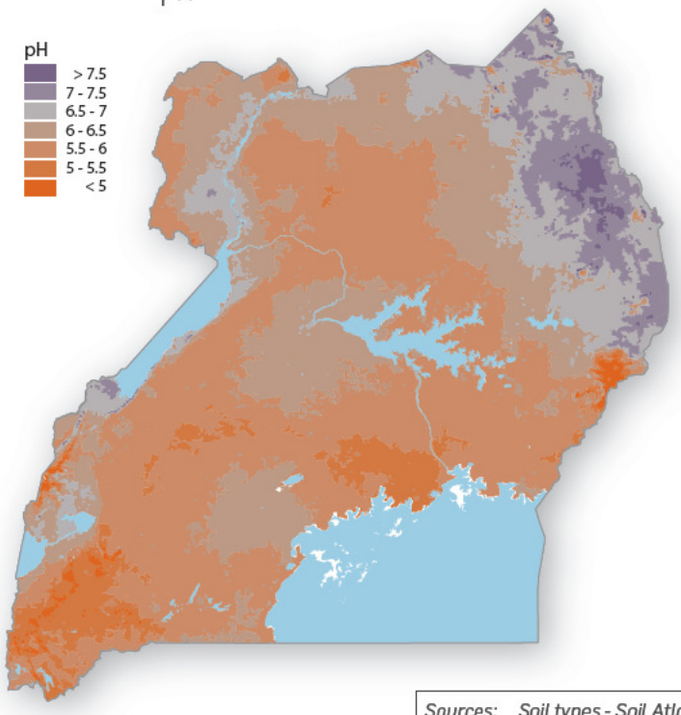
Silt content



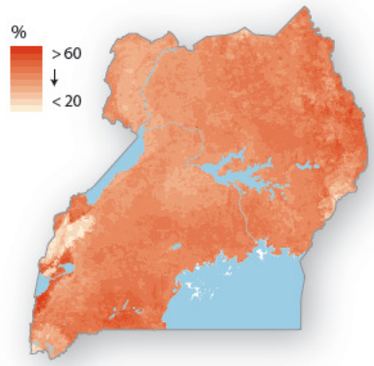
Cation exchange capacity



pH



Sand content



Sources: *Soil types - Soil Atlas of Africa, European Commission*
Soil properties - International Soil Reference and Information Centre

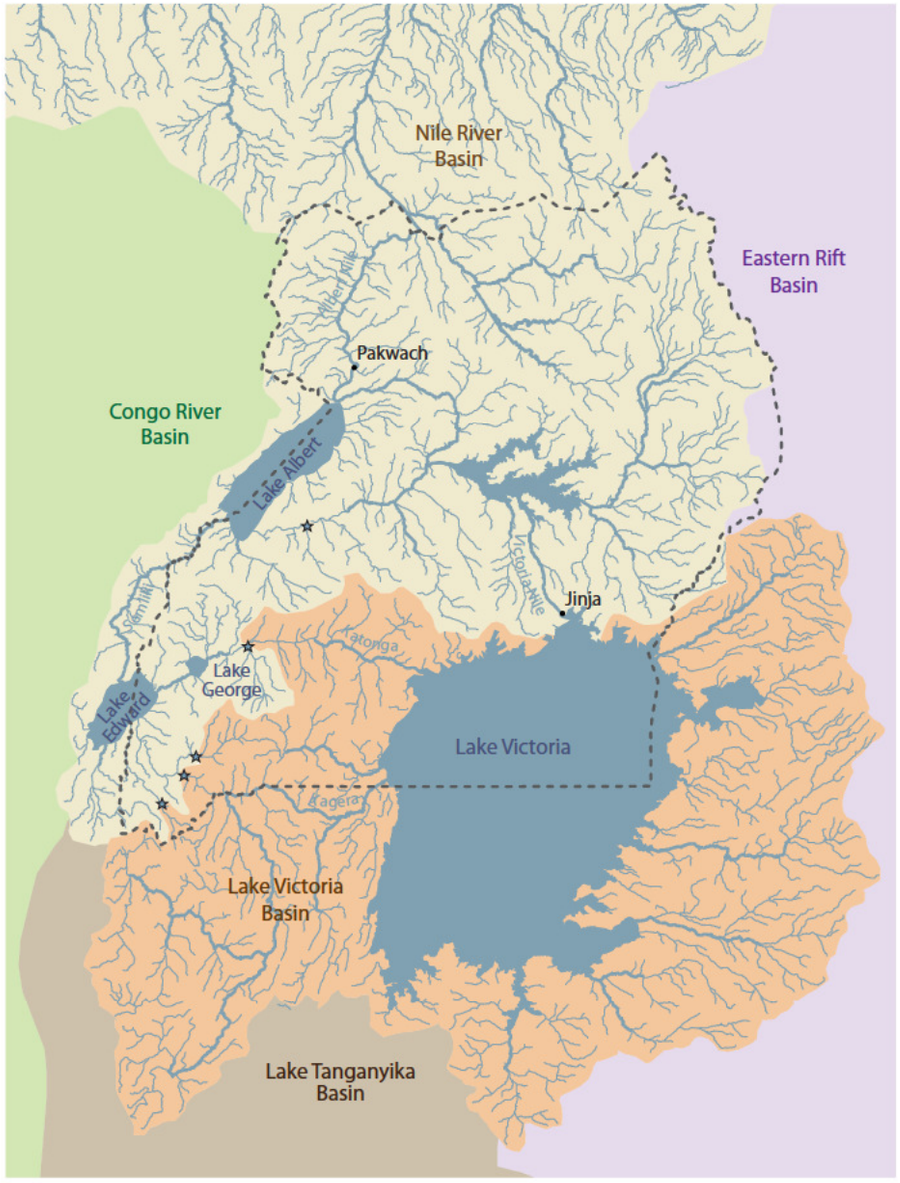
SURFACE WATER

No other country in Africa has as much fresh surface water per capita or per unit area as Uganda. About 15% of the country is open water, principally in lakes Victoria, Albert, Kyoga, George and Edward. At least another 9% of the country consists of swamps, seasonally flooded grassland or riverine forest. Together, these fresh water habitats cover almost one quarter of Uganda.

Sources: Map of surface water - RAISON, from multiple sources
Map of catchments - RAISON, from multiple sources

Murchison Falls viewed from the east as the waters of the Nile are forced through a gap just seven metres wide. On average, about 300 cubic metres of water flows down the falls each second.

Catchments



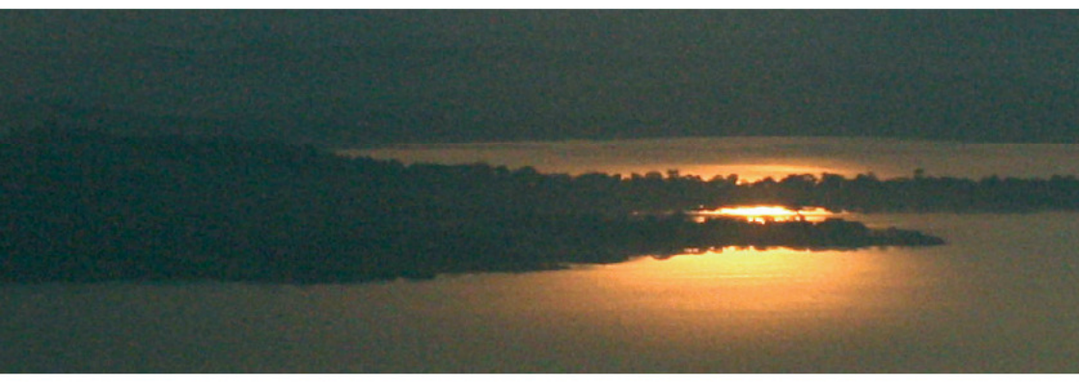
With the exception of small catchment areas of the Saumu River that flow eastwards into Lake Turkana in Kenya, all river catchments in Uganda feed their waters directly or indirectly into the Nile. Some rivers, such as the Kagera and Katonga, first flow into Lake Victoria from where the Nile begins its long course north at Jinja. Other rivers flow into Lakes Kyoga or Albert, or into Lakes George and Edward from where water flows down the Semliki River through the Democratic Republic of the Congo and into Lake Albert.

Uplift along the eastern rim during the formation of the Albertine Rift caused the westerly flows of several rivers to be reversed so that they now drain eastwards. This happened to the Kafu, Katonga, Rwizi and Kagera rivers at the places marked on the map (★).

The source of the Nile is said to be at Jinja. However, water that flows past Jinja comes from Lake Victoria which, in turn, is supplied from a vast catchment area stretching across parts of six countries: Uganda, Kenya, Tanzania, Rwanda, Burundi and a small area of the DRC. The total catchment of the lake covers about 194,000 square kilometres. Tanzania's part makes up 43% of the catchment, Kenya 23%, Uganda 16%, Rwanda 11%, Burundi 7% and the DRC less than 1%.

Rivers with the largest catchments that flow into Lake Victoria are: Kagera (58,650 km^2), Mara (20,000 km^2), Nzoia (15,800 km^2), Katonga (14,000 km^2), Grumeti (12,300 km^2) and Simiyu (11,200 km^2).

Water in Lake Victoria and the Nile thus comes from a large area and from diverse sources. Against that background, it is not surprising that Lake Victoria has suffered. Its waters are polluted by industrial and urban waste and sewage, significant damage has been caused by introduced fish and water hyacinth, and water levels have dropped at times when downstream usage exceeded inflow. The Lake Victoria Basin Commission (LVBC) and Nile Basin Initiative (NBI) were established as inter-governmental institutions responsible for the sustainable management and development of Lake Victoria and the Nile, respectively.



Lake Victoria is the largest tropical lake in the world with a surface area of 68,800 km^2. It is shared by three countries: Kenya (6% of the surface area), Uganda (43%) and Tanzania (51%). It has a shoreline 3,500 km long, of which approximately a quarter falls within Uganda. The average depth is 40 m and the maximum depth is almost 90 m. While many rivers flow into the lake the majority of the water it receives (85-90%) comes directly from rainfall (see page 10) caused by air rising at night above the relatively warm surface waters. The only drainage from the lake is by the Nile River which flows northwards out of Uganda into South Sudan, then into Sudan and Egypt where it finally flows into the Mediterranean Sea.

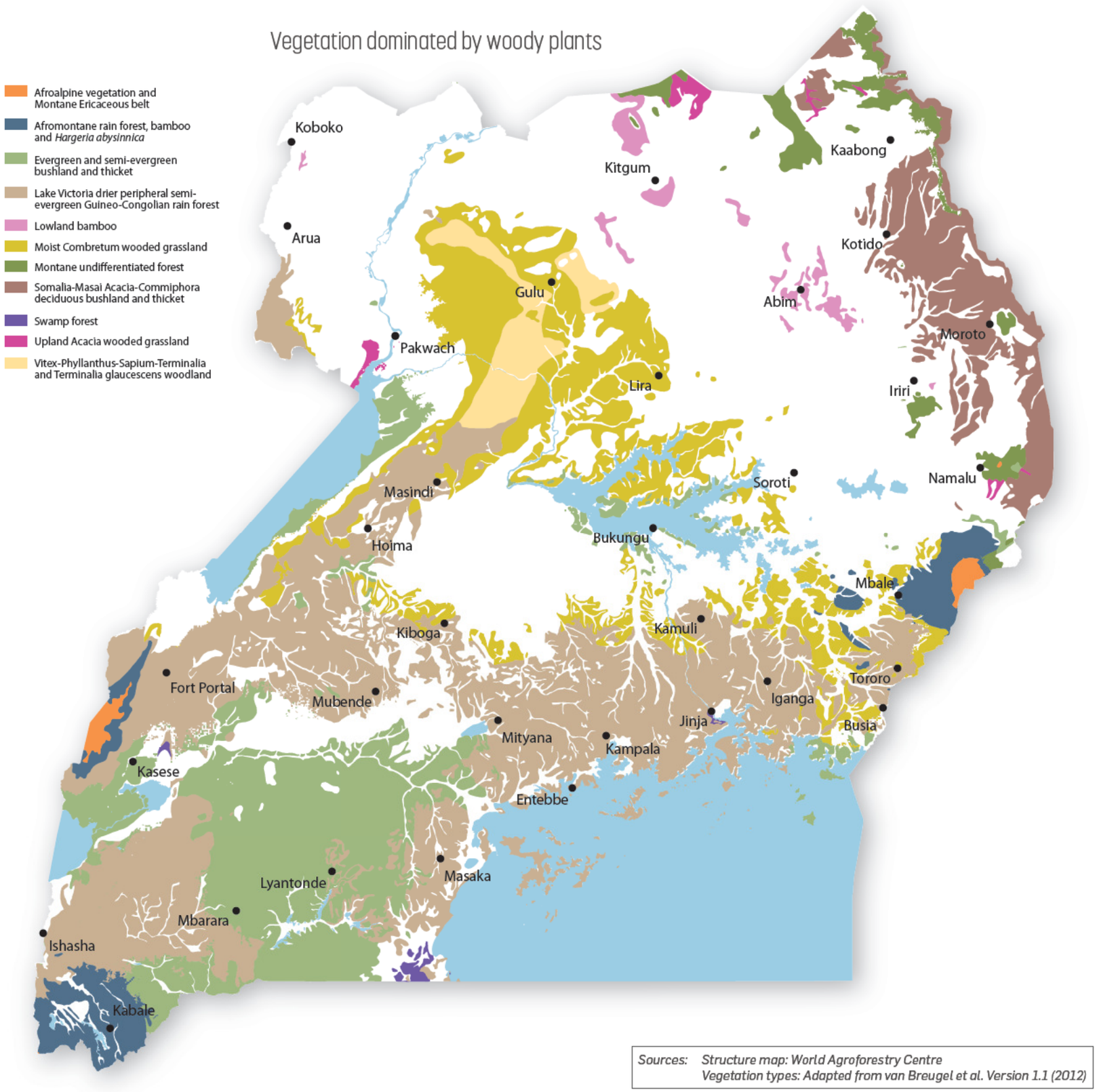
VEGETATION TYPES

These two maps of areas dominated by woody and non-woody plants show Uganda's vegetation types as they were before large areas of forest, woodland and swampland were transformed by farming and settlement.

