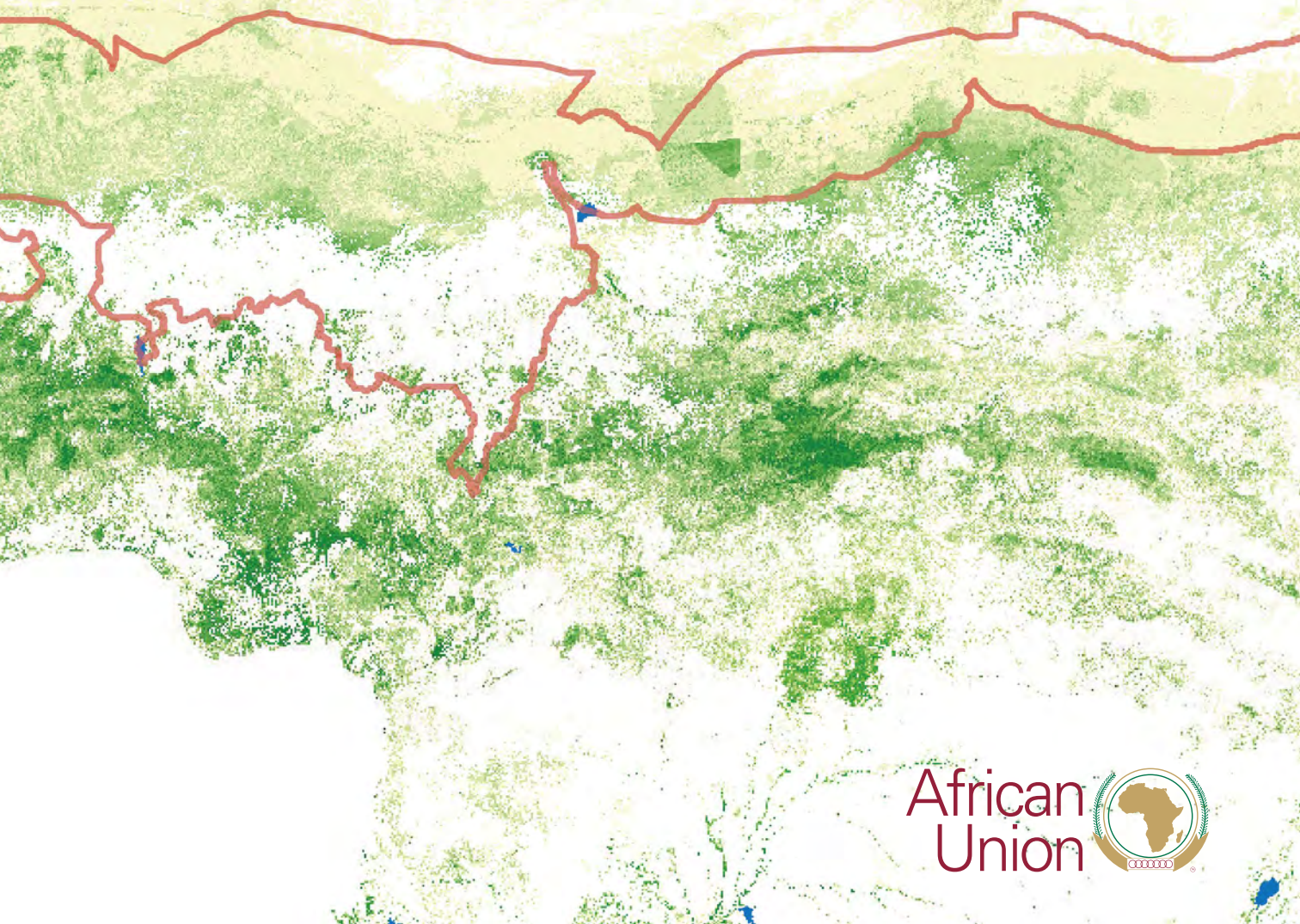
Food and Agriculture Organization of the United Nations

AFRICA OPEN DATA FOR ENVIRONMENT, AGRICULTURE AND LAND (DEAL) AND **AFRICA'S GREAT GREEN WALL**

Technical land use report



African Union

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Foreword

The Africa Open DEAL (Data for Environment, Agriculture and Land) initiative is a first-of-its-kind collection of accurate, comprehensive, and harmonized African land use and land use change data. It provides a detailed panorama of the entire continent, captured through more than 300 000 sampling points taken from very high-resolution satellite imagery using FAO's Collect Earth tools developed in partnership with Google. Led by the Food and Agriculture Organization of the United Nations (FAO) and supported by the Pan-African Agency of the Great Green Wall (PAAGGW), the Southern Africa Development Community (SADC), the African Union Commission (AUC) and 30 African countries, the technical land use report is the collective effort of more than 350 African experts. It presents the statistics and key findings of the survey and elaborates on the future prospects of land use change in Africa. Using maps and statistics generated from the assessments, the report is displayed in a comprehensive and accessible layout designed for all stakeholders to make use of the findings.

The report indicates that in Africa, as much as 65 percent of productive land is degraded, while desertification affects 45 percent of the land area. Between 2015 and 2020, Africa has lost 4.4 million hectares of forest each year primarily due to agriculture expansion and overexploitation of resources. However, the report reveals that out of the one billion ha of drylands, 393 million ha are still restorable, more than anywhere else to be found. The 356 million ha of land in Africa under cultivation amounts to more than double the area cultivated in the European Union.

Land restoration for livelihoods, biodiversity and carbon capture is achievable in Africa and this is confirmed by multiple large-scale initiatives and countries' commitments. Notable examples include restoration targets of 100 million ha for Africa's Great Green Wall, 100 million ha for the AFR100, both by 2030, and another 200 million ha for the Pan-African Agenda on Ecosystem Restoration, more than anywhere else globally and in addition to ecosystem based management of marine and coastal ecosystems, and mangroves.

Africa's drylands in the Sahel, Northern and Southern Africa regions are more adversely affected by reduced rainfall or extreme precipitation events than wetter areas, such as the Congo Basin for example. Land restoration and rehabilitation represent an important mitigation action to increase vegetation and land cover, and surface drainage. However, studies have projected that successfully restored lands in the Sahel under the Great Green Wall (GGW) would have a profound positive effect on the climate of the whole region including northern Africa. These changes could as much as double the amount of rainfall within the Sahel or decrease average summer temperatures throughout much of Northern Africa and into the Mediterranean.

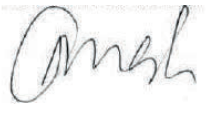
Africa Open DEAL and Africa's GGW data are set as biophysical baselines, to be reviewed and regularly updated at least every two years until 2030. The plan is to continue to produce technical and scientific publications accessible to wider audiences in order to better communicate on land's potentials in Africa.

The report is timely and supports informed decision-making on land use and land use change, and countries' national and international commitments to land restoration, climate change adaptation and mitigation. Countries and institutions will be able to use it as baselines for progress assessments on their agriculture and environment commitments and implementations, for their reporting to the three Rio Conventions - the United Nations Convention to Combat Desertification (UNCCD), the United Nations Framework Convention on Climate Change (UNFCCC) and the Convention on Biological Diversity (CBD) - and other international obligations, including the UN Decade on Ecosystem Restoration (2021–2030).

FAO and the AUC remain committed to working with member countries, African institutions and partners to leverage digital technologies to fast-track data on land use, land use change and restoration efforts on the continent.

Ambassador Josefa Leonel Correia Sacko
Commissioner
Agriculture, Rural Development,
Blue Economy and Sustainable Environment,
African Union Commission

Abebe Haile-Gabriel
Assistant Director-General and
Regional Representative for Africa
Food and Agriculture Organization of the United Nations (FAO)



Acknowledgements

The Africa Open DEAL & GGW technical land use report is a collaborative effort of the African Union, FAO, and all governmental counterparts of Africa who have joined the initiative.

Special thanks are due for the financial support provided by the European Union and Türkiye for the Action Against Desertification in support of the implementation of Africa's *Great Green Wall* and South southh Cooperaton and the German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU), through the International Climate Initiative (IKI) in the context of the *National Land Monitoring and Information System for a transparent NDC reporting* project, implemented by FAO in collaboration with Google. FAO's Technical Cooperation Programme fund supported workshops with the Panafrican Agency of the Great Green Wall.

Many thanks are given to the partner organizations and national technical coordinators and operators who participated directly in and guided the data collection process at country level, listed in Annex 4.

We acknowledge FAO's decentralised Offices in all countries involved in the Africa Open DEAL & GGW which hosted implementation workshops (i.e. Algeria, Botswana, Burkina Faso, Burundi, Cape Verde, Democratic Republic of Congo, Ethiopia, Ghana, Kenya, Madagascar, Mali, Mauritania, Morocco, Niger, Rwanda, Senegal, South Africa, Tunisia, and Zambia), as well as both the PA-GGW and SADC secretariats, who provided high quality logistic support. Dr. Ayhan ATEŞOĞLU and Ibrahim Belen are acknowledged for organizing and supporting the contribution of the Chamber of Forest Engineers (OMO) in Ankara, which has helped complete missing big datasets.

The coordinating authors of the publication are Moctar Sacande (NFO) and Danilo Mollicone (OCB).

Contributing authors are (in alphabetical order): Hugo De Lame, Daniel Dionisio, Laura Guarnieri, Danae Maniatis, Giulio Marchi, Antonio Martucci, Danilo Mollicone, Carmen Morales, Antoine Plumacker, Moctar Sacande and Alfonso Sanchez Paus Diaz.

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Alfonso Sanchez Paus Diaz provided, together with Daniel Dionisio, technical assistance throughout the whole initiative and implemented specific training on Open Foris Collect Earth for Rwanda, Türkiye, and Morocco. Marcelo Rezende, Jean Francois Bastin and Adia Bey, carried out training and Mapathons in Zambia, Ghana, Cape Verde, Democratic Republic of the Congo, Madagascar, Kenya and South Africa. Laura Guarnieri provided training on Collect Earth data collection and analysis for Senegal, Burkina Faso, Mali, Niger, Burundi, Morocco, Tunisia, Algeria, and Mauritania. Danilo Mollicone conducted national training workshops in Morocco and together with Moctar Sacande and Antonio Martucci a SADC regional training in Botswana. Giulio Marchi together with Danilo Mollicone and Danae Maniatis carried out regional training on data analysis for SADC and Sahel countries. Regis Oubida, Antonio Martucci and Ibrahim Yamac contributed to collecting and completing the various data gaps. Antonio Martucci was responsible for database aggregation, data quality checks, data analysis and generated the maps.

We thank Andrew Morris for proofreading the report and Maria Cappadozzi for designing the layout.

ABBREVIATIONS AND ACRONYMS

AAD	Action Against Desertification
AFOLU	Agriculture Forest and Other land Use
AI	Aridity Index
AOD	Africa Open DEAL
CBD	Convention on Biological Diversity
CBL	Land and Water Division
DEAL	Data for Environment, Agriculture and Land
ERD	extreme rain days
ECMWF	European Centre for Medium-Range Weather Forecasts
FAO	Food and Agriculture Organization of the United Nations
GEZ	Global Ecological Zone
GGW	Great Green Wall
GHG	greenhouse gas
HSD	heat stress days
NC	national communication
NDC	nationally determined contribution
NDFI	normalized difference fraction index
NDVI	normalized difference vegetation index
NICFI	Norway International Climate and Forest initiative
NPP	net primary production
SDG	Sustainable Development Goal
SRTM	shuttle radar topography mission
UNCCD	United Nations Convention to Combat Desertification
UNEP-WCMC	UN Environment Programme World Conservation Monitoring Centre
UNFCCC	United Nations Framework Convention on Climate Change
USGS	United States Geological Survey

EXECUTIVE SUMMARY

The Africa Open DEAL *(Data for Environment, Agriculture and Land)* initiative has made Africa the first continent to compile a complete collection of accurate, comprehensive, and harmonized land use and land use change data.