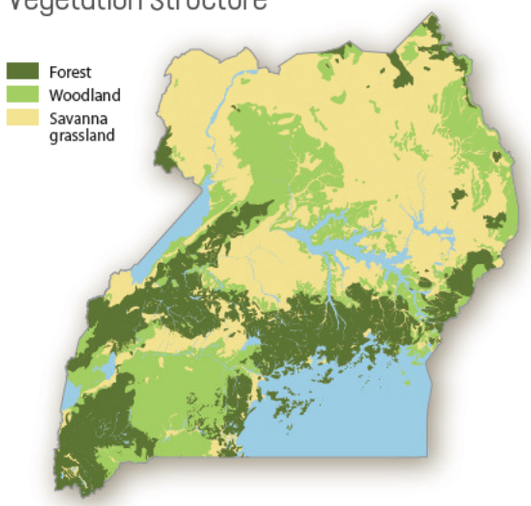
Aside from human influences, other major factors that mould Uganda's plant life are rainfall, water levels, fire and altitude. Plant cover becomes progressively taller, denser, woodier and more evergreen as rainfall increases from north to south, and from lower to higher elevations. At the highest, coldest levels above 3,200 metres on Mount Elgon and 3,600 metres on the Rwenzoris, tall trees give way to alpine heath and grassland. Regular burning and seasonal aridity creates a mix of taller trees and grassland that typifies the various wooded grassland or savanna vegetation types.

Few trees can grow in watery habitats. Grasses, sedges, papyrus and other aquatic plants thus dominate large areas in central Uganda covered by shallow water or where soils are saturated for much of the year.

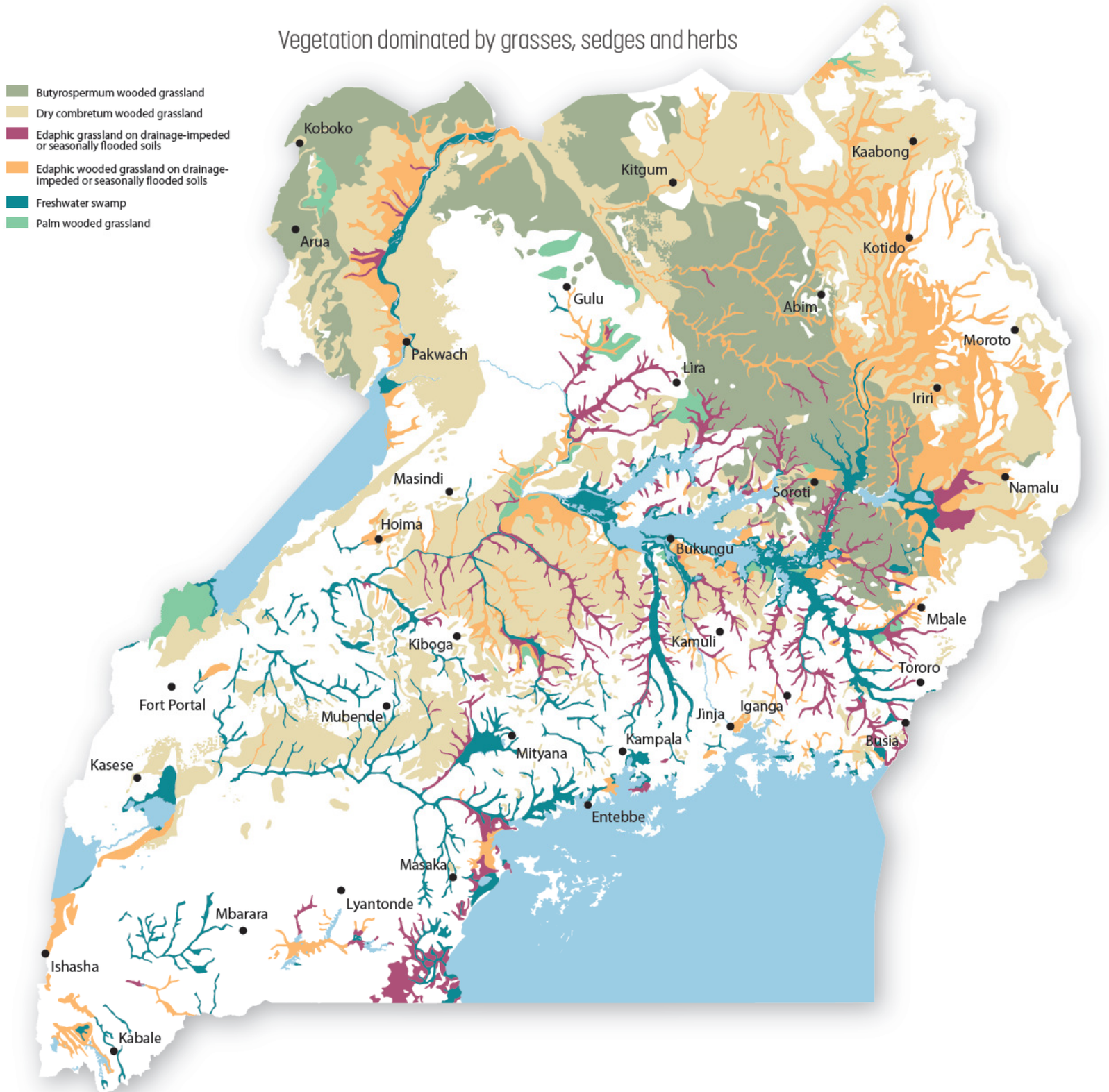
Vegetation dominated by woody plants



Vegetation structure



Sources: *Structure map: World Agroforestry Centre*
Vegetation types: Adapted from van Breugel et al. Version 1.1 (2012)



Top: Forests and woodlands provide substantial value to Uganda. For example, an evaluation in 2004 found that forests and trees contributed $173 million to the annual incomes of households, while the total economic value of forests amounted to $304 million, then equivalent to 5.2% of GDP.
Middle: At least 8% of Uganda's land area consists of swampland and flooded grassland, usually as broad swathes of papyrus, reeds, sedges and grass along rivers and lakes.
Bottom: The north-eastern areas of Uganda and also a zone between Mbarara, Lyantonde and Mubende are drier than the rest of Uganda. Tree cover is sparse and often thorny in these dry areas where grasses dominate the vegetation. Pastoralism, mainly with cattle and goats, is the dominant form of farming here.

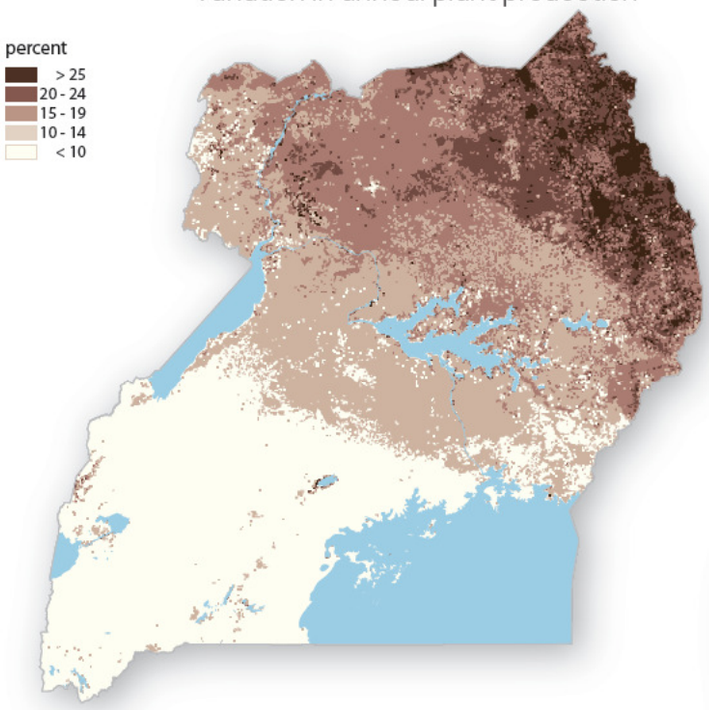
VEGETATION COVER AND PRODUCTION

Vegetation cover in Uganda varies a great deal, from dense, tall forest and woodlands to open wooded grasslands where scattered trees are surrounded by expanses of grass cover. There are also extensive areas of floodplain grasslands and swamps.

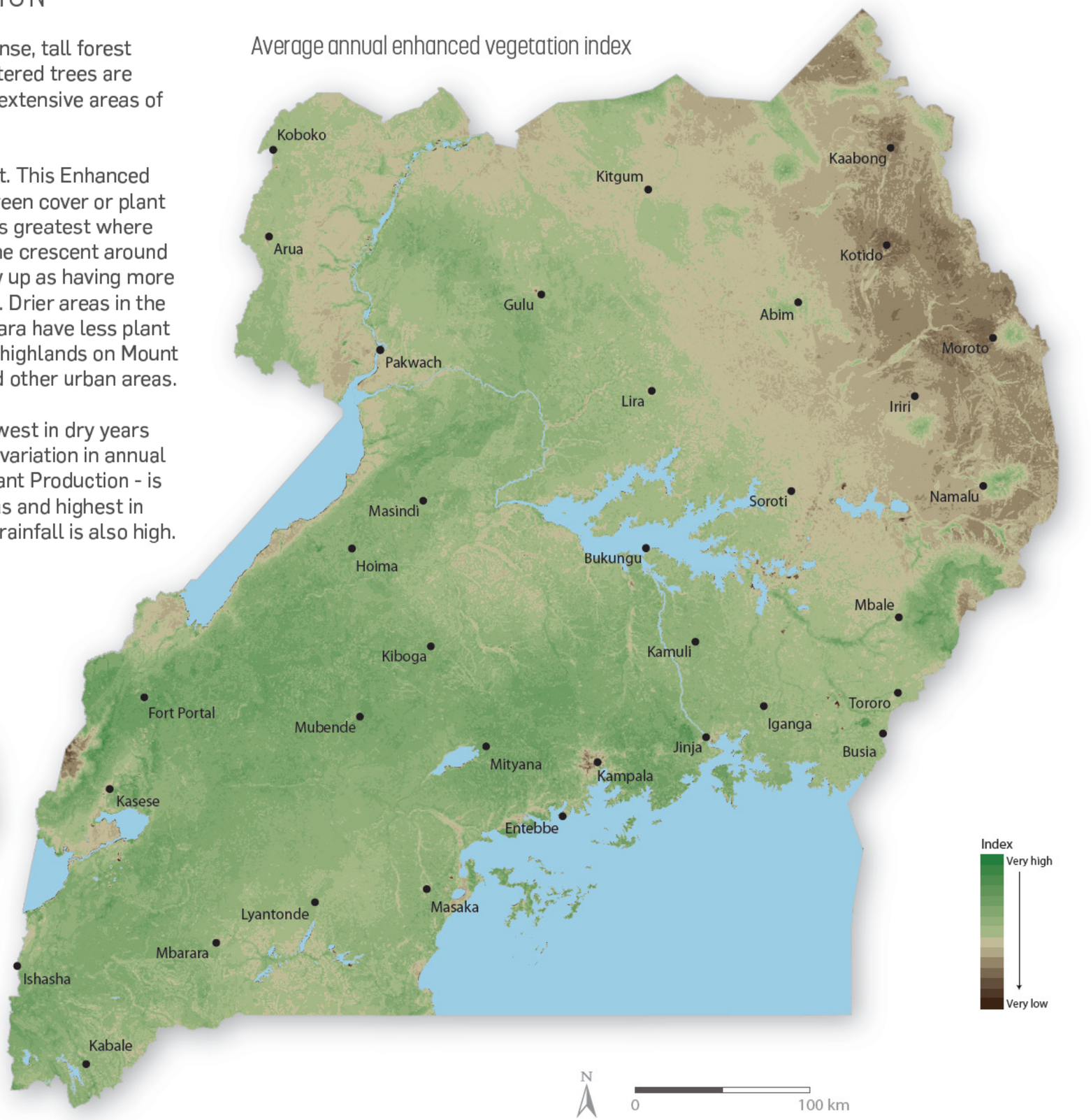
One measure of cover is provided in the map to the right. This Enhanced Vegetation Index (EVI) is an average of the amount of green cover or plant canopy cover over 12 years, from 2000 to 2012. Cover is greatest where annual rainfall is highest, particularly in the west and the crescent around Lake Victoria. Within those areas, protected areas show up as having more plant cover than the expanses of land cleared for crops. Drier areas in the north east and in the zone between Mubende and Mbarara have less plant cover. Other areas with sparse cover include the alpine highlands on Mount Elgon and the Rwenzoris, the footprints of Kampala and other urban areas.

Vegetation cover also varies from year to year, being lowest in dry years and greatest in years with abundant rain. A measure of variation in annual plant production - the co-efficient of variation of Net Plant Production - is shown below. Broadly, variation is least in forested areas and highest in places where grasses predominate and the variation in rainfall is also high.

Variation in annual plant production



Average annual enhanced vegetation index



Average monthly enhanced vegetation index

January

February

March

April

May

June

July

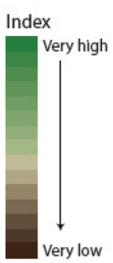
August

September

October

November

December



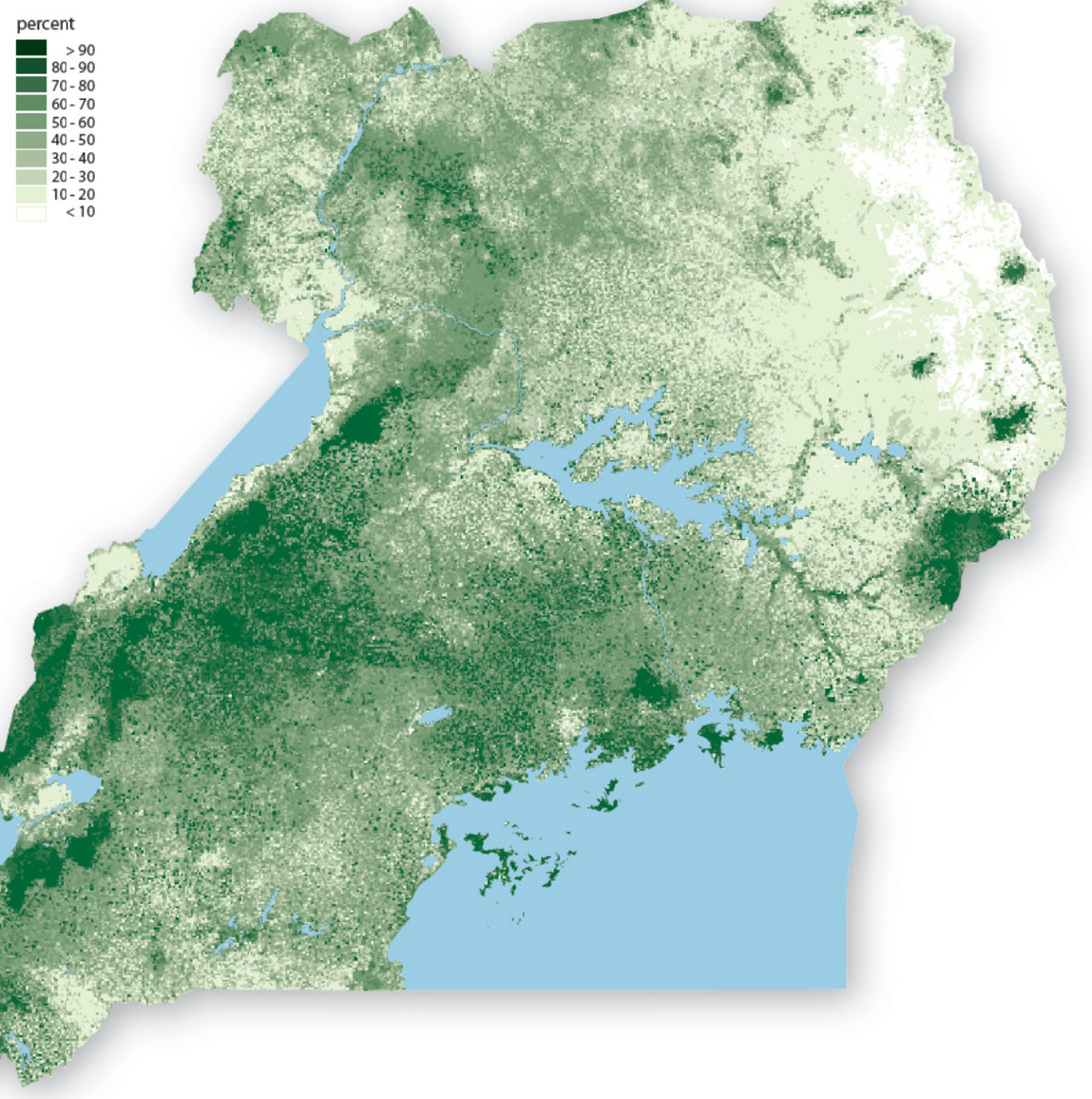
These maps show changes in green cover or plant canopy during the year, starting in January through the rainy seasons to December. Most changes in vegetation cover occur in response to rain, and many plants only start to grow after the early rains begin in March and April (see page 11). In the driest areas of Uganda, maximum plant cover is only achieved some months after the rains start.

Whereas differences in plant cover between the drier northern and wetter southern areas are stark over much of the year, the distinction is comparatively slight between June and September. Much of the change in cover in the southern areas reflects changes in crop growth.

Source: Africa Soil Information Service, 2000 - 2012

FOREST COVER, LOSS AND GAIN

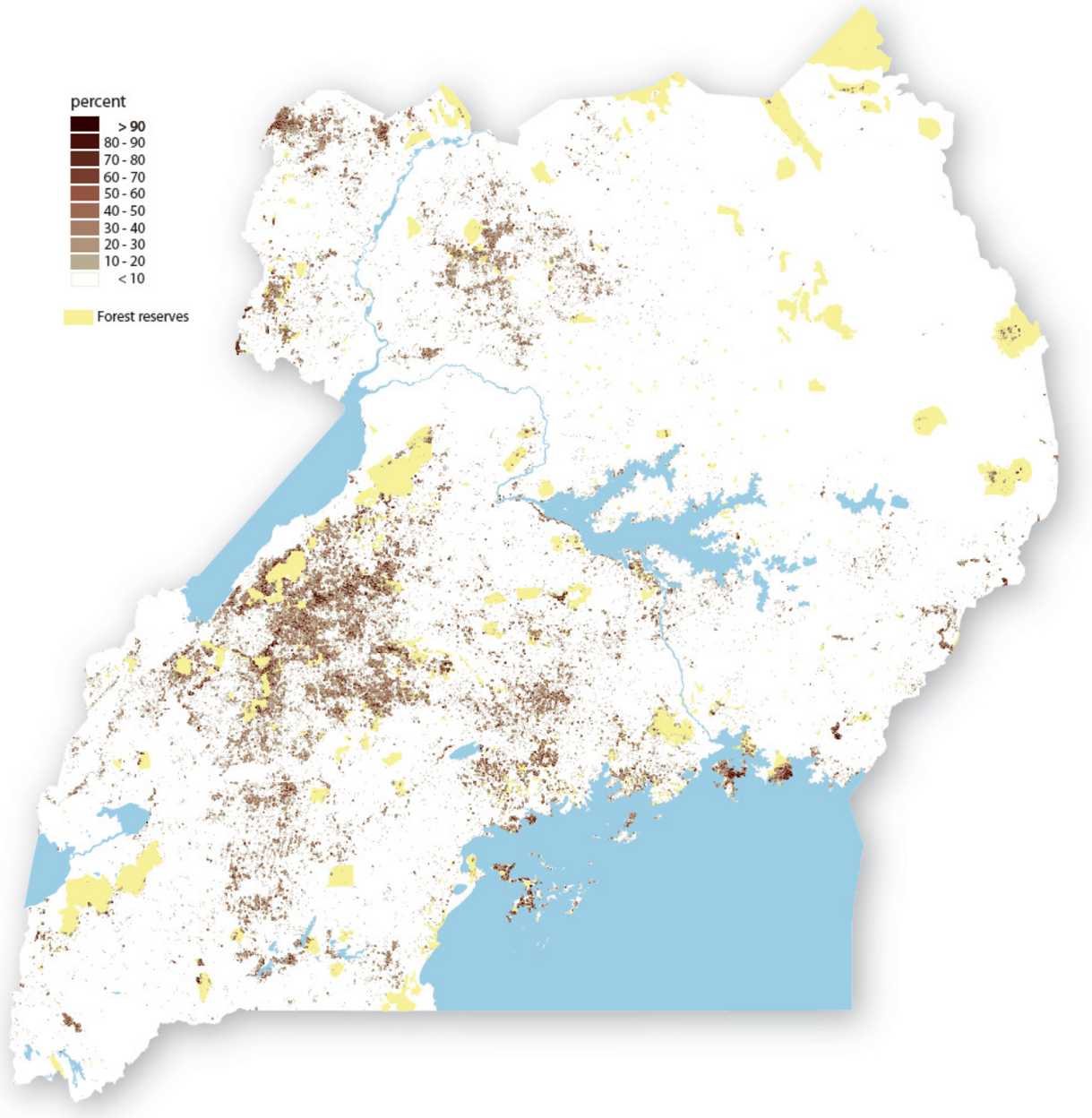
Forest cover in 2000



Forest is defined as vegetation dominated by trees that are mostly taller than 5 metres and where the canopy cover is more than 30%. This map shows the distribution and extent of forest in 2000. This was used as a baseline to assess and map losses and gains between then and 2010.

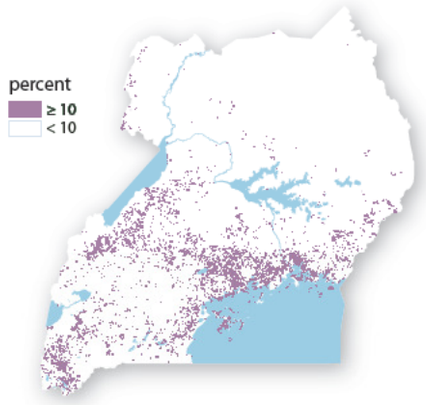
Source: Hansen/UMD/Google/USGS/NASA, 2013

Loss of forest cover between 2000 and 2010



Uganda has lost large areas of forest since 2000. Several features stand out. First, and not surprisingly, most losses were in the western and other areas where forests predominate. Second, few losses occurred in forest reserves and other protected areas, indicating effective measures to prevent deforestation. Third, while losses were extensive in many areas, there were also many places where losses were extremely concentrated. Finally, many of the areas that had been heavily cleared were immediately adjacent to protected areas. Good examples are around Mount Elgon and forest reserves just east of Lake Albert.

Gain in forest cover between 2000 and 2010



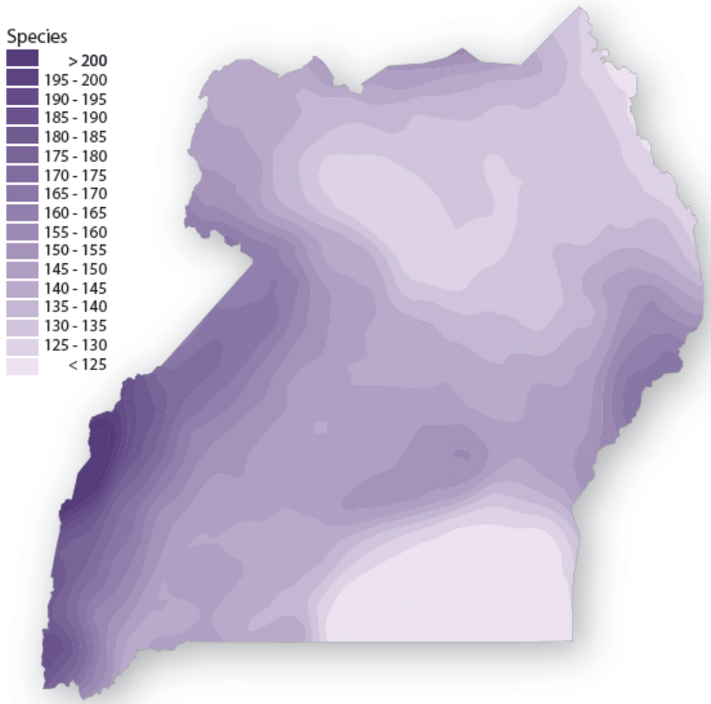
Increases in dense tree cover between 2000 and 2010 were also detected, especially in the densely settled areas north of Lake Victoria and in the far south-west of Uganda. These increases were mostly due to the growth of planted trees and regeneration of dense cover in places that had previously been cleared.

BIODIVERSITY

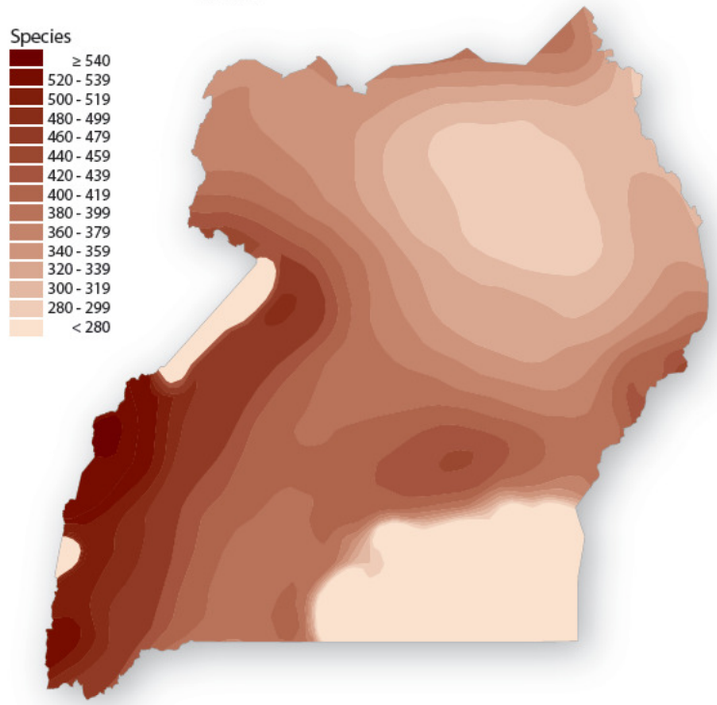
Tropical areas - particularly forests - usually support many more species than other parts of the world. Uganda is no exception since much of the country is very close to the Equator. Moreover, the most tropical, wet and forested areas within Uganda harbour the greatest number of species, as these maps show for birds, mammals, amphibians or frogs, damselflies and dragonflies (Odonata). The map of fish biodiversity shows the number of species in each major body of water in Uganda. Fish diversity is also high in the tropics, and especially in the large lakes of central Africa. Lake Victoria is famous for its fish diversity, as are Lakes Tanganyika and Nyasa.

Among many other groups of living organisms, the following numbers of species have been recorded in Uganda: butterflies 1,242 species; birds 1,007; mammals 345; flowering plants 4,500; fish 501; dragonflies 249; amphibians 86; reptiles 142 and termites 86 species.