It provides a detailed snapshot of the entire continent, captured through more than 300 000 sampling points collected by 350 operators in two years. Led by the Food and Agriculture Organization of the United Nations (FAO) and supported by the Pan-African Agency of the Great Green Wall (GGW), the Southern Africa Development Community (SADC), the African Union Commission (AUC) and 30 African countries, the land use data collections were carried out between 2018 and 2020 and analysed in 2021.

Experts and analysts were trained to use *Collect Earth*, an open-source tool developed by FAO with the support of Google Earth Engine. Over 100 parameters were collected on each sampling point of about 0.5 hectares, including vegetation cover, tree count, farmlands, wildfires, and existing infrastructure. The data were analysed to highlight land use change over the past 20 years and the potential for restoration at national level for every country. The use of very high-resolution imaging allowed analysts to assess places with difficult field accessibility. In addition, climate parameters such as temperature, precipitation, aridity, net primary production (NPP) and vegetation intensity were assessed to evaluate major changes in Africa's climate in the last 40 years, and how this relates to changes in land use and land cover that have been observed in Africa.

The data survey has revealed 7 billion previously unrecorded trees outside forests for the first time – among a range of other findings resulting from the first consistent land use representation of the continent – and discloses more forests and more arable lands than were previously detected.

The fact-based information reveals that the area of the continental GGW initiative has 393 million hectares of land with restoration potential and opportunities, and that 350 million hectares of cropland are cultivated in Africa, more than double that of the European Union. With 15 billion additional trees that can potentially be planted and grow in the GGW areas, a net carbon sequestration ranges between 1.1 and 3.5 $GtC0_2$ equivalent.

Presenting first the current state and panoramic overview of land use and vegetation cover in Africa, this technical report explores changes both in land use over the last 20 years and in climate over the last 40 years. The biophysical baselines and restoration opportunities of Africa's GGW are presented in its three regions of North Africa, the Sahel and the Southern Africa, and detailed nationally for each of those countries making up Africa's 1 billion ha drylands. The climate is also analysed for the impacts of temperature and precipitation variations on the vegetation at the continental level. The report concludes by highlighting why these land use data matter, offering an overview of derivative products, and presenting the outlook for the future.

This survey reveals huge opportunities for better management of the environment, agriculture, and land use in Africa, and increases countries' ability to track changes and conduct analyses for informed sustainable production, restoration interventions and climate action. The data and findings from Africa Open DEAL are embedded within FAO's Hand-in-Hand Initiative geospatial platform and are accessible to all through EarthMap.org. The initiative is expected to serve as a biophysical baseline and will support regular monitoring and evaluation of land use in Africa for years to come.

KEY MESSAGES

The key take-away messages for policymakers are presented below:

1. **Africa Open DEAL** provides a baseline for monitoring changes and reporting on Africa's Agriculture, Forest, Land Use and other Land use (AFOLU).

2. **Africa Open DEAL** helps countries and regional institutions across Africa benefit from existing and cost-effective imagery assessments and analyses, and track progress on their national, regional and international commitments quickly and flexibly, taking into account a large range of surface areas and sectors.

3. **Africa Open DEAL is connected with FAO's Hand-in-Hand Initiative** and provides a geospatial platform for reliable, independently verifiable data and fact-based information, as well as a foundation for guiding restoration efforts and climate action and tracking progress on implementation and biophysical impacts.

4. **Africa Open DEAL supports the implementation of the African Union's Agenda 2030 and Agenda 2063.** It benefits Africa's GGW and African Forest Landscape Restoration Initiative (AFR100), both pledged to restore 100 million trees in Africa by 2030 and to support countries and regional institutions in tracking progress and reporting on commitments and international obligations.

5. **Africa contains more restorable lands than any other part of the Earth.** There are **393 million hectares** of restoration opportunities for **Africa's GGW** alone. This accounts for more than one-third of the 1 billion hectares of global commitments to restore ecosystems on land and in water.

6. Over the past 20 years, **cropland expansion** has been an important land use change in Africa, with approximately **12.5 million hectares of forest land being converted to cropland.** At the same time, **heat stress days have increased by 14 days on average in Africa**, thus entailing the risk of a decline in crop production, which would drive further deforestation.

7. **Merging scientific and local knowledge:** High-quality geospatial data must be complemented with local knowledge and perceptions on what it is most suitable to plant – in ecological, social and economic terms – if restoration effects are to be long-lasting. Beyond the numbers, the monitoring of tree diversity is equally vital for successful restoration interventions.

8. Credible, satellite imagery assessments complement field ground-proof assessments, inventories and assessments of richness in biodiversity, rather than replacing them. **It is the responsibility of individual countries to review and validate the collected data nationally and regionally.** These data can be used in turn for reporting to their national, regional and international reporting systems.

Data analyses and the findings

356 million ha of land in Africa are cultivated, more than two times the area cultivated in the European Union.

10 percent of cropland are irrigated.

18 million ha of new cropland have been created since 2000, a **5 percent** increase.

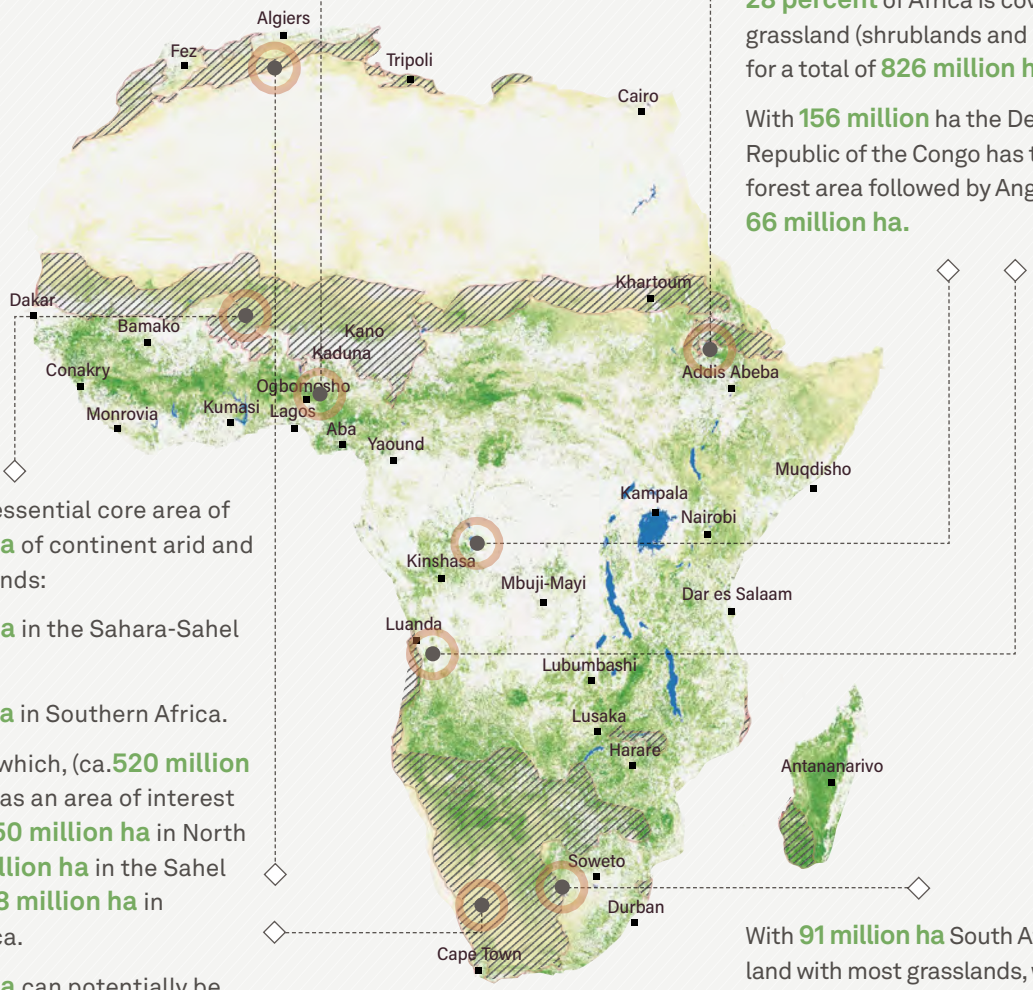
Africa is home to **7 billion trees** in non-forest land, distributed over **544 million ha** additional to forests.

26 percent of land In Africa are classified as forest, more than **100 million ha** of what previously reported by countries.

With **50 million ha** Nigeria is the country with most cropland followed by Ethiopia with **29 million ha.**

28 percent of Africa is covered by grassland (shrublands and savannahs) for a total of **826 million ha.**

With **156 million** ha the Democratic Republic of the Congo has the largest forest area followed by Angola with **66 million ha.**



Africa's GGW essential core area of the **1 billion ha** of continent arid and semiarid drylands:

780 million ha in the Sahara-Sahel region.

228 million ha in Southern Africa.

50 percent of which, (ca.**520 million ha**) is defined as an area of interest composed of **50 million ha** in North Africa, **241 million ha** in the Sahel region and **228 million ha** in Southern Africa.

393 million ha can potentially be restored and provide opportunities in the continental GGW areas (Bastin *et al.*, 2019), including **33 million ha** in Northern Africa, **162 million ha** in the Sahara-Sahel countries and **198 million ha** in the Kalahari-Namib countries.

15 billion additional trees can potentially be planted and grow in the GGW areas, with a net carbon sequestration ranging between **1.1** and **3.5 $GtCO_2$ equivalent.**

With **91 million ha** South Africa is the land with most grasslands, which cover **74 percent** of the whole national territory.

With **721 million trees**, South Africa is the country with most trees in non-forest land, followed by Ethiopia and Nigeria with **406** and **402 million trees** respectively.

Source: FAO based on Africa Open DEAL database, 2022. Adapted from United Nations World map, 2020.

01

AFRICA OPEN LAND USE DATA COLLECTION

THE CONTEXT

Between 2018 and 2020, the Food and Agriculture Organization of the United Nations (FAO) and the African Union, with the support of the Pan-African Agency of the GGW, and regional and national institutions from 30 countries, coordinated a continental-scale data collection on a range of parameters related to biophysical environment, agriculture and land use, known as "Africa Open DEAL."

Africa Open DEAL makes Africa the first continent to complete the collection of accurate, comprehensive, and harmonized land use and land use change data. These data are simultaneously important for the three Rio Conventions (the United Nations Convention to Combat Desertification [UNCCD], the United Nations Framework Convention on Climate Change [UNFCCC], and the Convention on Biological Diversity [CBD]), as well as for monitoring and reporting against the UN Sustainable Development Goals (SDG) indicators.

Africa Open DEAL builds on the regional experience of the GGW Sahel, where national Institutions and FAO have generated unique knowledge, biophysical baseline data and fact-based information through the Action Against Desertification programme. In support of the implementation of FAO's Climate Change Strategy, which sees FAO supporting its Member Nations in achieving their commitments under the Paris Agreement, as well as their priorities under the SDGs and other international and regional pledges, FAO and Google are working together to develop and promote advanced geospatial technology accessible to everyone along with a range of user-friendly tools (such as Collect Earth and EarthMap). Together the aim is to better manage the world's natural resources and contribute to sustainable development, in particular in developing countries. This new digital geospatial technology empowers data users and provides free access to Earth observation and climate data, together with free and extraordinary computational capacity.