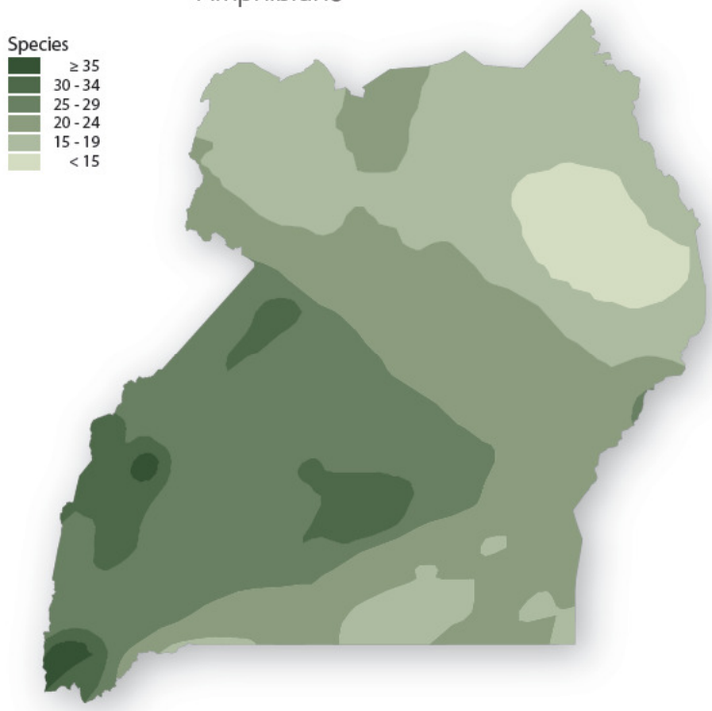
Mammals



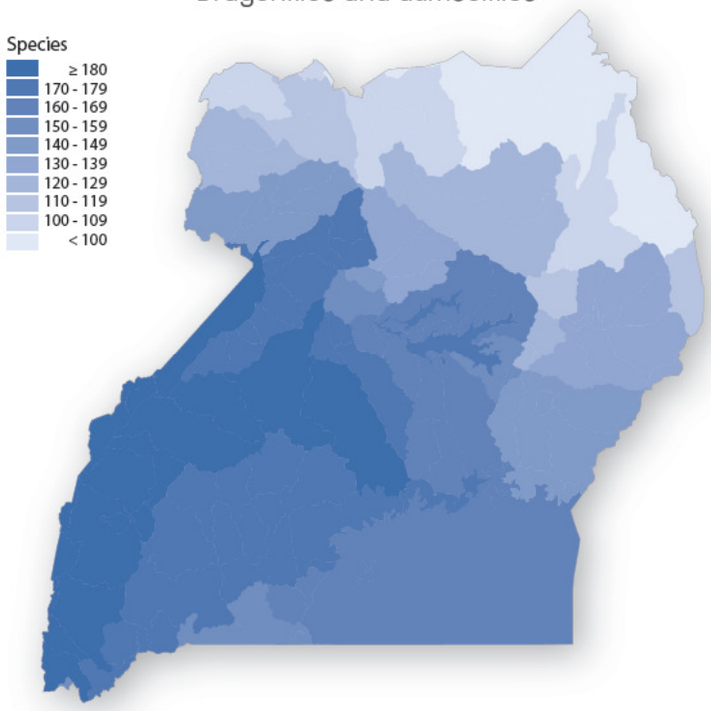
Birds



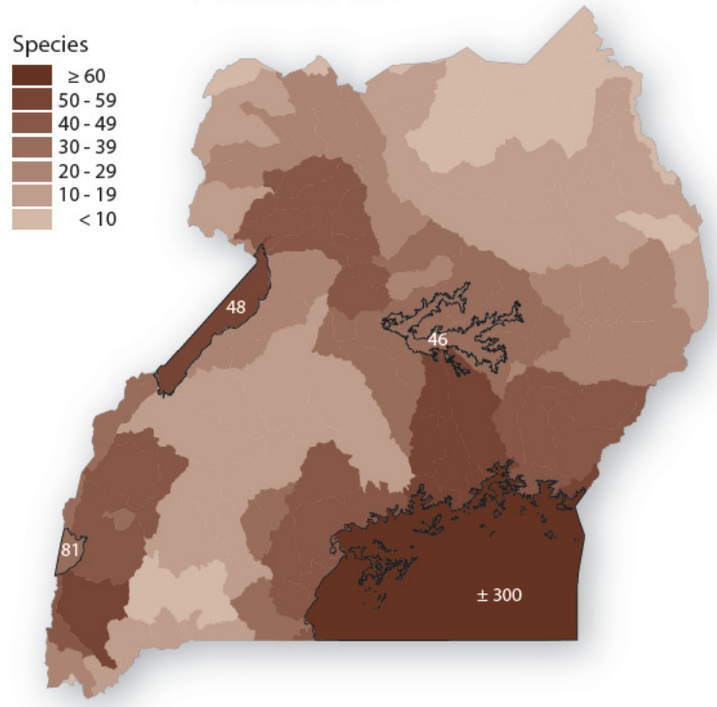
Amphibians



Dragonflies and damselflies



Freshwater fish



Grey Crowned Cranes (top), a Ugandan Kob (bottom left) and Defassa Waterbuck (bottom right), three icons of Uganda's rich biodiversity. Five iconic mammals have become extinct in Uganda in the last 50 years: Bongo, Derby's Eland, Black Rhino, White Rhino and Oryx.

Sources: *Maps of diversity - International Union for Conservation of Nature and biodiversitymapping.org*
Maps of endemism - Plumptre et al 2003

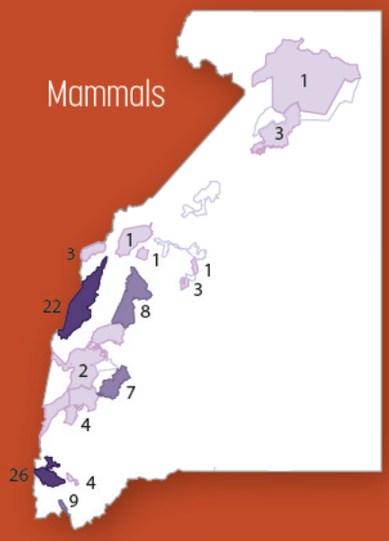
ENDEMISM

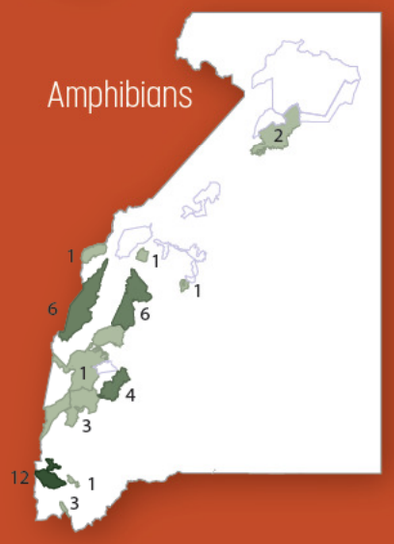
The Albertine Rift is famous for having the greatest diversity of vertebrate animals in Africa. It is also home to an extraordinary number of endemics, which are species found nowhere else in the world. Areas of the Rift that have been protected by Uganda are therefore of immense value to these localised, often rare and sometimes endangered species.

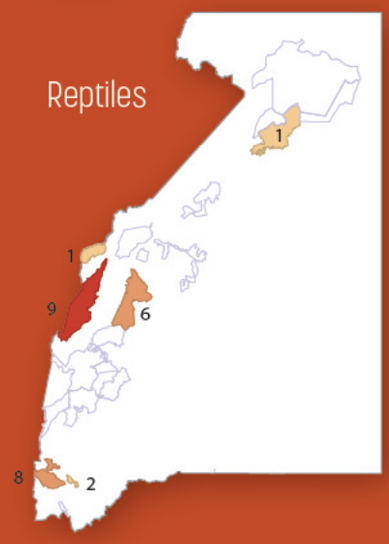
These maps show the number of endemic species of five groups of animals and flowering plants at various sites in Uganda which have been relatively undisturbed by people. The areas within Uganda of greatest value for these groups are Semliki, Kibale, Bwindi Impenetrable Forest, the Rwenzori Mountains and the Kasyoha-Kitomi Forest Reserve.

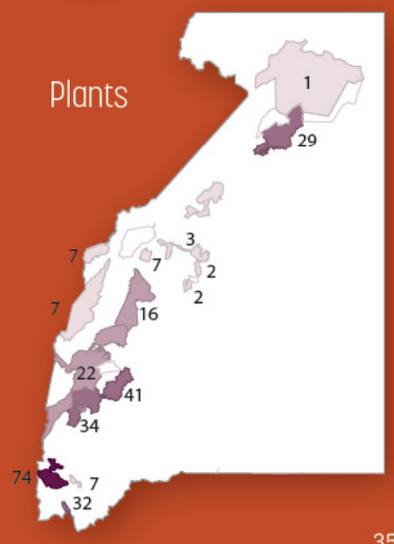
Many fish species in the Rift's lakes are also endemic. Lake Tanganyika leads with hundreds of endemic species, but 56 of the 81 species in Lakes George and Edward are endemic, as well as six of the 48 species in Lake Albert.

a Murchison Falls
b Bugungu
c Karuma
d Budongo
e Bugoma
f Semliki
g Semuliki
h Kagombe
i Kitechura
j Ibambaro
k Matiri
l Rwenzori Mountains
m Kibale
n Itwara
o Queen Elizabeth
p Kyambura
q Kasyoha - Kitomi
r Kalinzu Maramagambo
s Bwindi Impenetrable
t Mafuga
u Echuya









PROTECTED AREAS

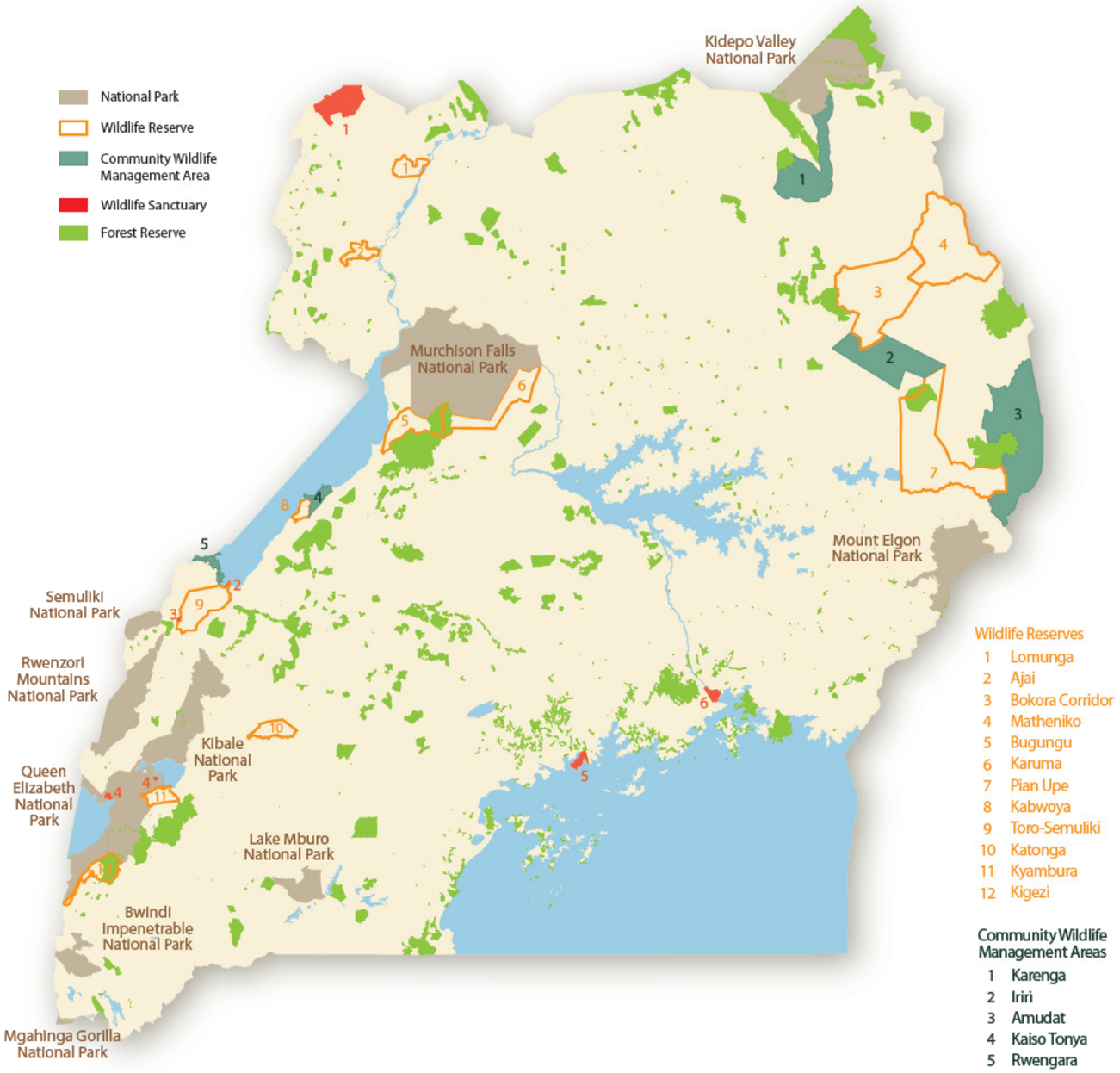
About one sixth or 15.5% of Uganda is managed for conservation and biodiversity, 10.3% in wildlife protected areas and 5.2% in forest reserves. Responsibility for the management of wildlife protected areas lies with the Uganda Wildlife Authority, while forest reserves are the responsibility of the National Forestry Authority.

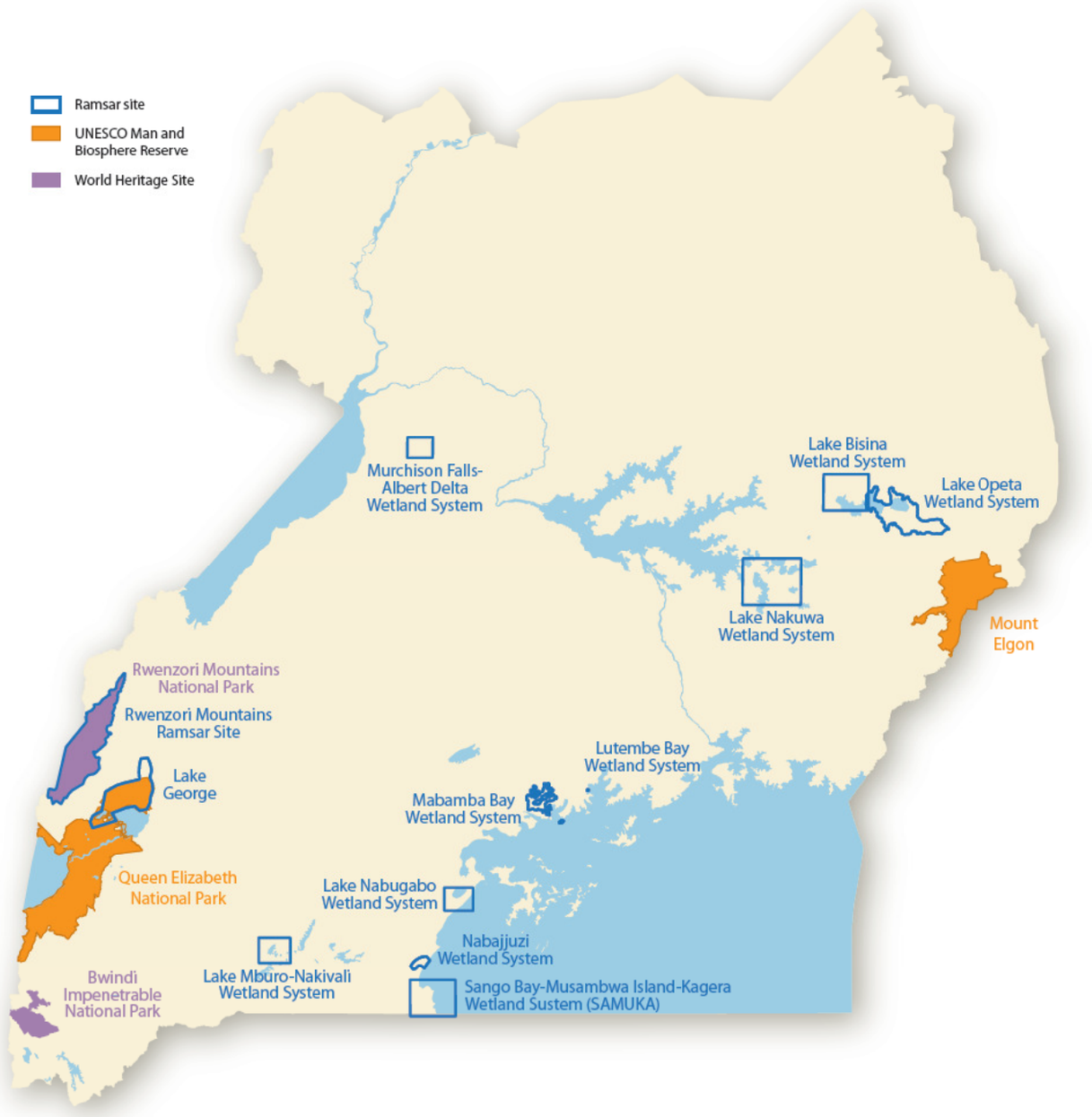
The following table lists the number, areas and IUCN Protection Categories for protected areas in Uganda.

Category	Number	Area (sq km)	% of protected areas	IUCN category
National Park	10	11,329	30.4	II
Wildlife Reserve	12	8,518	22.8	III
Community Wildlife Management Area	5	4,267	11.4	VI
Wildlife Sanctuary	6	738	2.0	VI
Forest Reserve	661	12,427	33.3	
Ramsar Site	12	45	0.1	
Total	**706**	**37,324**	**100**	

Two national parks - Bwindi Impenetrable National Park and Rwenzori Mountains National Park – have been declared as UNESCO World Heritage sites, while two others - Mount Elgon National Park and Queen Elizabeth National Park - are recognised by UNESCO (United Nations Educational, Scientific and Cultural Organisation) as Man and Biosphere Reserves. Twelve wetlands have been designated as wetlands of international significance in terms of the Ramsar Convention.

Uganda's protected areas offer a variety of benefits. For instance, they provide ecosystem services - such as food, water, climate regulation and soil nutrients - as well as conserving biological resources and fulfilling many consumptive, moral and recreational purposes. National parks form the basis of Uganda's tourism industry: in 2013, about 214,000 people visited the parks, and tourists spent around US$979 million in Uganda.





Sources: *Maps of protected areas - World Database on Protected Areas, 2013*
Maps of burning frequency and cloud cover - derived by Archibald from MODIS Burnt Area products produced by Roy, 2000 - 2010

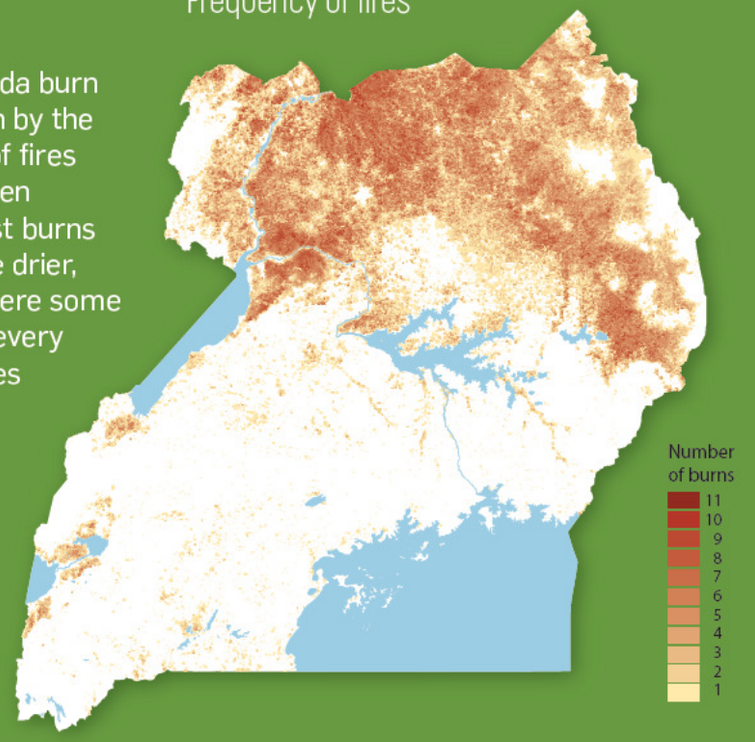
FIRE

Large areas of Uganda burn every year, as shown by the mapped frequency of fires over 10 years between 2000 and 2010. Most burns were recorded in the drier, northern regions where some areas burnt almost every year. Many of the fires are set to bring on the growth of new pastures or to open up dense cover to hunt cane or *anyeri* rats and other animals.

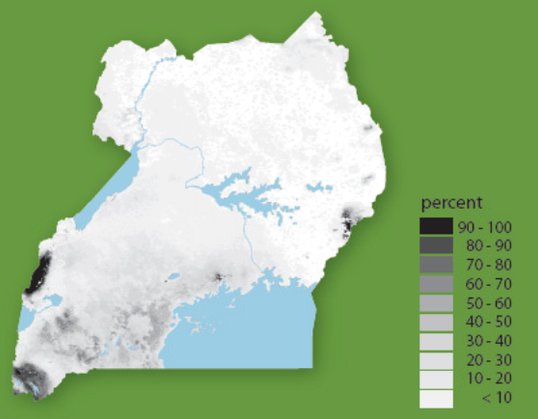
Although fires are often set in the southern areas to clear fields and rank vegetation, they are generally more confined and less intense than those in the north.

Some burns in the southern zones could not be detected by satellite because of frequent cloud cover, which is shown in the small map as the percentage of months during those 10 years that were too cloudy for fires to be detected. Cloud cover was most frequent in high rainfall areas, and particularly so over high elevations (see page 13).

Frequency of fires



Cloudy months



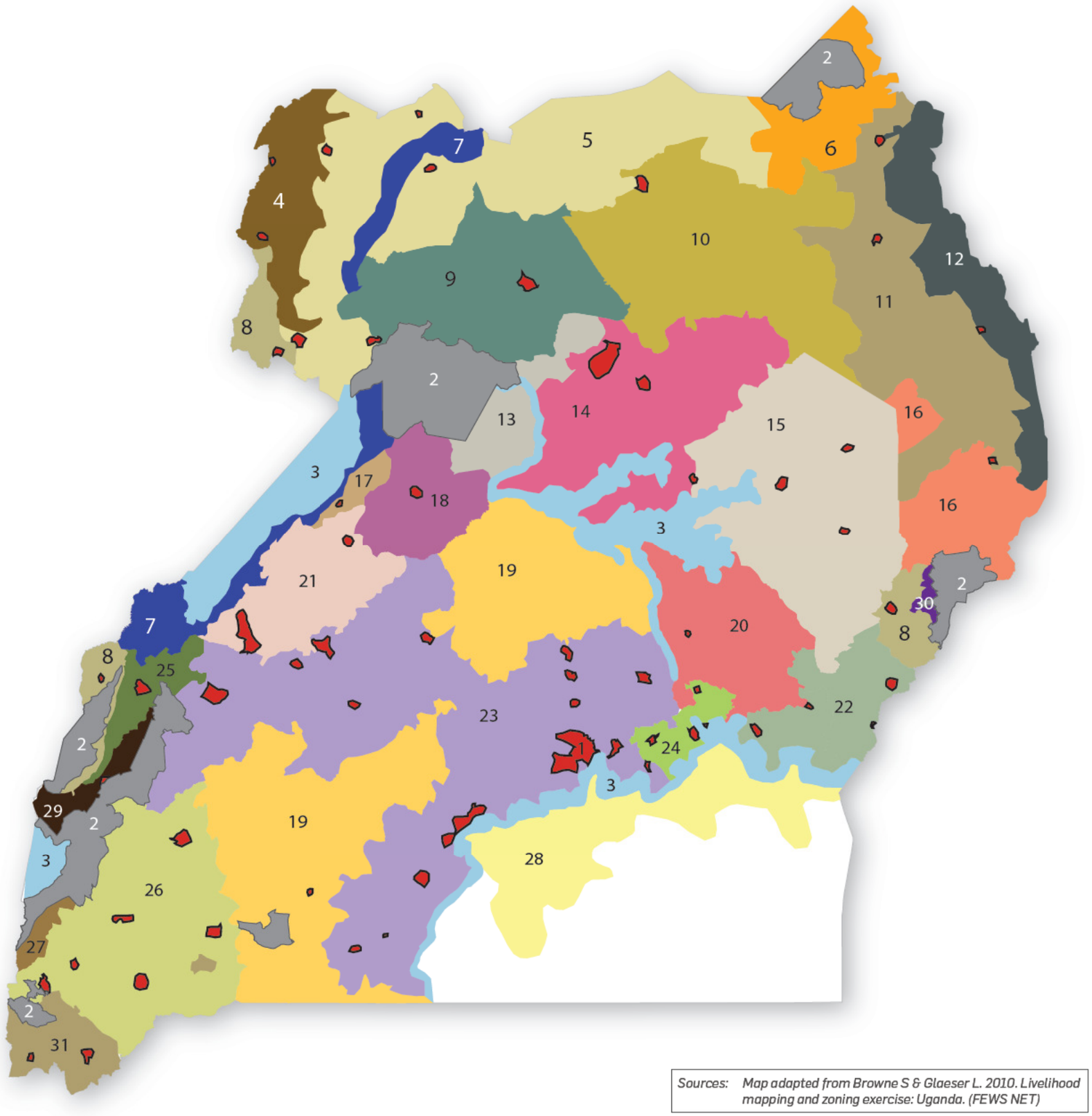
Livelihoods

LIVELIHOOD ZONES

Ugandans make a living in many ways. Much of the variation is geographic, as reflected in this map. There is also enormous variation from family to family, particularly between those with good incomes and those with little. Urban livelihoods are increasingly attractive where incomes come from services and commerce.

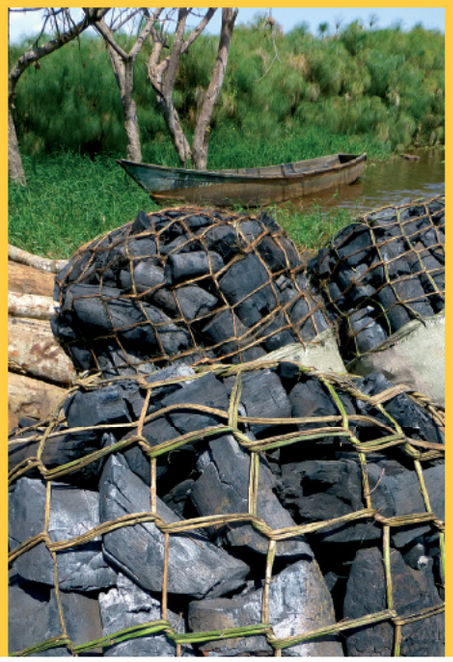
Nowadays, farming is driven by the need to produce food for domestic consumption and to sell for income. Food and income security are equally vital, and nutrition often comes from cash incomes. Rural people thus now spend much of their time earning money to buy food and pay for the necessities of modern life such as clothes, transport, school fees, mobile phones and medicine. Markets are essential for farmers to sell their produce, as are incomes from off-farm sources such as remittances, retail trade and labour, which is often provided on a piecemeal basis.

Crop farming dominates where soils are fertile, rainfall is adequate and markets are available. Relatively wealthy farmers have substantial fields and labour to prepare, plant, weed and harvest their land. By contrast, pastoralism is the basis of livelihoods in arid areas where livestock provide capital security, and sources of food and monetary incomes. This is also true for agro-pastoralists who have crops and livestock. Wealth often depends on the number of animals that are kept. Markets provide livestock owners with the chance to sell their animals or livestock products, in particular milk and meat.