[1] Algeria, Burkina Faso, Botswana, Burundi, Cabo Verde, Comoros, Congo, Democratic Republic of the Congo, Djibouti, Eritrea, Ethiopia, Ghana, Kenya, Lesotho, Madagascar, Malawi, Mali, Mauritania, Morocco, Mozambique, Namibia, Niger, Nigeria, Rwanda, Senegal, Sudan, South Africa, Tunisia, Zambia and Zimbabwe.

[2] openforis.org/tools/collect-earth

[3] openforis.org/tools/earth-map

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THE GOALS

The aim of Africa Open DEAL is to help and support all African countries and the AUC in collecting and reporting on environmental, agricultural land use and climate data that:

- **increase countries' abilities** in land monitoring, tracking associated changes and environmental related analyses;
- **support and improve accuracy** and transparency of international and national reporting from African countries, on:
  - → Agriculture, Forestry and Other land Use (AFOLU) sector under UNFCCC
  - → LDN indicators under UNCCD
  - → landscape biodiversity indicators under CBD
  - → Sustainable Development Goals indicators on Climate Action (SDG 13) and Life on Land (SDG 15)
  - → agriculture statistics under FAOSTAT
  - → Ramsar Convention on wetland; and
- **strengthen countries' capacities** to monitor and plan their preparedness for climate-related hazards and disasters using new geospatial technologies and new open data policies.

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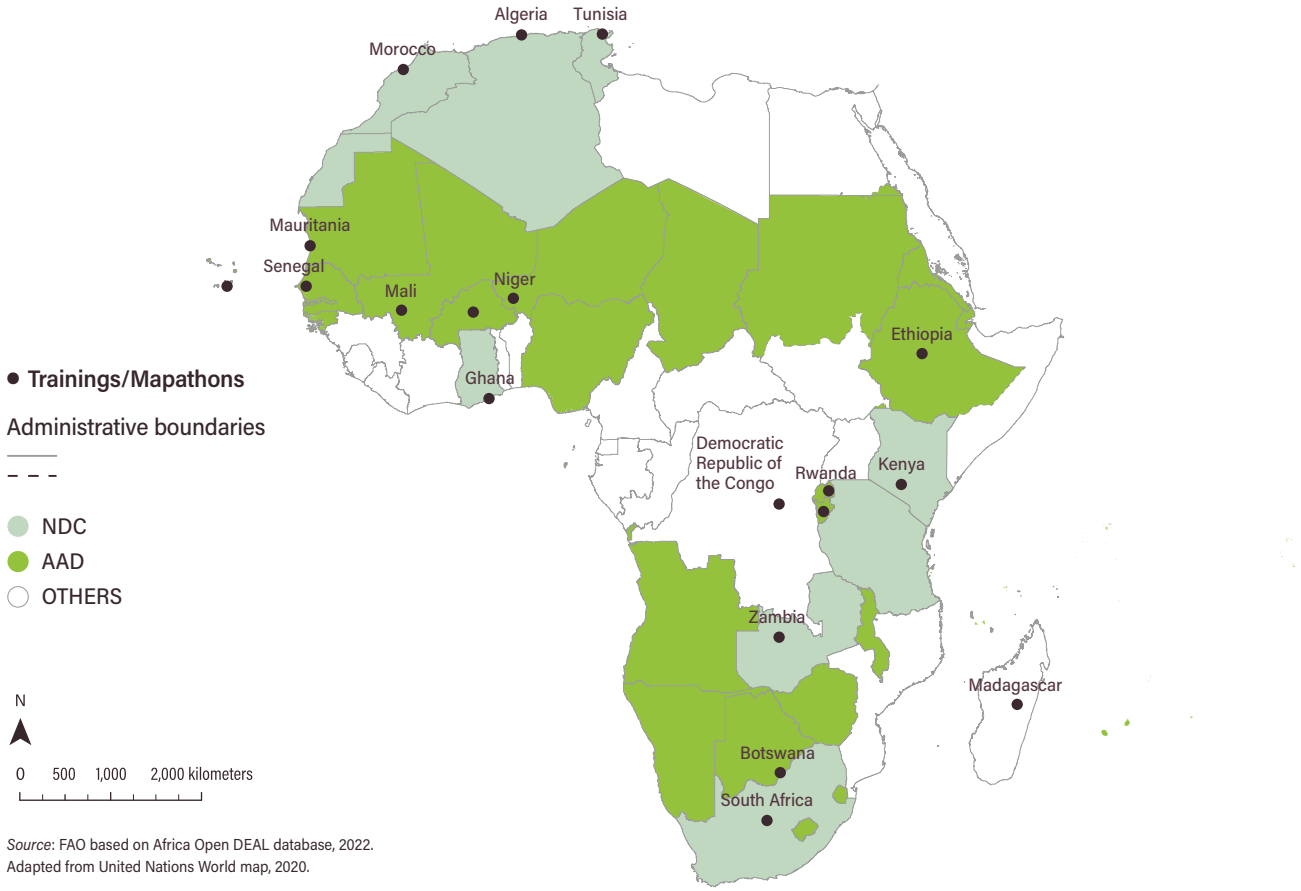
DATA COLLECTION

The digital data collection for Africa Open DEAL & Africa's GGW was carried out through large-scale capacity development. In total, 17 Collect Earth trainings and so-called 'mapathons', or data collection sessions, were conducted across Africa during 2018–2020, in: Botswana, Burkina Faso, Burundi, Cabo Verde, the Democratic Republic of the Congo, Ethiopia, Ghana, Kenya, Madagascar, Morocco, Niger, Rwanda, Senegal, South Africa, Tunisia and Zambia and in FAO headquarters in Rome.

Over 350 operators that followed the harmonized methodology to collect data through Collect Earth, national and regional experts, and reviewers, worked together in synergy for this ambitious initiative.

In total 318 000 systematic sampling plots were assessed, of which 88 000 (or 28 percent) covered Africa's GGW. Sample plots are half-hectare square-shaped areas for which biophysical, land use, land management and disturbance information was collected. This included the collection of 120 environmental variables and land parameters (see Methodology in the Annexes section) for each plot.

FIGURE 1. MAPS WITH NDC/AAD COUNTRIES AND TRAINING/MAPATHONS PLACES MARKS



Source: FAO based on Africa Open DEAL database, 2022.
Adapted from United Nations World map, 2020.

02

RESULTS

LAND USE IN AFRICA

Land use distribution

The main land-use types in Africa, following the Intergovernmental Panel on Climate Change (IPCC, 2019), land representation classification is presented in Figure 2, Figure 3 and Table 1. The central region of the continent is covered with extensive tropical forests (dark green) which merge to the north and south with grassland/shrubland (light green) prevalent areas. A concentration of cropland (orange) is detected in various areas mixed with grassland and forests, indicating the human alterations of natural vegetation patterns. With increasing aridity, vegetation presence decreases toward drylands and desert-like conditions (light yellow). The most common land use in Africa is other land (958 million ha), followed by grassland (826 million ha) and forest land (777 million ha). Cropland covers some 12 percent of the land area, while wetland and settlement only represent small areas of the land (1.5 percent and 0.9 percent respectively).

TABLE 1.
SUMMARY OF LAND-USE DISTRIBUTION BY IPCC CATEGORY IN 2019.

Land use	Area *Mha*	Proportion
Cropland	356.30	11.9 percent
Forest land	777.35	26.0 percent
Grassland	826.12	27.6 percent
Other land	958.34	32.1 percent
Settlements	26.93	0.9 percent
Wetlands	43.83	1.5 percent
TOTAL	**2 988.87**	**100.0 percent**

Source: All tables and charts in this Section 2 are FAO based on Africa Open DEAL database, 2022, unless referenced differently.

FIGURE 2. LAND-USE DISTRIBUTION IN AFRICA (PERCENTAGES) ACCORDING TO THE IPCC'S MAIN LAND USE CATEGORIES

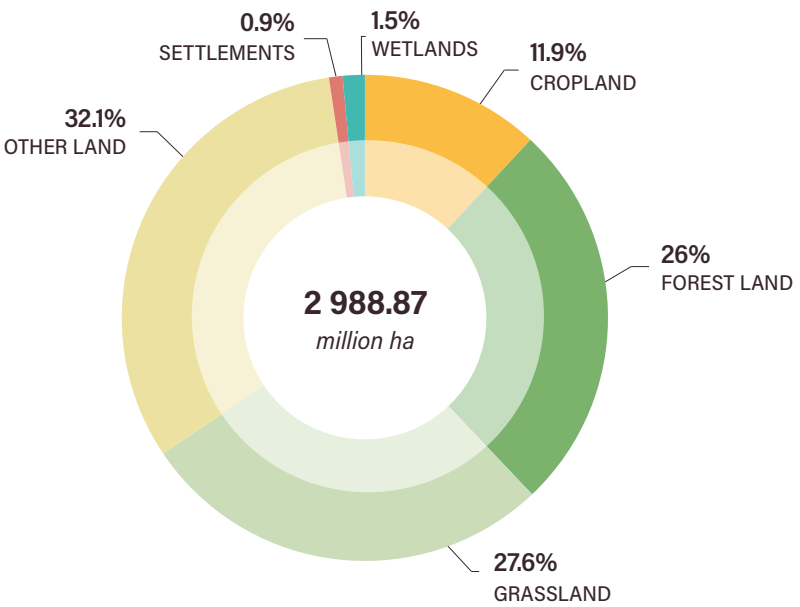
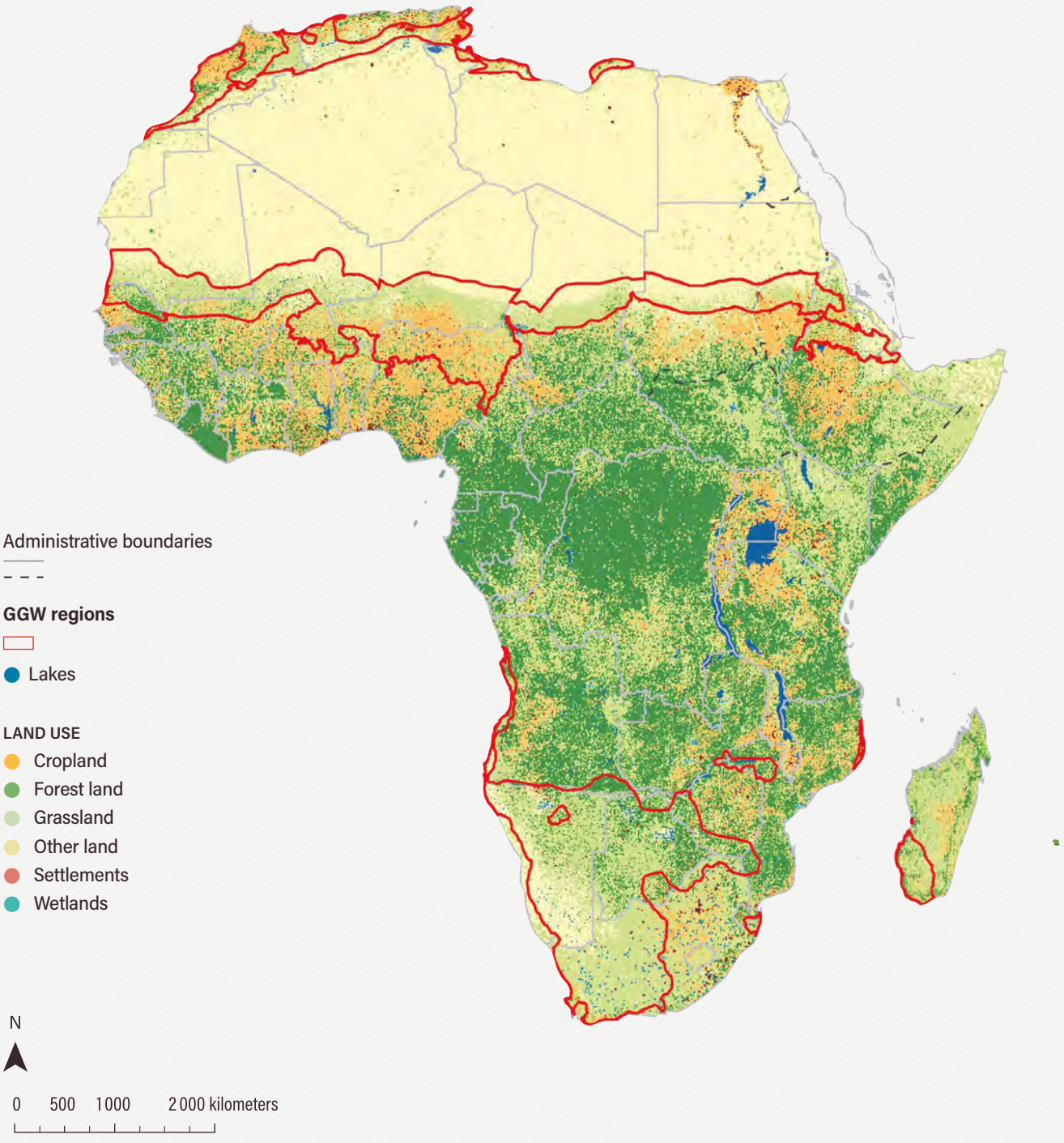