Sources: *Map adapted from Browne S & Glaeser L. 2010. Livelihood mapping and zoning exercise: Uganda. (FEWS NET)*

	Zone	Main sources of income	Main food crops	Main livestock kept
1	Urban	Labour and trade		
2	National Park			
3	Lakeshore and riverbank fishing zone	Fish, pigs, chickens	Cassava, sweet potatoes, maize	Chickens, pigs
4	West Nile agro-pastoralism	Tobacco, groundnuts, cassava, livestock, land rental	Cassava, beans, sorghum, millet	Goats, cattle, chickens
5	North Kitgum-Gulu-Amuru agro-pastoralism	Simsim, sorghum, cotton, beans, pigeon peas, livestock, shea butter, labour, trade, wood	Sorghum, cassava, simsim, pigeon pea, finger millet, maize	Chickens, small ruminants, pigs
6	Northeast agro-pastoralism	Labour, woodfuel, sorghum, maize, simsim, livestock, petty trade	Sorghum, maize, simsim	Sheep, goats, pigs, cattle
7	Albertine-West Nile cattle zone	Labour, livestock, fish, woodfuel		Cattle, goats
8	Mt. Rwenzori-Mt. Elgon-West Nile coffee and bananas	Coffee, bananas, vegetables, cocoa, livestock and livestock products, labour	Bananas, Irish potatoes, vegetables, cassava, rice	Cattle, goats, chickens
9	Gulu-Amuru agro-pastoralism	Rice, groundnuts, beans, maize, simsim, labour, small livestock, firewood and charcoal	Sorghum, beans, millet, cassava, pigeon peas	Small ruminants, chickens, cattle
10	South Kitgum-Pader-Abim-Kotido agro-pastoralism	Labour, simsim, groundnuts, sorghum, woodfuel, chickens, goats	Sorghum, finger millet, pigeon peas	Chickens, goats, cattle
11	Karamoja agro-pastoralism zone	Small livestock, milk, butter, beer, labour, woodfuel	Sorghum, bulrush millet, maize	Goats, sheep, cattle
12	Karamoja pastoral zone	Sheep, goats, labour, wood fuel		Goats, sheep, cattle
13	Karuma-Masinga-Oyam agro-pastoralism	Tobacco, maize, beans, sunflower, labour, livestock, remittances, timber, thatch	Maize, cassava, beans	Chickens, goats, cattle
14	Mid-north agro-pastoralism	Beans, simsim, maize, livestock, labour, petty trade, woodfuel, stone and sand	Sorghum, millet, beans	Chickens, goats, cattle
15	Eastern Central agro-pastoralism	Cassava, rice, labour, woodfuel, livestock and livestock products	Cassava, sorghum, groundnuts	Cattle, goats, chickens
16	Eastern Lowland agro-pastoralism	Labour, maize, beans, woodfuel, livestock and livestock products	Maize, beans, rice	Cattle, goats, sheep
17	Albertine escarpment agro-pastoralism	Maize, cassava, cotton, livestock, labour	Cassava, maize, rice	Goats, cattle, pigs
18	Bwijanga-Pakami sugarcane and agro-pastoralism	Maize, sugarcane, sunflowers, livestock, liquor, petty trade, labour, charcoal	Cassava, maize, rice	Goats, sheep, cattle, chickens, pigs
19	Central and southern agro-pastoralism	Labour, woodfuel, maize	Cassava, maize	Cattle, goats
20	Southeastern coffee and cattle zone	Beans, coffee, maize, livestock, petty trade, brick-making and sand mining	Maize, sweet potatoes, beans	Cattle, goats, chickens
21	Kafu-Muzizi agro-pastoralism	Labour, maize, beans, rice, livestock and livestock products	Maize, beans, cassava	Cattle, goats, chickens
22	Southeastern lowland agro-pastoralism	Cotton, maize, rice, labour, livestock, fish	Cassava, finger millet, sweet potatoes, sorghum, groundnuts	Chickens, cattle, goats
23	Mid-west central agro-pastoralism	Coffee, maize, bananas, pineapples, woodfuel, livestock products	Bananas, cassava, maize	Chickens, pigs, cattle
24	East Central plantation outgrower zone	Sugar cane, labour, chickens, beer	Sweet potatoes, maize, beans	Chickens, goats
25	Rwenzori midland agro-pastoralism	Bananas, fruit, vegetables, tea, milk, livestock, labour, petty trade	Bananas, Irish potatoes, sweet potatoes, cassava	Cattle, goats, chickens
26	Southwestern midlands agro-pastoralism	Coffee, bananas, beans, labour, livestock	Bananas, beans, cassava	Cattle, goats, sheep
27	Southwest Rift Valley agro-pastoralism	Pineapple, sunflower, cotton, maize, labour, petty trade, artisanal mining	Beans, millet, groundnuts	Cattle, goats, sheep
28	Kalangala fishing and oil palm zone	Fish, palm oil, maize, cassava, labour	Cassava, bananas, maize	Pigs, chickens
29	Rwenzori Lowland-Kazinga Channel agro-pastoralism	Maize, bananas, vegetables, rice, cotton, labour, livestock, artisanal mining	Maize, bananas, cassava, vegetables	Cattle, sheep, goats
30	Mt. Elgon agro-pastoralism	Labour, Irish potatoes, wheat, barley, livestock, woodfuel	Irish potatoes, wheat, beans	Goats, sheep, cattle
31	Southwest highlands agro-pastoralism	Irish potatoes, vegetables, labour, craft, livestock and livestock products	Irish potatoes, sorghum, beans	Goats, sheep, cattle



LIVESTOCK PRODUCTION AND FISHERIES

Livestock production

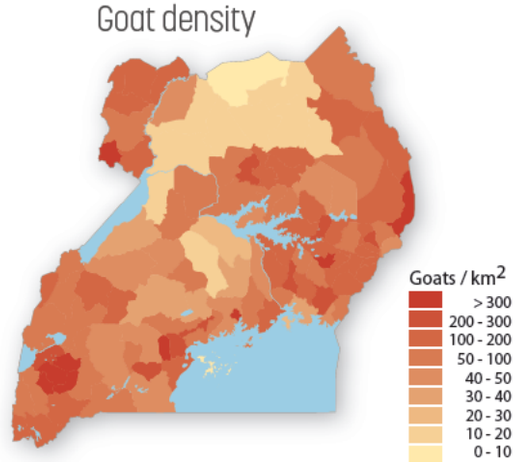
About 71% of rural households keep livestock: 50.8% keep chickens, 39.2% goats, 26.1% cattle, 17.8% pigs and 9.0% sheep.

Uganda had approximately 13.0 million cattle in 2013, of which indigenous breeds comprised 93.8% and exotic breeds 6.2%. Of the indigenous cattle, around 70% were Zebu/Nganda and 30% were Ankole breeds. Dairy cattle made up most of the exotic breeds.

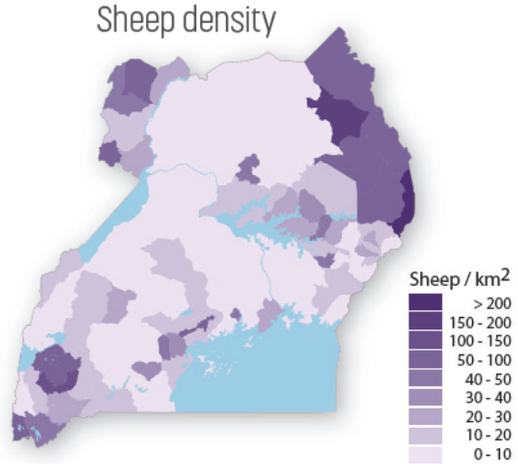
The total population of goats in 2013 was 14.6 million. There were also 3.9 million sheep, 3.7 million pigs and 43.4 million chickens, of which 87.7% were indigenous breeds.

Apart from products such as meat, milk, manure and hides, livestock (especially cattle) provide a store of wealth and security that can be utilised when needed.

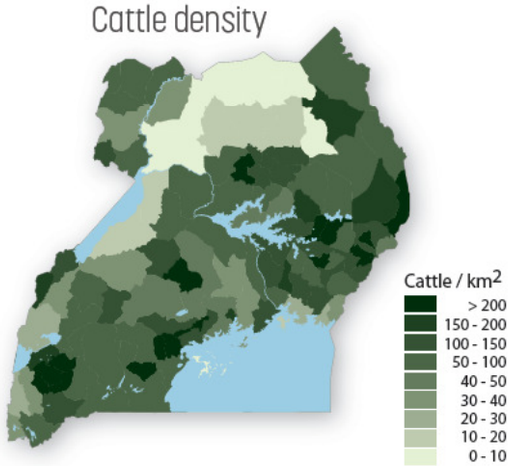
Goat density



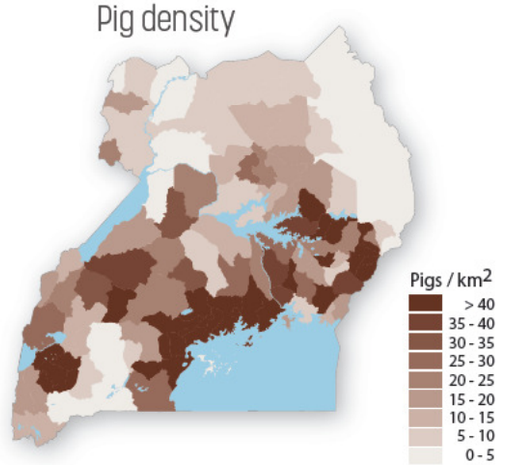
Sheep density



Cattle density

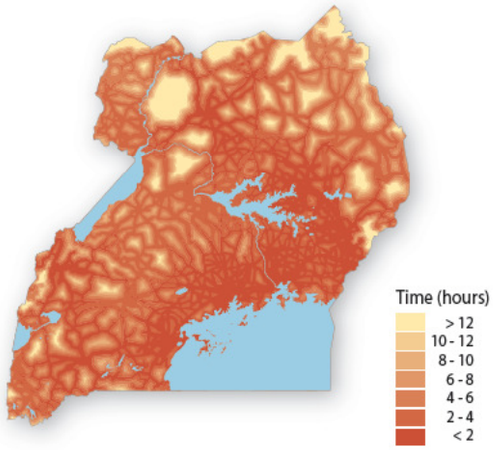


Pig density

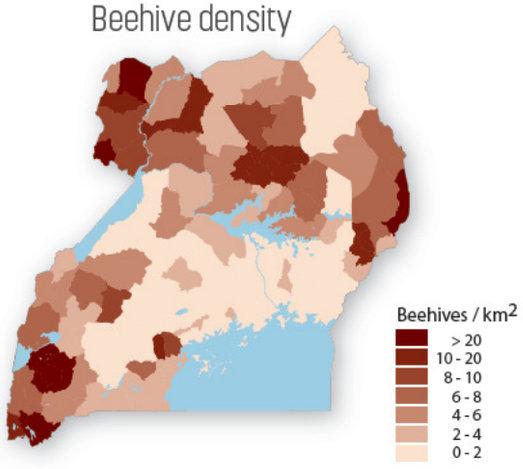


Access to markets

Access to markets, demand, prices and production volumes all influence decisions on the use and sale of agricultural produce. The map below shows where people have ready access to urban markets or to roads from where their produce can be carried to markets. Most of the areas with poor market access are sparsely populated or unpopulated (see page 20) and, in fact, most people have relatively good access to markets.



Beehive density



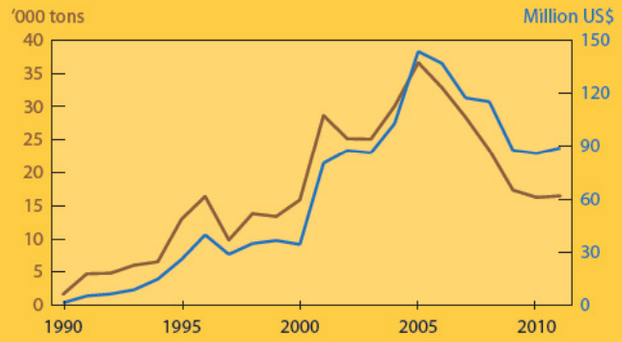
Fisheries

The fishing industry employs about 1.2 million people and contributes 2.5% to Uganda's GDP. The major commercial species include the Nile perch, tilapia and *mukene*. Exports peaked at US$ 143 million in 2005, dropping to US$ 89 million in 2011. Over 90 percent of the fish catch is harvested from Lakes Victoria, Albert and Kyoga. The introduction of predatory Nile perch and four tilapia species into Lake Kyoga (in the 1950s) and Lake Victoria (1960s) caused a severe drop in native cichlid species with some estimates suggesting that about 300 species were exterminated.

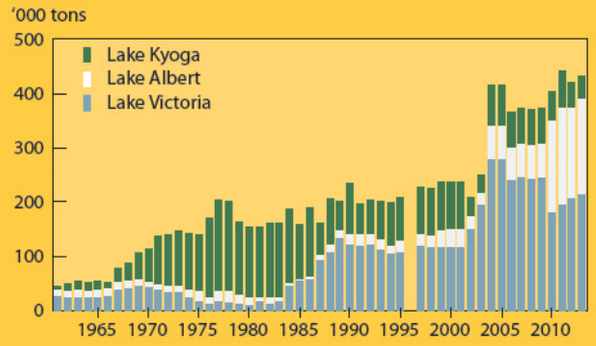
In recent years numbers of Nile perch in Lake Victoria have declined progressively, largely because of greater fishing effort and the harvesting of young fish. Their decline has led to increases in tilapia and *mukene* catches and, interestingly, the reappearance of a small number of cichlid species thought to have disappeared.

Catches of other species have also dropped in both Lake Victoria and Lake Kyoga since 2005. In addition to the effects of over-fishing, eutrophication (caused by industrial pollution and sewage inflows) is considered to be a serious problem, not only for commercial species but also for the remaining highly vulnerable native species. The human population in the catchment area of Lake Victoria has increased rapidly in recent decades and is expected to reach 53 million by 2020.

Fish exports to the international market



Total fish landings

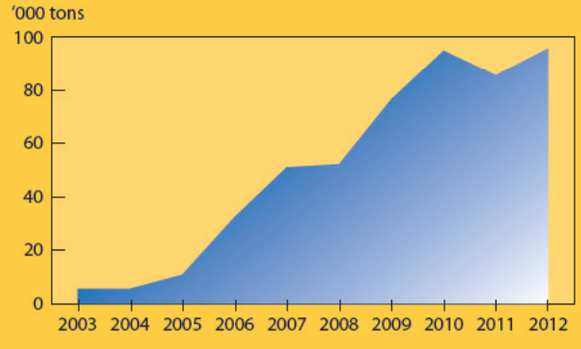


Aquaculture

There has been a rapid increase in production of fish through aquaculture in Uganda. Approximately 96,000 tons of fish were produced in 2012 and the sector employs around 53,000 people.

Three types of aquaculture are practiced: rural or subsistence aquaculture; small-scale aquaculture and commercial fish farming. The two species which dominate production are Nile tilapia and North African catfish. Other important species are common carp, redbelly tilapia and *Oreochromis leucostictus*. In addition to fish, crustaceans such as giant river prawn and red swamp crawfish are also produced.

Fish production by aquaculture



Sources: Livestock maps and text from 2008 National Livestock Census.
Map of access to markets - Joint Research Centre, European Commission.
Fisheries charts and text - Ministry of Agriculture, Animal Industry & Fisheries; Lowe-McConnell, 2009

CROP PRODUCTION

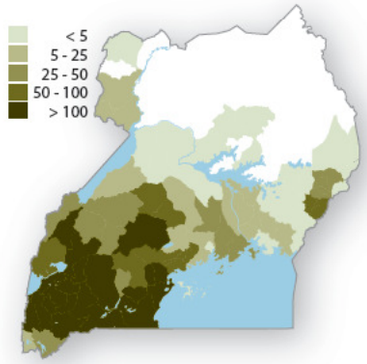
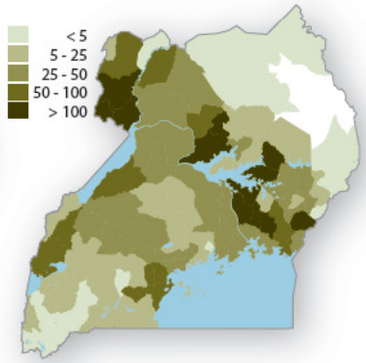
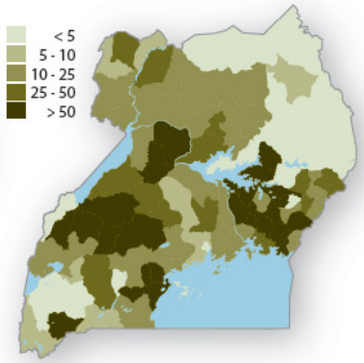
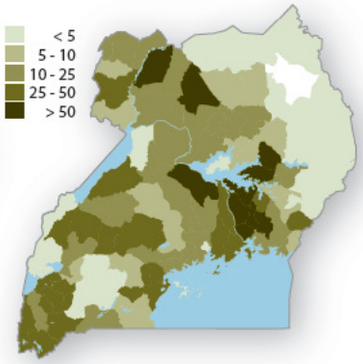
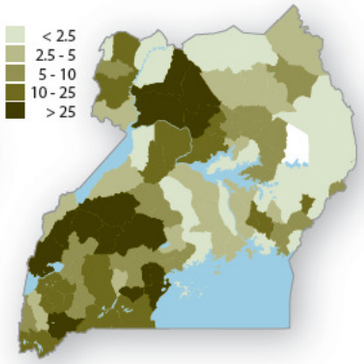
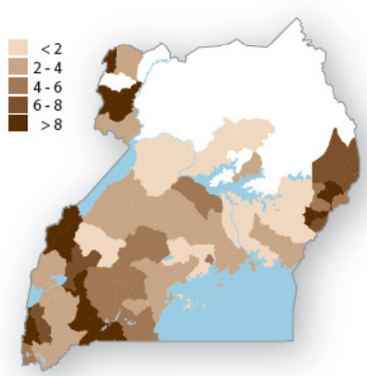
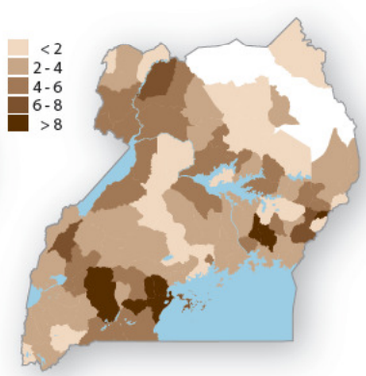
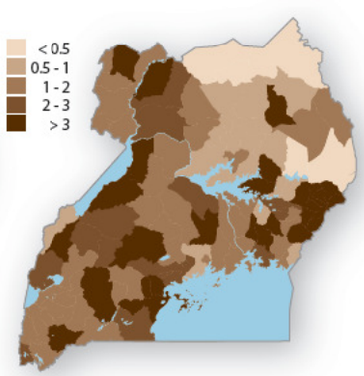
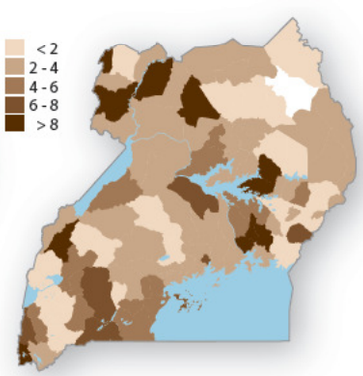
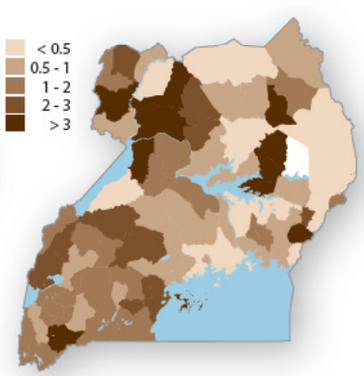
Fertile soils, abundant rain and easy access to markets make much of Uganda a paradise for growing crops. A high proportion of farms provide most or all of the nutritional needs of their owners, and surpluses are often available for sale to consumers in Uganda and beyond. For example, in 2013 Uganda supplied 95% of the sorghum, 90% of the maize and 74% of the beans that were traded within East Africa.

The main staple crops are food or *matooke* banana, cassava, maize, sweet potato, sorghum, finger millet, rice and Irish potato. Non-staple crops ranked by volume are beans, groundnuts, beer banana, simsim (sesame), sweet banana, soya beans, field peas, pigeon peas and cowpeas.

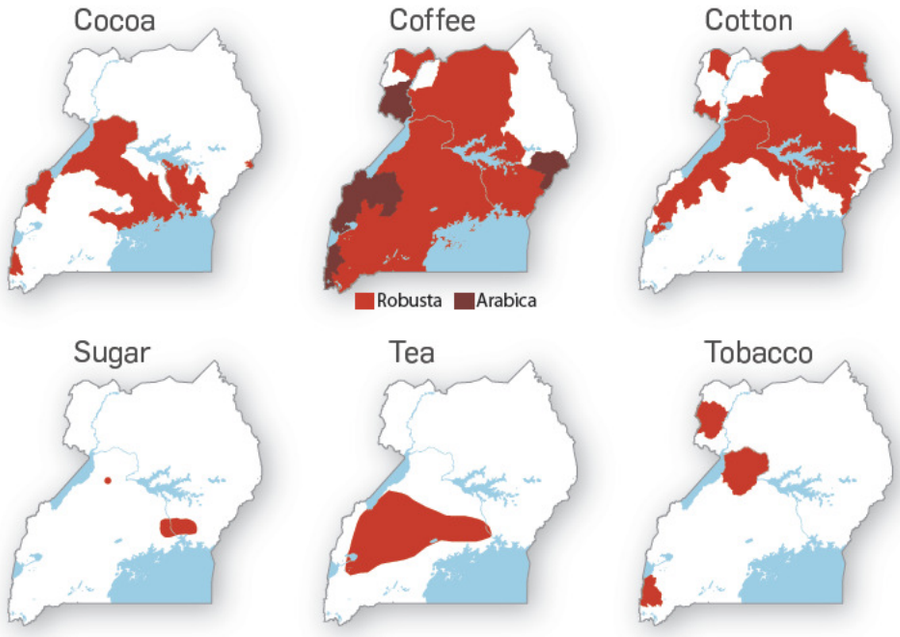
The proportions of each crop that are sold or kept for consumption vary. Even for the same crop there is considerable variation in sales from district to district, and house to house, depending on what surplus is available, people's needs for income, and access to markets and prices. Coffee, tea, sugar, tobacco, cocoa and cotton are also grown commercially by smallholder farmers and on some larger commercial holdings.

Despite conditions being excellent for crops in many areas, production per household is now lower than in the past. This is a consequence of reduced soil fertility caused by inadequate use of organic or inorganic fertilisers and the ongoing fragmentation of farm plots into smaller parcels to accommodate the growing population.

The series of maps below show the production and yields of a selection of crops in 2008/09.

	Banana (food)	Cassava	Maize	Sweet potato	Bean
Production (thousand tonnes) in 2008/2009 →					
Yield (tonnes per hectare) in 2008/2009 →					

Areas used for major export and cash crops



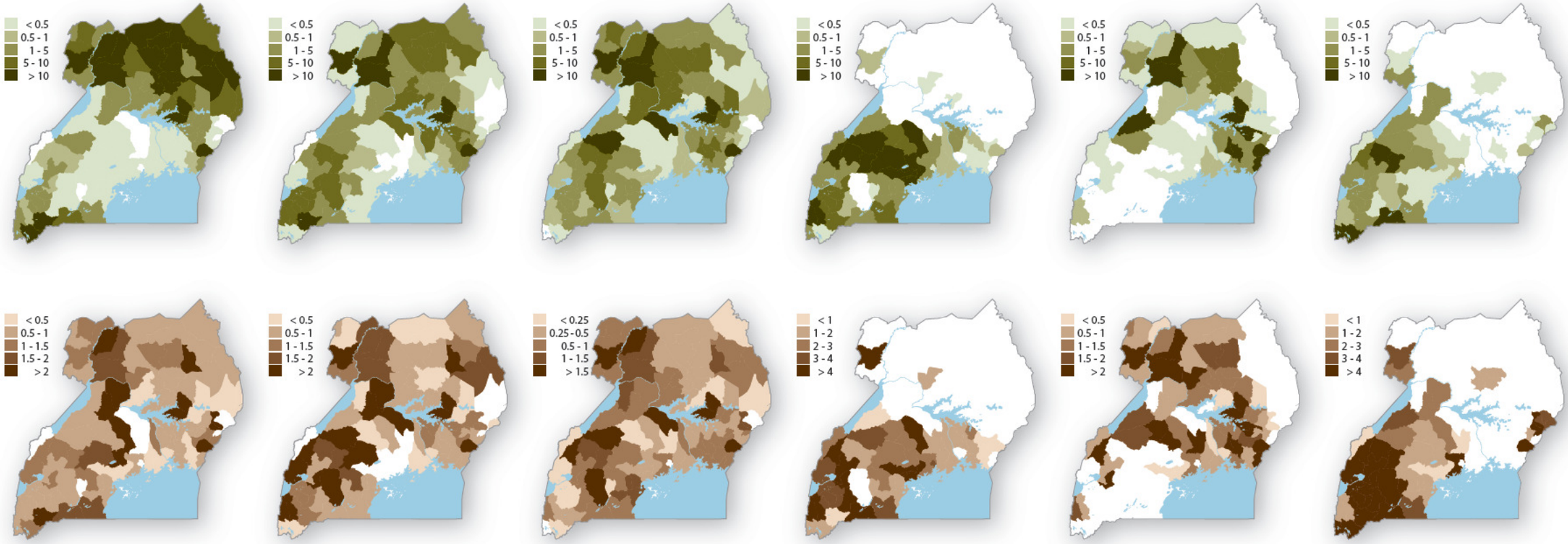
Production (thousands of tonnes), average annual yield (tonnes per hectare) and percentage sold in 2008/09:

Crop	Production	Yield	% sold
Banana (food)	4,018	5.0	34.6
Cassava	2,894	3.3	22.2
Maize	2,362	2.3	40.5
Sweet potato	1,819	4.1	12.1
Bean	929	1.5	31.6
Sorghum	376	0.9	14.3
Finger millet	277	1.1	19.0
Groundnut	245	0.7	31.7
Banana (beer)	243	2.8	77.8

Crop	Production	Yield	% sold
Rice	191	2.5	54.5
Irish potato	154	4.7	40.5
Simsim	101	0.6	33.2
Banana (sweet)	37	0.6	55.3
Soya bean	24	0.6	64.2
Field pea	16	0.4	16.4
Pigeon pea	11	0.4	6.0
Cowpea	11	0.5	20.7

Sources: Tables and maps of crop production show 2008-2009 data from Uganda Bureau of Statistics; and RAISON from various sources.

Sorghum | Finger millet | Groundnut | Banana (beer) | Rice | Irish potato



ENDNOTES

Data Sources

Page 4
Map data for regions and districts from GIST portal https://gistdata.itos.uga.edu/. Statistics: 2014 Statistical Abstract. Uganda Bureau of Statistics, Kampala; Uganda Bureau of Statistics, 2014, National Population and Housing Census Provisional Results. Revised Edition. Available at http://www.ubos.org/onlinefiles/uploads/ubos/NPHC/NPHC 2014 PROVISIONAL RESULTS REPORT.pdf; Encyclopaedia Britannica http://www.britannica.com/Uganda; World Fact Book (http://www.cia.gov/library/publications/the-world-factbook/geos/gh.html); www.statoids.com/uug.html.

Page 5
Introduction map: roads, towns and cities from Open Street Map (http://www.openstreetmap.org), protected areas from World Database on Protected Areas (WDPA; http://www.wdpa.org), lakes and rivers (HydroSHEDS data http://hydrosheds.cr.usgs.gov and various satellite images).

Page 6
Mosaic of images provided by Google (http://maps.google.com) through TerraIncognita (http://www.zubak.sk).

Page 7
Topography and elevation profiles: SRTM 90 metre digital elevation data from National Aeronautics and Space Administration (NASA; http://www2.jpl.nasa.gov/srtm).

Pages 8-9
Minerals: adapted from "Geological prospectivity of Uganda". 2013. Presentation by Baguma Zachary Mosimoson Atwoki, Ag. Assistant Commissioner/Geology Geological Survey and Mines Department; and Mineral Occurrences of Uganda; map produced by Department of Geological Survey and Mines of Uganda, accessed from http://www.uganda-mining.go.ug, http://www.worldbank.org/en/results/2013/03/19/developing-uganda-s-mining-sector; and www.petroleum.go.ug. Geology text based largely on: Westerhof, A. B, Harma, P., Isabirye, E., Katto, E., Koistinen, T., Kuosmanen, E., Lehto, T., Lehtonen, M. I., Makitie, H., Manninen, T., Manttari, I., Pekkala, Y., Pokki, J., Saalmann, K. & Virransalo, P. 2014. Geology and Geodynamic Development of Uganda with Explanation of the 1:1,000,000-Scale Geological Map. *Geological Survey of Finland, Special Paper 55*, 387 pages. Geology map: Adapted from Preliminary Geological Map of Uganda 1:500 0000. 2009. Published by Department of Geological Survey and Mines of Uganda, accessed from http://www.uganda-mining.go.ug, 1:1,2 million geological map produced by Department of Geological Survey and Mines of Uganda, accessed from http://portal.onegeology.org/; and Westerhof, A. B, Harma, P., Isabirye, E., Katto, E., Koistinen, T., Kuosmanen, E., Lehto, T., Lehtonen, M. I., Makitie, H., Manninen, T., Manttari, I., Pekkala, Y., Pokki, J., Saalmann, K. & Virransalo, P. 2014. Geology and Geodynamic Development of Uganda with Explanation of the 1:1,000,000 -Scale Geological Map. *Geological Survey of Finland, Special Paper 55*, 387 pages.