FIGURE 3. MAP OF LAND-USE DISTRIBUTION IN AFRICA ACCORDING TO THE IPCC'S MAIN LAND USE CATEGORIES



Source: FAO based on Africa Open DEAL database, 2022. Adapted from United Nations World map, 2020.

Land use distribution in drylands

Dryland areas cover two-fifths of the Earth's land surface. The geographical scope of drylands is delineated by the definition adopted by the United Nations Environment Programme World Conservation Monitoring Centre (IPCC, 2018): lands having an Aridity Index (AI) lower than 0.65. The AI is the ratio between average annual precipitation and total annual potential evapotranspiration (16). The dryland domain is typically divided into four distinct "zones" according to their AI: (i) the "hyperarid" zone (AI < 0.05); (ii) the "arid" zone (AI = 0.05 to 0.2); (iii) the "semiarid" zone (AI = 0.2 to 0.5); and (iv) the "dry subhumid" zone (AI = 0.5 to 0.65). Using this definition, drylands cover 6 132 million ha, or 41.5 percent of the Earth's land surface (Bastin *et al.*, 2017). It is therefore interesting to look at the land use distribution in drylands and non-drylands (Table 2 and Figure 4) as well as within the dryland category (Table 3 and Figure 5). The distribution of land use categories is distinctly different between dryland and non-dryland areas in Africa. For example, in non-drylands, the forest land category followed by grassland are the dominant land uses, while other land and grassland prevail in drylands.

Within drylands, the land use distribution varies considerably among the dryland categories. Unsurprisingly, in the hyperarid and arid areas, other land and grassland are the dominant land uses. Although the percentage is different between the categories, grassland followed by forest land and cropland are the dominant land uses in the semiarid and dry subhumid categories. Settlement only represents a small percentage for all dryland categories. Approximately 66 percent of Africa's land is classified as dryland (2 billion ha). The table shows the distribution of land uses as proportion of total land, by dryland categories. The proportion of forest land decreases from dry subhumid to hyperarid, while the proportion of other land increases. Grassland is equally represented in all categories of dryland except hyperarid.

The geographical distribution of land use categories by dryland categories in Africa is shown in Figure 6.

TABLE 2. LAND-USE DISTRIBUTION IN DRYLANDS AND NON-DRYLANDS

Dryland	Cropland	Forest land	Grassland	Other land	Settlements	Wetlands	TOTAL
	Mha	*Mha*	*Mha*	*Mha*	*Mha*	*Mha*	*Mha*
Drylands	188.88	254.26	545.55	945.38	13.05	14.31	1 961.42
Non-drylands	167.42	523.09	280.58	12.95	13.88	29.52	1 027.44
TOTAL	**356.30**	**777.35**	**826.12**	**958.34**	**26.93**	**43.83**	**2 988.87**

TABLE 3. LAND USE SUBDIVISIONS WITHIN DRYLAND CATEGORIES

Dryland	Cropland	Forest land	Grassland	Other land	Settlements	Wetlands	TOTAL
Dry subhumid	63.73	108.90	95.92	3.86	4.12	3.66	280.19
Semiarid	97.64	118.00	252.07	29.71	5.97	5.88	509.27
Arid	22.68	26.89	174.17	268.73	1.89	4.23	498.60
Hyperarid	4.83	0.46	23.38	643.09	1.07	0.54	673.36
TOTAL	**188.88**	**254.26**	**545.55**	**945.38**	**13.05**	**14.31**	**1 961.42**

FIGURE 4. LAND-USE DISTRIBUTION IN AFRICA (PERCENTAGES) IN DRYLANDS AND NON-DRYLANDS

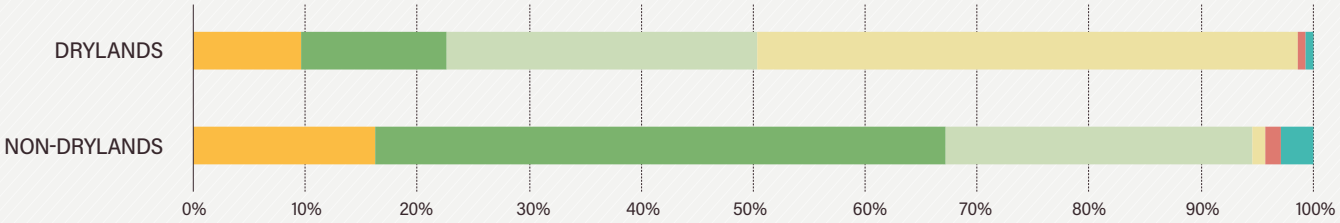


FIGURE 5. LAND USE DISTRIBUTION (PERCENTAGES) BY DRYLAND CATEGORY

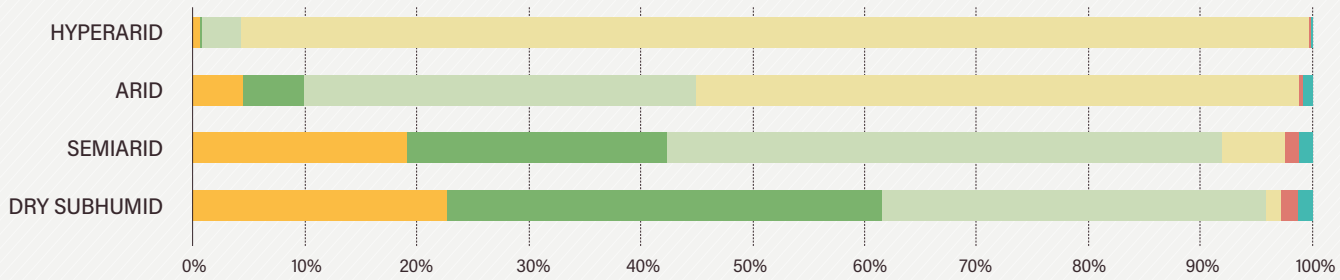
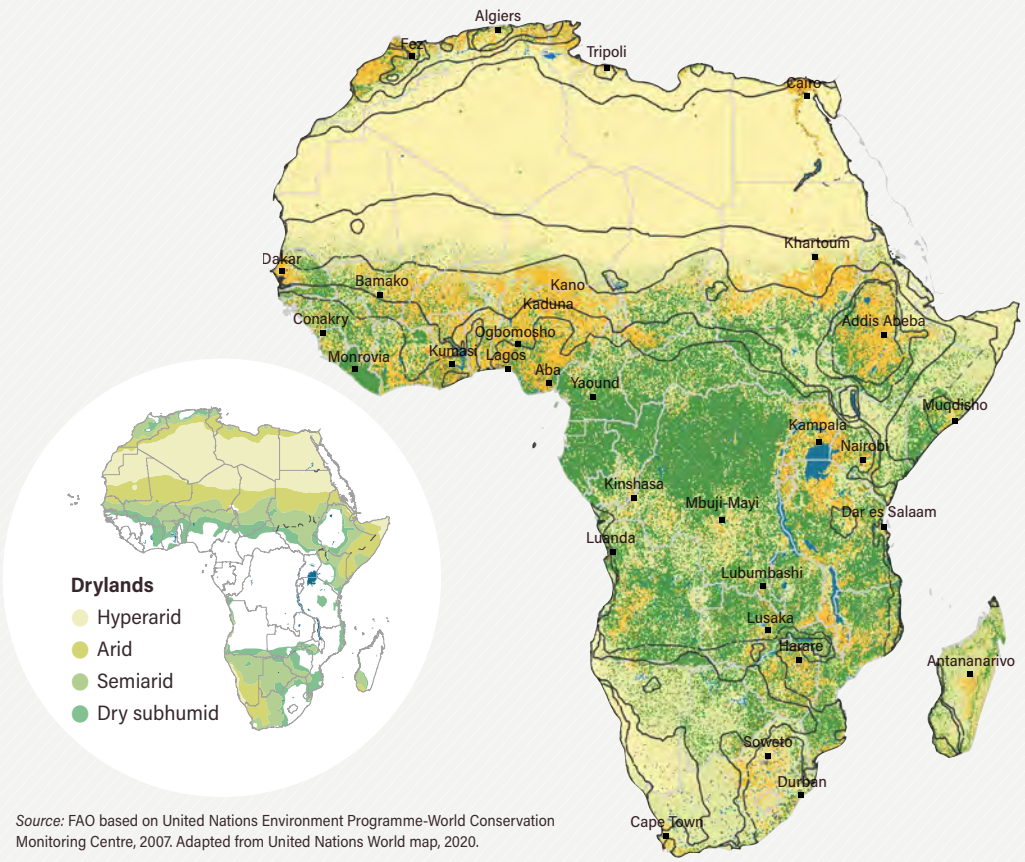


FIGURE 6. MAP OF LAND USE IN AFRICA WITH DRYLAND BOUNDARIES



LAND USE
- Cropland
- Forest land
- Grassland
- Other land
- Settlements
- Wetlands

Administrative boundaries

Drylands (UNEP-WCMC)

- Populated places (major cities)
- Lakes

N

0 500 1000 2000 kilometers

Source: FAO based on United Nations Environment Programme-World Conservation Monitoring Centre, 2007. Adapted from United Nations World map, 2020.

Source: FAO based on Africa Open DEAL database, 2022. Adapted from United Nations World map, 2020.

Cropland subdivisions

The cropland subdivisions for 2019 in Africa show that of the land that is used for crops, 81.8 percent are temporary and 12.7 percent are permanent crops (Table 4 and Figure 7), followed by orchards, palm, rice paddies and greenhouses.