Page 10
Map of annual average rainfall from WorldClim data set which covers the period 1950 to 2000 (http://www.worldclim.org). Worldclim interpolated layers are derived using major climate databases (GHCN, FAO, WMO, CIAT, R-HYdronet) as well as the SRTM elevation database. Resolution is 30 arc seconds. Graphs: monthly rainfall records from the Uganda Meteorological Agency.

Page 11
Maps created from rainfall estimates from 1996 to 2013 produced by FEWS NET (Famine Early Warning System Network; http://earlywarning.usgs.gov/fews). Resolution is 8 km.

Page 12
Map created from estimates of rainfall from 1996 to 2013 produced by FEWS NET (Famine Early Warning System Network; http://earlywarning.usgs.gov/fews). Resolution is 8 km. Average annual rainfall was calculated for each year in the period 1996 to 2013. The standard deviation in annual totals was then calculated to produce the coefficient of variation (standard deviation as a percentage of the mean). Graphs: annual rainfall records from from Uganda Meteorological Agency covering 1961 - 2010.

Page 13
Map of solar radiation from data covering the period 1998 to 2011, from Joint Research Centre, Institute for Energy and Transport, European Union. http://re.jrc.ec.europa.eu/pvgis/download/solar_radiation_cmsaf_download.html. Resolution is 1.5 arc minutes. Graphs: sunshine hours records from Karume K, Banda EJKB, Mubiru J and M Majaliwa. 2007. Correlation between sunshine hours and climatic parameters at four locations in Uganda. *Tanzania Journal of Science* 33, 93-100

Pages 14-15
Maps of temperature from WorldClim data set which covers the period 1950 to 2000 (http://www.worldclim.org). Resolution is 30 arc seconds. Graphs: maximum and minimum temperature records from Uganda Meteorological Agency covering 1961 - 2010.

Page 16
Maps of evapotranspiration and PET created from MODIS Global Evapotranspiration Project (MOD16; http://www.ntsg.umt.edu/project/mod16) which covers the period from 2000 to 2012. Resolution is 1 km.

Page 17
Graphs: relative humidity records from Karume K, Banda EJKB, Mubiru J and M Majaliwa. 2007. Correlation between sunshine hours and climatic parameters at four locations in Uganda. *Tanzania Journal of Science* 33, 93-100

Maps of bioclimate zones from http://rmgsc.cr.usgs.gov/ecosystems/dataviewer.shtml and see http://pubs.usgs.gov/sim/3084 and Rivas-Martínez S, Sánchez-Mata D & Costa M. 2004. *Synoptical Worldwide Bioclimatic Classification System*: http://www.globalbioclimatics.org/book/bioc/tabla3.htm. Map of agroclimatic zones from Food and Agriculture Organisation of the United Nations (http://www.fao.org/ ag/againfo/resources/en/glw/GLW_prod-sys.html).

Pages 18-19
Maps were produced by the CSIR Natural Resources and the Environment: Climate Studies, Modelling and Environmental Health, South Africa for two emission scenarios: RCP 4.5 and RCP 8.5 modelled at 0.5 degree resolution. Each scenario comprised 2 and 3 models respectively and the mean (RCP 4.5) and median (RCP 8.5) of each set was used for each time period. The RCP 4.5 and 8.5 data were not bias-corrected and were therefore adjusted relative to A2 scenario baselines for rainfall and temperature. For rainfall maps, percentage change was calculated between baseline projections (1970 - 2005) and modelled projections for the periods 2040-2060 and 2080-2100. Annual rainfall totals were derived by summing the four seasonal totals JAS (July, August, September), OND (October, November, December), JFM (January, February, March) and AMJ (April, May, June) for each model in each time period. For temperature maps two seasons were selected containing the coolest and warmest months across the majority of the country i.e. FMA and JAS. For each model, average seasonal temperature was calculated as the midpoint between the average seasonal maximum and minimum temperatures for model periods 1970-2005, 2040-2060 and 2080-2100. Maps depict temperature change in degrees Celsius for the periods 2040- 2060 and 2080-2100. For more information see: Engelbrecht FA, Landman WA, Engelbrecht CJ, Landman S, Bopape MM, Roux B, McGregor JL & Thatcher M. 2011. Multi-scale climate modeling over Southern Africa using a variable-resolution global model. *Water SA* 37: 647–658; Malherbe J, Engelbrecht FA & WA Landman. 2013. Projected changes in tropical cyclone climatology and landfall in the Southwest Indian Ocean region under enhanced anthropogenic forcing. *Climate Dynamics* (Impact Factor: 4.23). 40(11-12); DOI:10.1007/s00382-012-1635-2; DEA (Department of Environmental Affairs). 2013. *Long-Term Adaptation Scenarios Flagship Research Programme (LTAS) for South Africa.* Climate Trends and Scenarios for South Africa. Pretoria, South Africa.

Page 20
Map of population densities in 2010, compiled by and available from WorldPop Project (http://www.worldpop.org.uk), UN adjusted. The 100 m resolution grid was resampled (using neighbourhood summing) to depict numbers of people in each 1km grid cell. Text: 2014 Statistical Abstract. Uganda Bureau of Statistics, Kampala; Uganda Bureau of Statistics, 2014, National Population and Housing Census Provisional Results. Revised Edition. Available at http://www.ubos.org/onlinefiles/uploads/ubos/NPHC/NPHC 2014 PROVISIONAL RESULTS REPORT.pdf; National Association of Professional Environmentalists (FoE –Uganda). 2012. A study on Land Grabbing cases in Uganda. Available at http://reliefweb.int/sites/reliefweb.int/files/resources/Full_Report_3823.pdf. Martiniello G. 2012. The Accumulation of Dispossession and Resistance in Northern Uganda. Paper presented at the International

Conference on Global Land Grabbing II. Land Deals Politics Initiative (LDPI). Available at http://www.cornell-landproject.org/download/landgrab2012papers/martiniello.pdf

Pages 21-22
Images from Google Earth.

Page 23
Statistics on population: 2014 Statistical Abstract. Uganda Bureau of Statistics, Kampala; The State of Uganda Population Report 2013. Ministry of Finance, Planning and Economic Development, Uganda; Uganda Bureau of Statistics, 2014, National Population and Housing Census Provisional Results. Revised Edition. Available at http://www.ubos.org/onlinefiles/uploads/ubos/NPHC/NPHC 2014 PROVISIONAL RESULTS REPORT.pdf.

Pages 24-25
Maps of soil types from Soil Atlas of Africa which can be downloaded from http://eusoils.jrc.ec.europa.eu/library/maps/africa_atlas. Maps of soil properties from International Soil Reference and Information Centre (ISRIC) World Soil Information African Soils Information Service (AfSIS; http://www.isric.org/data/ soilproperty-maps-africa-1-km). Resolution is 1 km.

Pages 26-27
Map of rivers and catchments compiled by RAISON from multiple sources including HydroSHEDS data (http://hydrosheds.cr.usgs.gov) and satellite images.

Page 28-29
Vegetation type maps adapted from: van Breugel P, Kindt R, Lillesø JPB, Bingham M, Demissew S, Dudley C, Friis I, Gachathi F, Kalema J, Mbago F, Moshi HN, Mulumba, J, Ngda H, Namaganda M, Ruffo CK, Védaste M, Jamnadass R and Graudal L. 2012. *Potential Natural Vegetation Map of Eastern Africa: An interactive vegetation map for Ethiopia, Kenya, Malawi, Rwanda, Tanzania, Uganda and Zambia.* Version 1.1. Forest and Landscape (Denmark) and World Agroforestry Centre (ICRAF). Visit http://vegetationmap4africa.org to obtain updated maps and detailed information on the characteristics of each vegetation type. Text sources: Obua J, Jacob G, Agea JG & Ogwal JJ. 2010. Status of forests in Uganda. *African Journal of Ecology* 48: 853-859; National Forestry Authority. 2008. Strategic action plan for the period 2008/9 to 2012/13 with priorities for the first five years. Government of Uganda, Kampala.

Page 30
Map of variation in annual plant production (expressed as coefficient of variation) derived from data for 2000 to 2012 obtained from Africa Soil Information Service (AfSIS; http://www.africasoils. net/data/datasets?page=1). Resolution is 1 km. Map of Enhanced Vegetation Index (EVI) derived from data for 2000 to 2012 obtained from Africa Soil Information Service (http:// www.africasoils.net/data/datasets?page=1). Resolution is 250 m.

Page 31
Maps of Enhanced Vegetation Index (EVI) per month derived from data for 2000 to 2012 obtained from Africa Soil Information Service (AfSIS; http://www.africasoils.net/data/datasets?page=1). Resolution is 250 m.

Pages 32-33
Forest cover, loss and gain maps: Hansen/UMD/Google/USGS/NASA (http://earthenginepartners.appspot.com/science-2013-global-forest). See Hansen MC, PV Potapov, R Moore, M Hancher, S A Turubanova, A Tyukavina, D Thau, SV Stehman, SJ Goetz, TR Loveland, A Kommareddy, A Egorov, L Chini, CO Justice & JRG Townshend. 2013. High-Resolution Global Maps of 21st-Century Forest Cover Change. *Science* 342: 850–53. Resolution 30 m grid cells. Forest cover in 2000 represents the percentage canopy closure for trees taller than 5 m. Forest gain and loss was coded as 1 or 0 for stand-replacement disturbance or change during the 2000-2012 period. For the purposes of presentation in maps loss and gain grids were resampled to 900 m pixel resolution and represent the percentage of 30 m grid cells in each 900 m pixel which had a value of 1. Additional source for text: Obua J, Jacob G. Agea JG & Ogwal JJ. 2010. Status of forests in Uganda. *African Journal of Ecology* 48: 853-859.

Page 34
Maps of diversity - International Union for Conservation of Nature and biodiversitymapping.org; Text: Winterbottom & G Eliu. 2006. Uganda biodiversity and tropical forest assessment. 2006. International Resources Group, Washington DC (available from http://www.vub.ac.be/klimostoolkit/sites/default/files/documents/uganda_biodiversity_assessment_usaid.pdf); Mbabazi D, Ogutu-Ohwayo R, Wandera SB & Kiziito Y. 2004. Fish species and trophic diversity of haplochromine cichlids in the Kyoga satellite lakes (Uganda). *African Journal of Ecology* 42: 59-68; National Biodiversity Databank, Makerere University, Uganda (http://nbdb.mak.ac.ug/index.php/ugandas-biodiversity)

Page 35
Maps of endemism - data from Plumptre AJ, Behangana M, Davenport TRB, Kahindo C, Kityo R, Ndomba E, Nkuutu D, Owiunji I, Ssegawa P & Eilu G. 2003. *The Biodiversity of the Albertine Rift. Albertine Rift Technical Reports* No. 3

Page 36
Maps and sizes of protected areas in 2014: World Database on Protected Areas (WDPA; http://www.wdpa.org). Text from Uganda Wildlife Authority www.ugandawildlife.org, Integrated Biodiversity Assessment Tool www.ibatforbusiness.org/home, Tourism Uganda http://www.visituganda.com and 2014 Statistical Abstract. Uganda Bureau of Statistics, Kampala.

Page 37
Maps of burning frequency from Sally Archibald, and Modis Burnt Area products produced by David Roy, for the years 2000 to 2010, at 500 metre pixel resolution; available from http://wamis. meraka.org.za/products/fire-frequency-map; and described by Archibald S, Scholes R, Roy D, Roberts G & Boschetti L. 2010. Southern African fire regimes as revealed by remote sensing. *International Journal of Wildland Fire*, 19 (7) 861-878.

Pages 38-39
Map of livelihood zones and text adapted from Browne S & Glaeser L. 2010. Livelihood mapping and zoning exercise: Uganda. Famine Early Warning Systems Network (FEWS NET).

Page 40
Maps of cattle, goat, pig, sheep and beehive density (page 41) from Government of Uganda. 2008. The National Livestock Census Report. Ministry of Agriculture, Animal Industry & Fisheries (Entebbe) and Uganda Bureau of Statistics (Kampala). Livestock numbers from 2014 Statistical Abstract. Uganda Bureau of Statistics, Kampala.

Page 41
The map of access to markets shows the travel time using land- or water-based travel to cities of 50,000 people or more in 2007 - 2008. Compiled by Andy Nelson and available from the Joint Research Centre of the European Commission (http://bioval.jrc.ec.europa.eu/products/gam/index.htm). Fisheries information: Ministry of Agriculture, Animal Industry & Fisheries, 2010. Agriculture for Food and Income Security. Agriculture Sector Development Strategy and Investment Plan: 2010/11-2014/15; Ministry of Agriculture, Animal Industry & Fisheries, 2012. Operationalisation of the non-ataas component of the development strategy and investment plan (dsip). Draft final situation analysis report: fish production; R. Lowe-McConnell, 2009. Fisheries and cichlid evolution in the great lakes. Freshwater Reviews 2009 2; Ministry of Agriculture, Animal Industry & Fisheries, 2012. Agriculture sector performance summarised report. 1st-2nd November, Speke resort, Munyonyo; Statistical Abstracts 2002 to 2014. Uganda Bureau of Statistics, Kampala; FAO yearbook. Fishery and Aquaculture Statistics. 2012

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Most maps in this book were projected using the following parameters:

Projection: Albers Equal Area
Datum: WGS84
Central meridian: 32.5°E
First standard parallel: 0.5°S
Second standard parallel: 3°N
Latitude of origin: 1°N

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