The geographical distribution of cropland subdivisions in Africa in 2019 is shown in Figure 8.

TABLE 4. CROPLAND SUBDIVISIONS 2019

Cropland types	Area *(Mha)*	Proportion
Land under temporary crops	291.54	81.8%
Land under permanent crops	45.16	12.7%
Orchard	11.55	3.2%
Palm	5.60	1.6%
Rice paddy	2.19	0.6%
Greenhouse	0.25	0.1%
TOTAL	**356.30**	**100.0%**

FIGURE 7.
DISTRIBUTION OF CROPLAND SUBDIVISIONS 2019

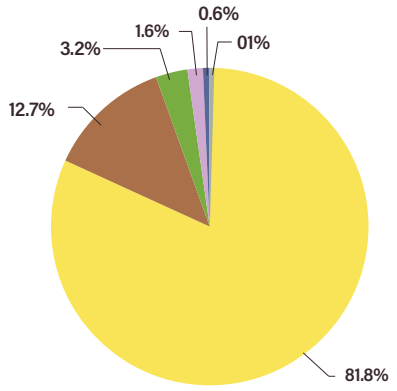
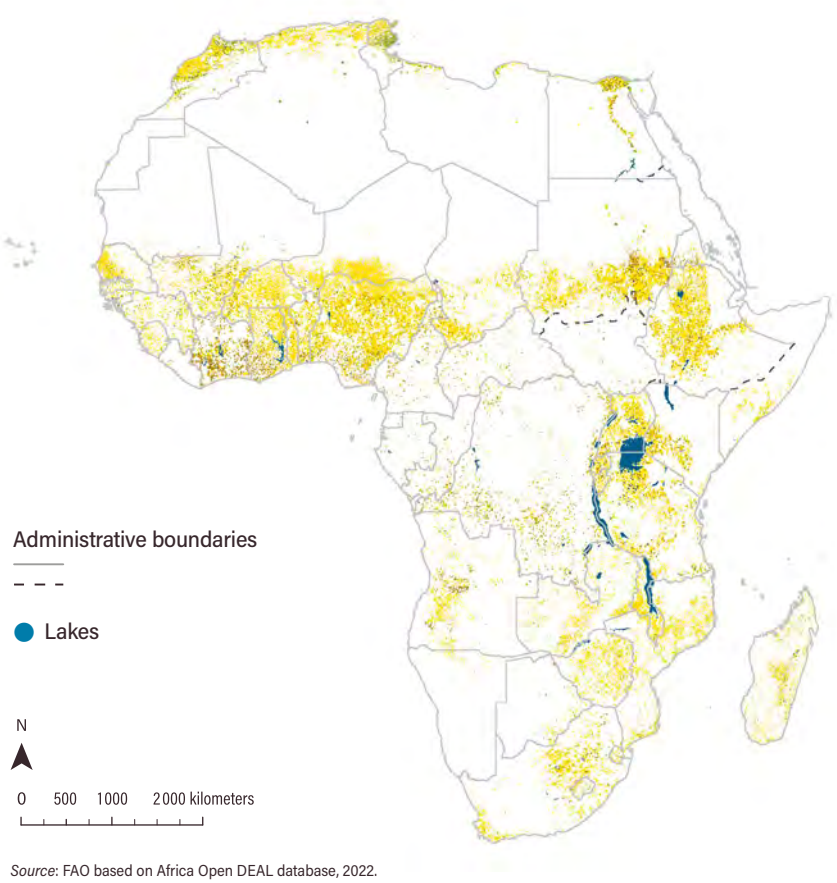


FIGURE 8.
MAP OF CROPLAND SUBDIVISIONS 2019



Source: FAO based on Africa Open DEAL database, 2022.
Adapted from United Nations World map, 2020.

Grassland subdivisions

The grassland subdivisions for 2019 in Africa show that 33.7 percent is considered as grassland, 18.9 percent as shrubland, 14.6 percent as shrubland with trees and 13.8 percent as grassland with trees (Table 5 and Figure 9). This is followed by grassland with trees and shrubs, grassland with shrubs and a very small percentage of lichens and mosses.

The geographic distribution of grassland subdivisions in Africa in 2019 is shown in Figure 10.

TABLE 5. GRASSLAND SUBDIVISIONS 2019

Grassland types	Area *(Mha)*	Proportion
Grassland	278.16	33.7%
Grassland with shrubs	74.80	9.1%
Grassland with trees	113.78	13.8%
Grassland with trees and shrubs	81.26	9.8%
Lichens and mosses	1.22	0.1%
Shrubland	156.34	18.9%
Shrubland with trees	120.56	14.6%
TOTAL	**826.12**	**100.0%**

FIGURE 9.
DISTRIBUTION OF GRASSLAND SUBDIVISIONS 2019

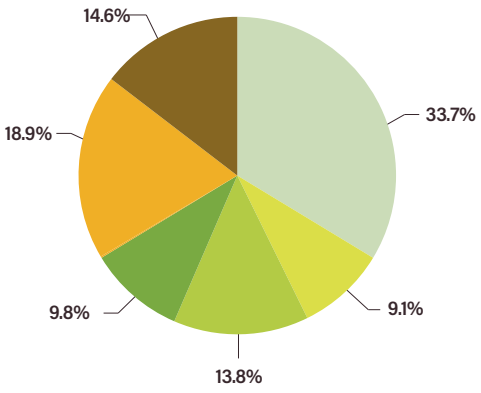
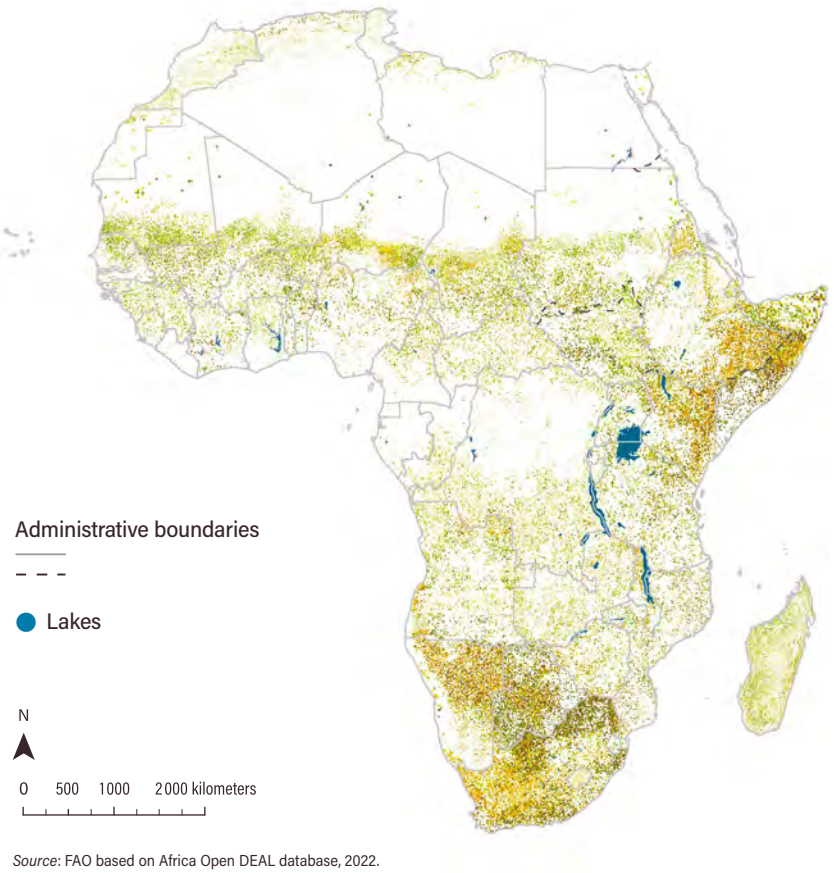


FIGURE 10.
MAP OF GRASSLAND SUBDIVISIONS 2019



Source: FAO based on Africa Open DEAL database, 2022. Adapted from United Nations World map, 2020.

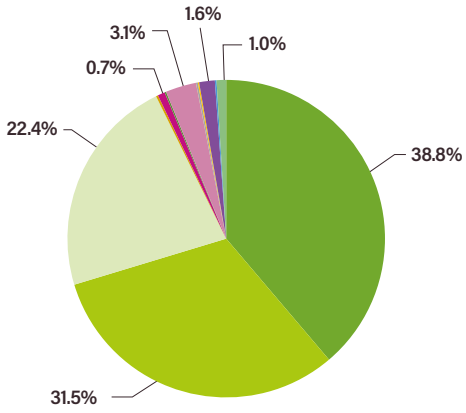
Forest land subdivisions

The forest land subdivisions for 2019 in Africa show that of the land that is considered as forest, 38.8 percent is considered as broadleaf deciduous, 31.5 percent as broadleaf evergreen and 22.4 percent as broadleaf mixed (Table 6 and Figure 11). This is followed by mixed forest (broadleaf-coniferous), other plantations and riparian forest. The geographic distribution of the forest lands in Africa in 2019 is shown in Figure 12.

TABLE 6. FOREST SUBDIVISIONS FOR 2019

Forest types	Area *(Mha)*	Proportion
Broadleaf deciduous	301.54	38.8%
Broadleaf evergreen	245.08	31.5%
Broadleaf mixed	174.08	22.4%
Coniferous deciduous	1.64	0.2%
Coniferous evergreen	5.67	0.7%
Coniferous mixed	1.25	0.2%
Mixed forest (broadleaf-coniferous)	24.24	3.1%
Acacia plantation	0.13	0.0%
Coniferous plantation	1.43	0.2%
Eucalyptus plantation	1.03	0.1%
Other plantations	12.35	1.6%
Mangrove forest	1.33	0.2%
Riparian forest	7.58	1.0%
TOTAL	**777.35**	**100.0%**

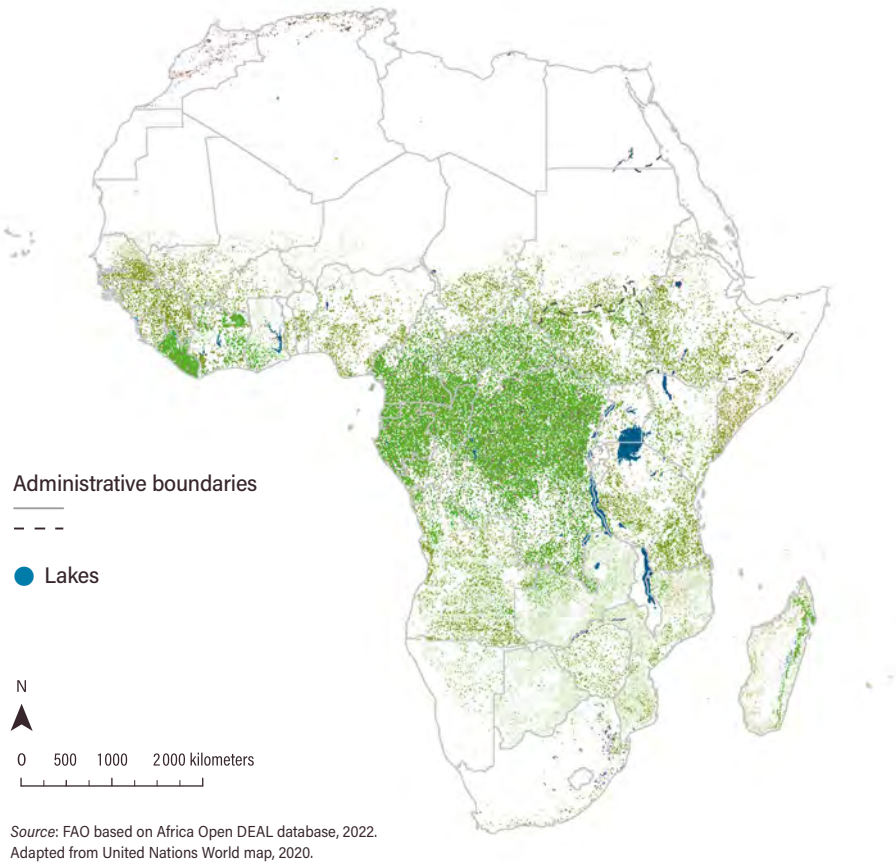
FIGURE 11.
DISTRIBUTION OF FOREST LAND SUBDIVISIONS 2019



FOREST LAND

- Broadleaf deciduous
- Broadleaf evergreen
- Broadleaf mixed
- Coniferous deciduous
- Coniferous evergreen
- Coniferous mixed
- Mixed forest (broadleaf-coniferous)
- Acacia plantation
- Coniferous plantation
- Eucalyptus plantation
- Other plantations
- Mangrove forest
- Riparian forest

FIGURE 12.
MAP OF FOREST LAND SUBDIVISIONS 2019



Source: FAO based on Africa Open DEAL database, 2022.
Adapted from United Nations World map, 2020.

Settlement subdivisions

The settlement subdivisions for 2019 in Africa show that of the land that is considered as settlement, 41.5 percent is classified as village, 31.3 percent as cities, 13.6 percent as infrastructure (e.g. roads) and 10.2 percent as built-up (Table 7 and Figure 13). This is followed by mining, urban parks and other types of settlement.

Wetland subdivisions

The wetland subdivisions for 2019 in Africa show that of the land considered as wetland, 46.6 percent are considered permanent lakes, 14.5 percent permanent rivers, 9.3 percent seasonal lakes and 9.2 percent seasonal rivers (Table 8 and Figure 14). This is followed by swamps and other wetland subdivisions.

Other land subdivisions

The other land subdivisions for 2019 in Africa show that of the land that is classified as other land, 73.7 percent is considered as sand dunes, 12.9 percent as rocks and/or stone and 9.4 percent as barren soil. This is followed by other types of other land and snow (Table 9 and Figure 15).

TABLE 7. SETTLEMENT SUBDIVISIONS FOR 2019

Settlement types	Area *(Mha)*	Proportion
Village	11.17	**41.5%**
City	8.42	**31.3%**
Infrastructure	3.67	**13.6%**
Built-up	2.74	**10.2%**
Mining	0.68	**2.5%**
Other	0.15	**0.6%**
Urban parks	0.10	**0.4%**

FIGURE 13. DISTRIBUTION OF SETTLEMENT SUBDIVISIONS 2019

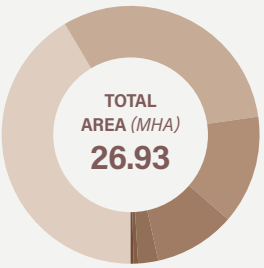


TABLE 8. WETLAND SUBDIVISIONS FOR 2019

Wetland types	Area *(Mha)*	Proportion
Permanent lakes	20.43	**46.6%**
Permanent rivers	6.36	**14.5%**
Seasonal lakes	4.06	**9.3%**
Seasonal rivers	4.04	**9.2%**
Swamp	3.55	**8.1%**
Other	3.30	**7.5%**
Artificial water bodies	0.77	**1.7%**
Lagoon	0.66	**1.5%**
Peatland	0.55	**1.3%**
Salt extraction	0.11	**0.3%**

FIGURE 14. DISTRIBUTION OF WETLAND SUBDIVISIONS 2019

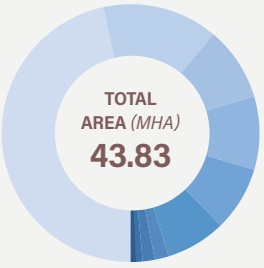
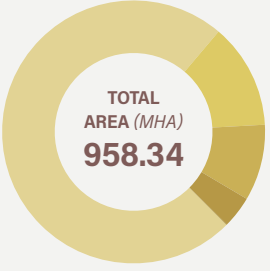


TABLE 9. OTHER LAND SUBDIVISIONS FOR 2019

Other land types	Area *(Mha)*	Proportion
Sand dunes	706.16	**73.7%**
Rock stone	124.02	**12.9%**
Barren soil	89.88	**9.4%**
Other	37.69	**3.9%**
Snow	0.58	**0.1%**

FIGURE 15. DISTRIBUTION OF OTHER LAND SUBDIVISIONS 2019



TREES IN AFRICA

This section will present the key results of the analysis concerning the tree canopy cover distribution and presence of trees in Africa in 2019.

Tree canopy distribution

Unsurprisingly, tree canopy distribution in Africa in 2019 is highest in forest land (Figure 16) where 50 percent of forest land has more than 80 percent tree canopy cover. What is more surprising however, is that up to 10 percent of cropland has a tree canopy cover of 30 percent or more, which is probably related to agroforestry systems. Tree canopy cover is also important in wetland and settlement, with approximately 20 percent of wetland, while settlement have more than 20 percent tree cover.

We also observe that the weighted average tree cover is highest in forest land (60.25 percent), followed by settlement (9.43 percent) and cropland (6.05 percent) (Figure 17 and Table 10). Note that the tree cover presented in this technical report includes trees in forests, but also trees outside forests (i.e. any other land use).

We can observe from the map of average tree canopy cover in forest land (Figure 18) that the highest average tree cover can be found in Central and West Africa and an important mid-range (10-59 percent) in North Africa, East Africa, Southern Africa (Botswana, Namibia, Angola and Zimbabwe) and on the coasts of Madagascar.

We can observe from the map of average tree canopy cover by land outside forests (Figure 19) that more tree cover is detected in parts of North Africa, West Africa and East Africa compared to the rest of the continent.

We can observe from the map of average shrub cover (Figure 20) that shrub cover is predominant in Southern (Namibia, Botswana, South Africa) and Eastern Africa (Somalia, Kenya and Ethiopia).

FIGURE 16. TREE CANOPY COVER DISTRIBUTION (PERCENTAGES) IN 2019 WITH TREE COVER CLASSES, BY LAND USE

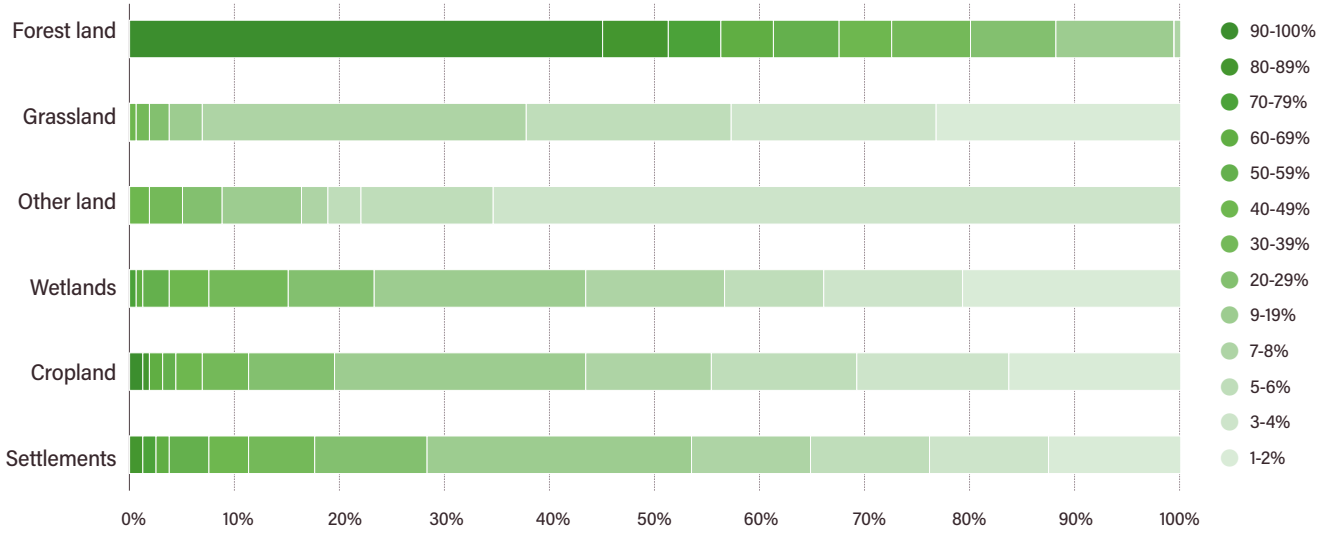


TABLE 10. TABLE OF TREE CANOPY COVER BY CLASS OF COVER LAND USE

		Forest land	Grassland	Other land	Wetlands	Cropland	Settlements
Total land area	*Mha*	777.35	826.12	958.34	43.83	356.30	26.93
Cumulated canopy cover[8]	*Mha*	468.36	21.47	0.83	0.59	21.56	2.53
Average canopy cover		60.25%	2.60%	0.09%	1.35%	6.05%	9.41%

FIGURE 17. WEIGHTED AVERAGE TREE COVER (PERCENTAGES) BY LAND USE

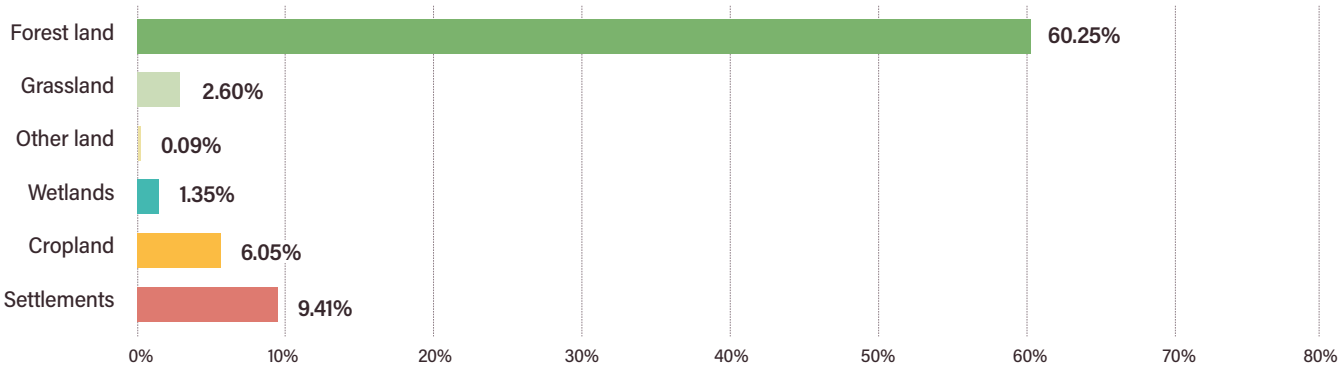
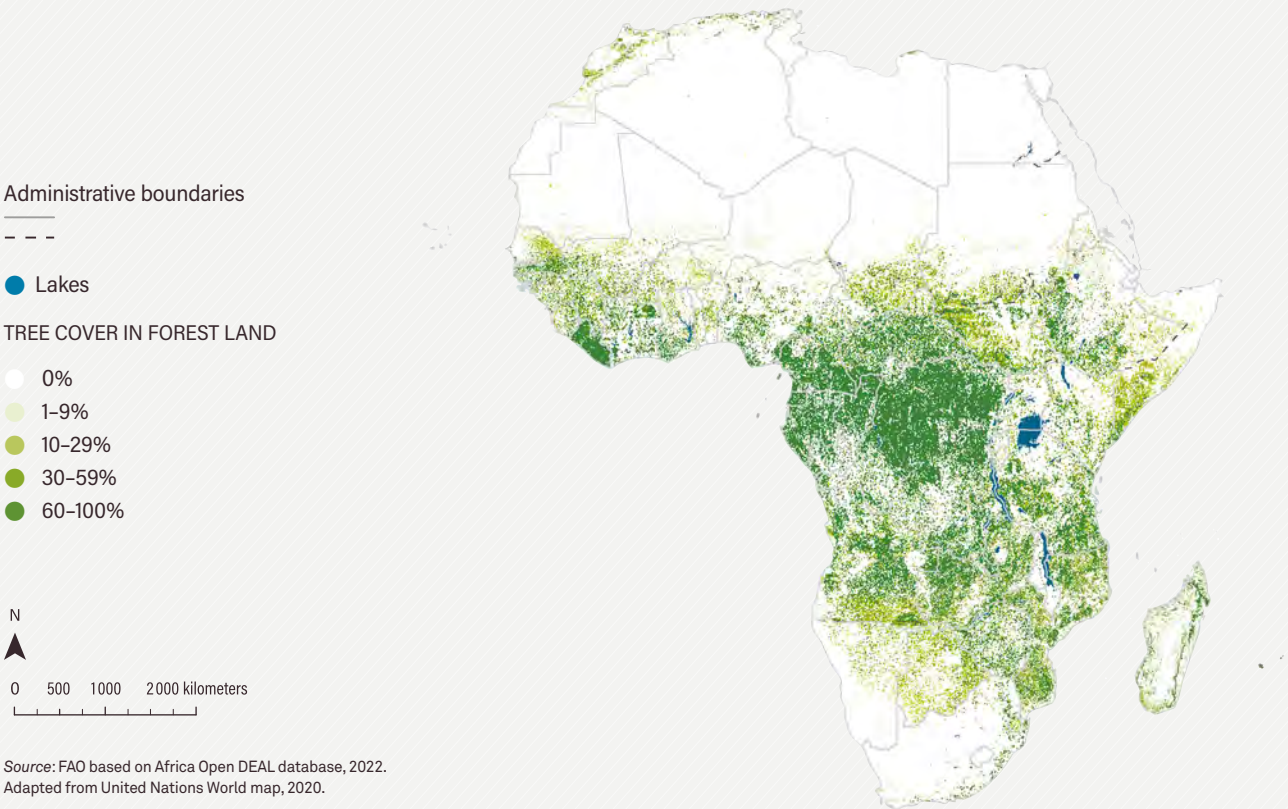
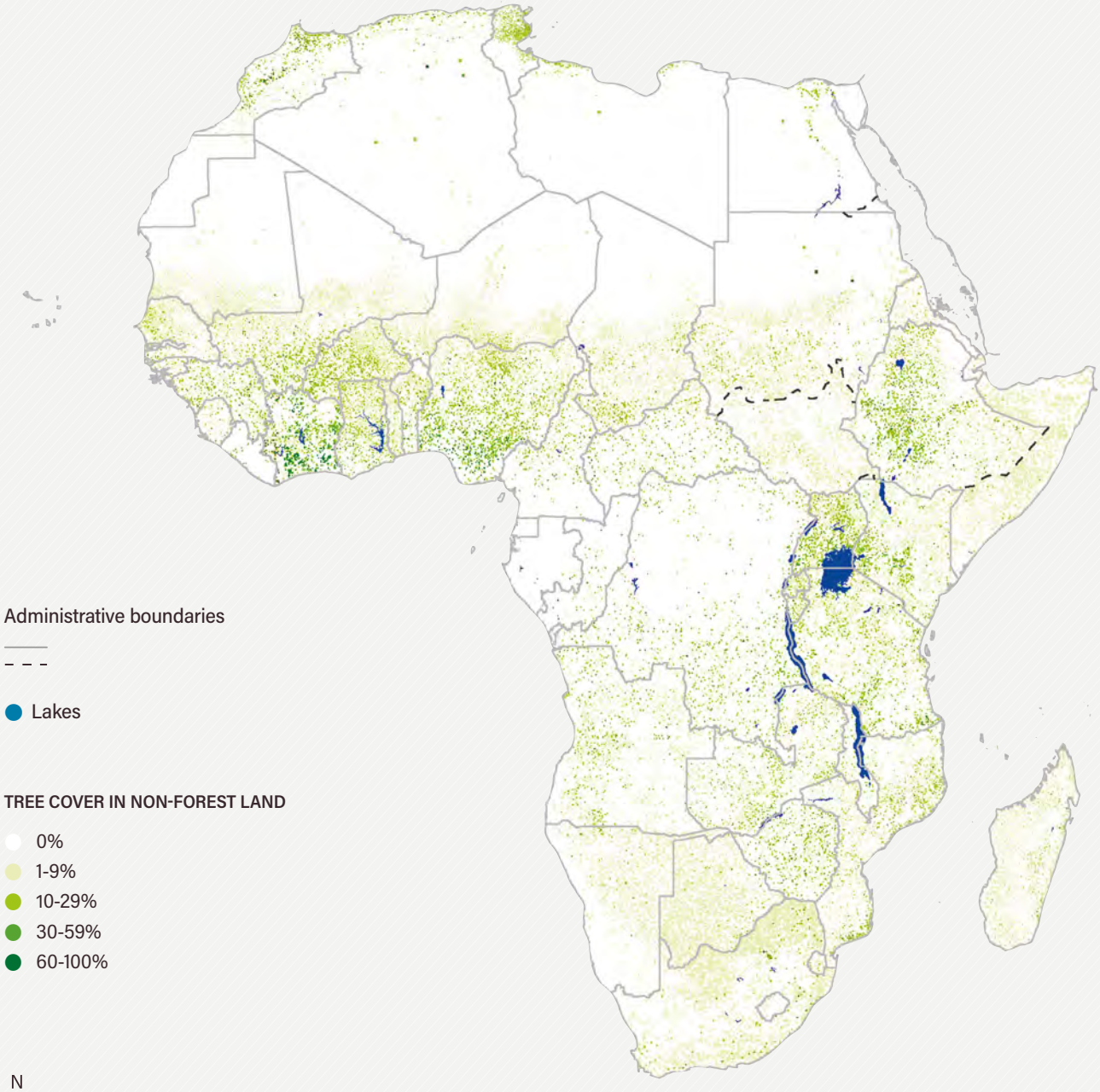


FIGURE 18. MAP OF AVERAGE TREE COVER IN FOREST LAND 2019



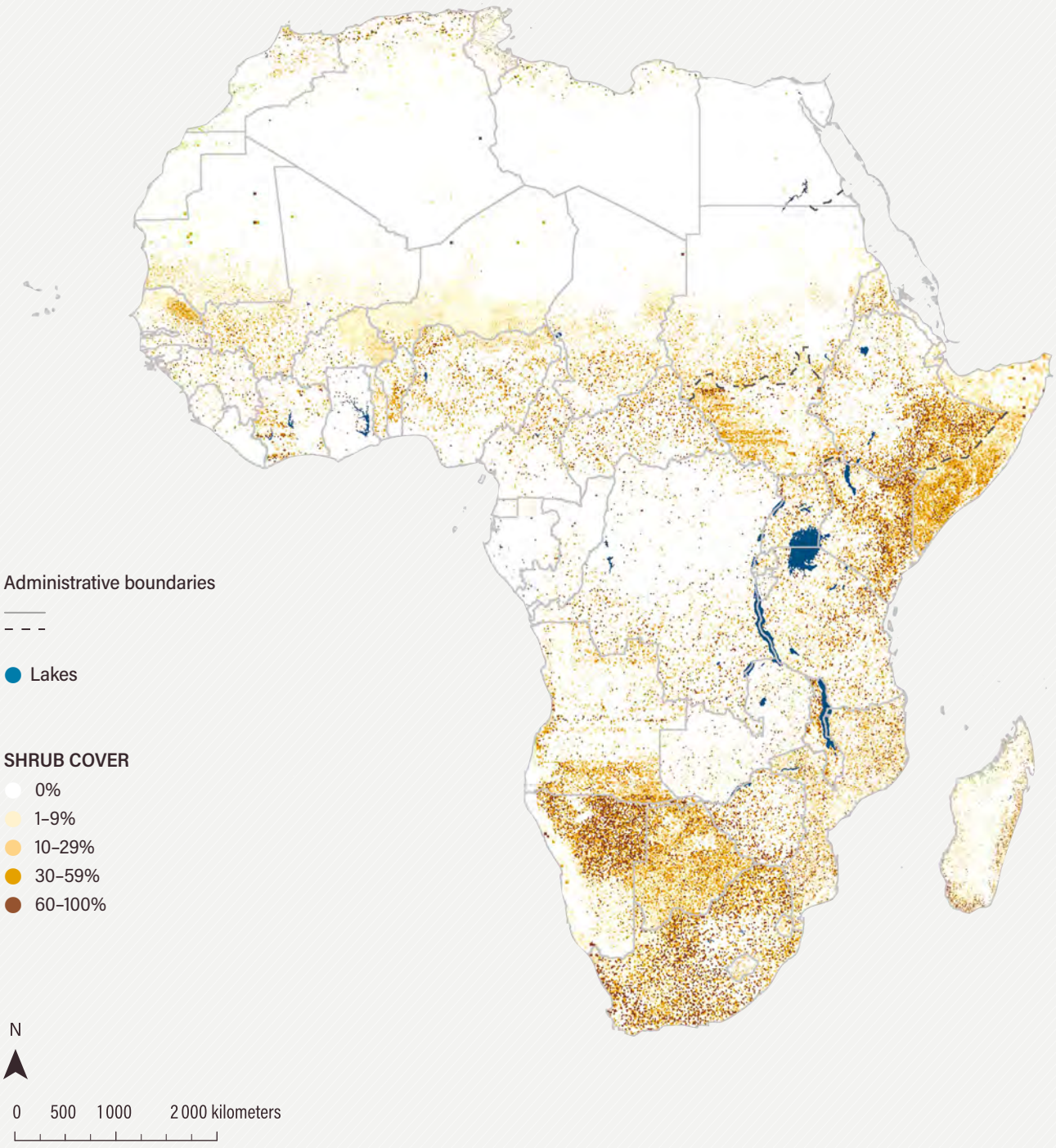
Source: FAO based on Africa Open DEAL database, 2022.
Adapted from United Nations World map, 2020.

FIGURE 19. MAP OF AVERAGE TREE COVER IN NON-FOREST LAND 2019



Source: FAO based on Africa Open DEAL database, 2022. Adapted from United Nations World map, 2020.

FIGURE 20. MAP OF AVERAGE SHRUB COVER 2019



Source: FAO based on Africa Open DEAL database, 2022. Adapted from United Nations World map, 2020.

Woody canopy distribution

The **total woody canopy** cover (defined as the sum of the canopy coverage of all woody vegetation, including shrub and tree species, naturally growing, or planted, inside or outside forest) distribution in Africa in 2019 shows that of a grand total of 2 988.87 million ha, 958.34 million ha of woody canopy cover are found in other land, followed by 826.12 million ha in grassland and 777.35 million ha in forest land (Table 11).

The **average wood canopy** cover distribution in Africa in 2019 shows that 66 percent of average woody canopy is in forests (prevalence of canopy cover from trees), followed by 17 percent in grassland (higher impact of shrub cover) 3 percent in wetland, 12 percent in settlement, 7.5 percent in cropland and, as expected, less than 1 percent in other land (Table 12 and Figure 21). Dense areas of woody vegetation cover stand out particularly in the Congo Basin (unsurprisingly) and in Liberia (Figure 22).

Tree canopy cover distribution in agroforestry ecosystems

It is also interesting to look at tree canopy cover distribution in agroforestry systems, more specifically at tree cover respectively in orchards and agrosilvopastoral systems (Table 13 and Figure 23).

By agrosilvopastoral systems we mean integrated crops, trees, pastures and animal systems, as per the FAO definition. We find that there is important tree canopy cover especially in orchard systems.

TABLE 11. TOTAL WOODY CANOPY COVER DISTRIBUTION IN 2019 BY LAND USE[4]

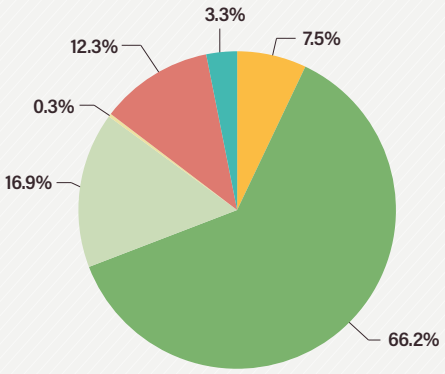
Woody cover	Forest land	Grassland	Other land	Wetlands	Cropland	Settlements	TOTAL
	Mha	*Mha*	*Mha*	*Mha*	*Mha*	*Mha*	*Mha*
90-100%	364.67	27.76	0.83	0.14	3.15	0.09	**396.65**
80-89%	62.79	15.07	0.27	0.15	0.77	0.23	**79.30**
70-79%	51.36	19.14	0.09	0.19	1.07	0.32	**72.18**
60-69%	49.42	21.33	0.14	0.23	1.75	0.46	**73.33**
50-59%	55.32	32.27	0.11	0.30	3.75	0.85	**92.60**
40-49%	44.15	32.22	0.39	0.38	6.62	1.00	**84.77**
30-39%	43.77	43.82	0.57	0.61	10.83	1.53	**101.14**
20-29%	42.06	51.41	0.59	0.95	19.13	2.23	**116.36**
9-19%	35.32	125.69	1.52	1.60	53.94	4.72	**222.80**
7-8%	0.04	71.71	0.63	0.53	22.17	1.66	**96.75**
5-6%	0.05	47.45	3.22	0.50	23.28	1.80	**76.30**
3-4%	0.00	45.85	23.96	0.44	23.54	1.55	**95.34**
1-2%	0.00	48.04	15.61	0.75	24.17	1.50	**90.07**
0	28.40	244.36	910.39	37.04	162.11	8.99	**1391.28**
Grand Total	**777.35**	**826.12**	**958.34**	**43.83**	**356.30**	**26.93**	**2 988.87**

TABLE 12. AVERAGE WOODY CANOPY COVER DISTRIBUTION BY LAND USE

	Forest land	Grassland	Other land	Wetlands	Cropland	Settlements	TOTAL
Total area (Mha)	777.35	826.12	958.34	43.83	356.30	26.93	**2 988.87**
Cumulated woody canopy cover *(Mha)*	514.44	139.64	3.28	1.46	26.85	3.31	**688.98**
Average woody cover (percent)	66.18%	16.90%	0.34%	3.33%	7.53%	12.28%	**23.05%**

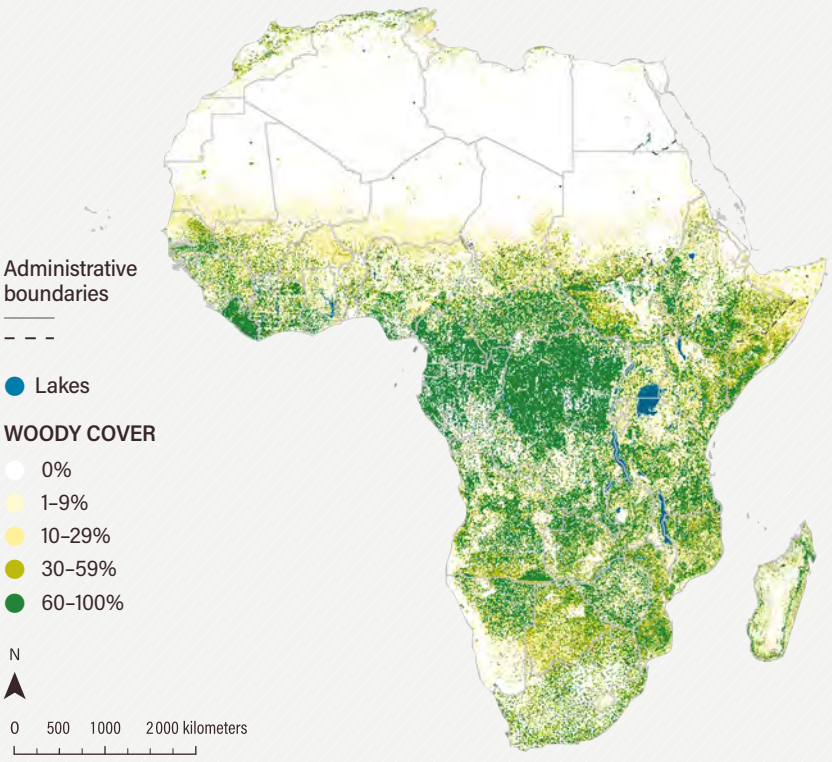
[4] Tree cover + shrub cover, with values combined and scaled 0-100 percent.

FIGURE 21.
AVERAGE WOODY CANOPY COVER DISTRIBUTION BY LAND USE



- Cropland
- Forest land
- Grassland
- Other land
- Settlements
- Wetlands

FIGURE 22. MAP OF WOODY VEGETATION COVER 2019



Source: FAO based on Africa Open DEAL database, 2022.
Adapted from United Nations World map, 2020.

FIGURE 23. TREE CANOPY COVER DISTRIBUTION [PERCENTAGES] IN AGROFORESTRY ECOSYSTEMS

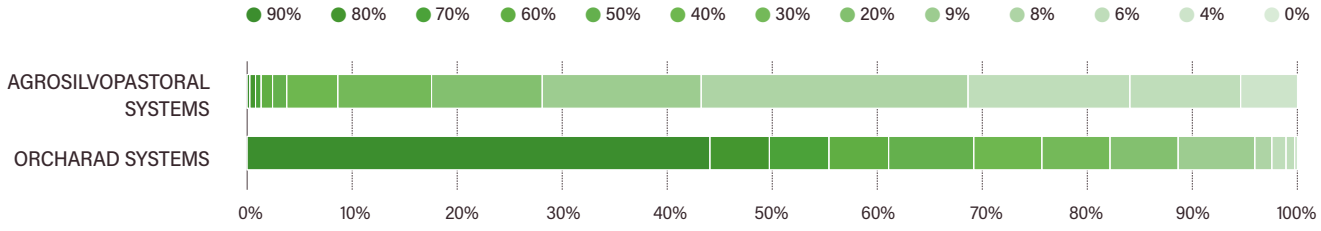


TABLE 13. TREE CANOPY COVER DISTRIBUTION IN ORCHARD SYSTEMS[5] AND AGROSILVOPASTORAL SYSTEMS[6]

		Orchard systems	Agrosilvopastoral systems
Total land	*Mha*	62.29	606.65
Cumulated canopy cover[7]	*Mha*	10.99	18.76
Average canopy cover		17.64%	3.09%

[5] Including orchards, permanent crops and palms (cropland subdivisions)
[6] Including grazed grassland and non-irrigated temporal crops
[7] The cumulated canopy cover is the sum of all projected canopy areas occupied by the trees. Canopy cover means the extent of the canopy for an individual tree, or the cumulative areal extent of the canopy of all trees on a site (the area that could be entirely covered by trees).

Trees inside and outside forest land

We find that there are over 7 billion trees distributed in over 2 billion hectares of non-forest land (average of more than three trees per hectare) – an area the size of more than twice the largest country in Africa, which is Algeria. Approximately 36 billion trees were counted within 777 million hectares of forest land, averaging 46 trees per ha (Table 14).

Most trees outside forest land are found in grassland (54.9 percent) and in cropland (37 percent), followed by settlement, other land and wetland.

The situation is very different for the average tree density outside forest land, where the highest average tree density is found in settlement (11.72 percent) followed by cropland (7.35 percent) and grassland (4.69 percent) (Table 15, Figure 24 and Figure 25).

As it might be expected, we find the highest tree count in the Congo Basin and in Liberia (Figure 26). Tree count in land uses other than forest land (Figure 27) is significant across Africa and Madagascar outside of the Congo Basin and Sahel areas.

TABLE 14. NUMBER OF TREES AND TREE DENSITY (PERCENTAGES) IN FOREST LAND AND IN NON-FOREST LAND

	Count	Total area	Tree density	Total area with trees	Tree density
	Million	*Mha*	*Trees/ha*	*Mha*	*Trees/ha*
Trees in forest land	35 805	777.35	46.06	748.06	47.86
Trees in non-forest land	7 022	2 211.52	3.17	544.32	12.90
TOTAL	**42 827**	**2 988.87**	**14.33**	**1 292.38**	**33.14**

TABLE 15. TREE COUNT DISTRIBUTION (MILLION) AND AVERAGE TREE DENSITY (TREES/HA) IN NON-FOREST LAND USES

Land use 2019	Tree count	Rate of total tree count	Total area	Tree density
	Million	*Proportion*	*Mha*	*Trees/ha*
Cropland	2 620	37.3%	356.30	7.35
Grassland	3 882	55.3%	826.12	4.70
Other land	123	1.8%	958.34	0.13
Settlements	316	4.5%	26.93	11.73
Wetlands	81	1.2%	43.83	1.85
TOTAL	**7 022**	**100.0%**	**2 211.52**	**3.17**

FIGURE 24.
TREE COUNT DISTRIBUTION (MILLION) BY LAND USE IN NON-FOREST LAND

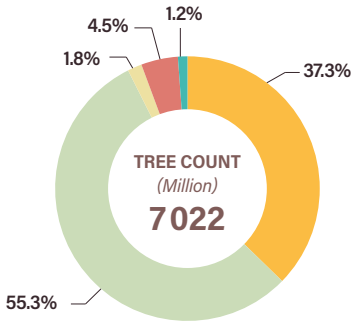


FIGURE 25.
AVERAGE TREE DENSITY (TREES/HA) IN NON-FOREST LAND USES

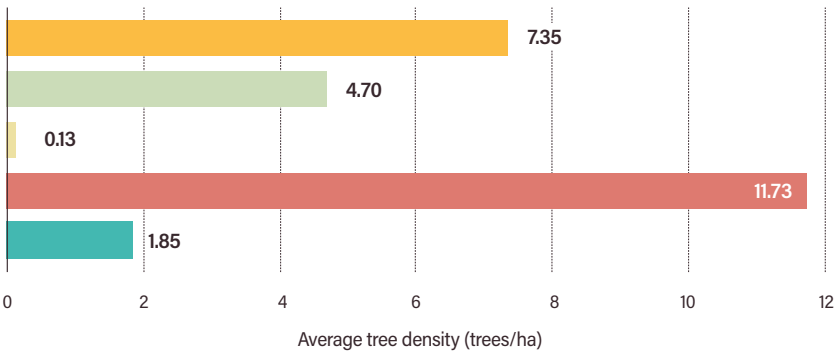
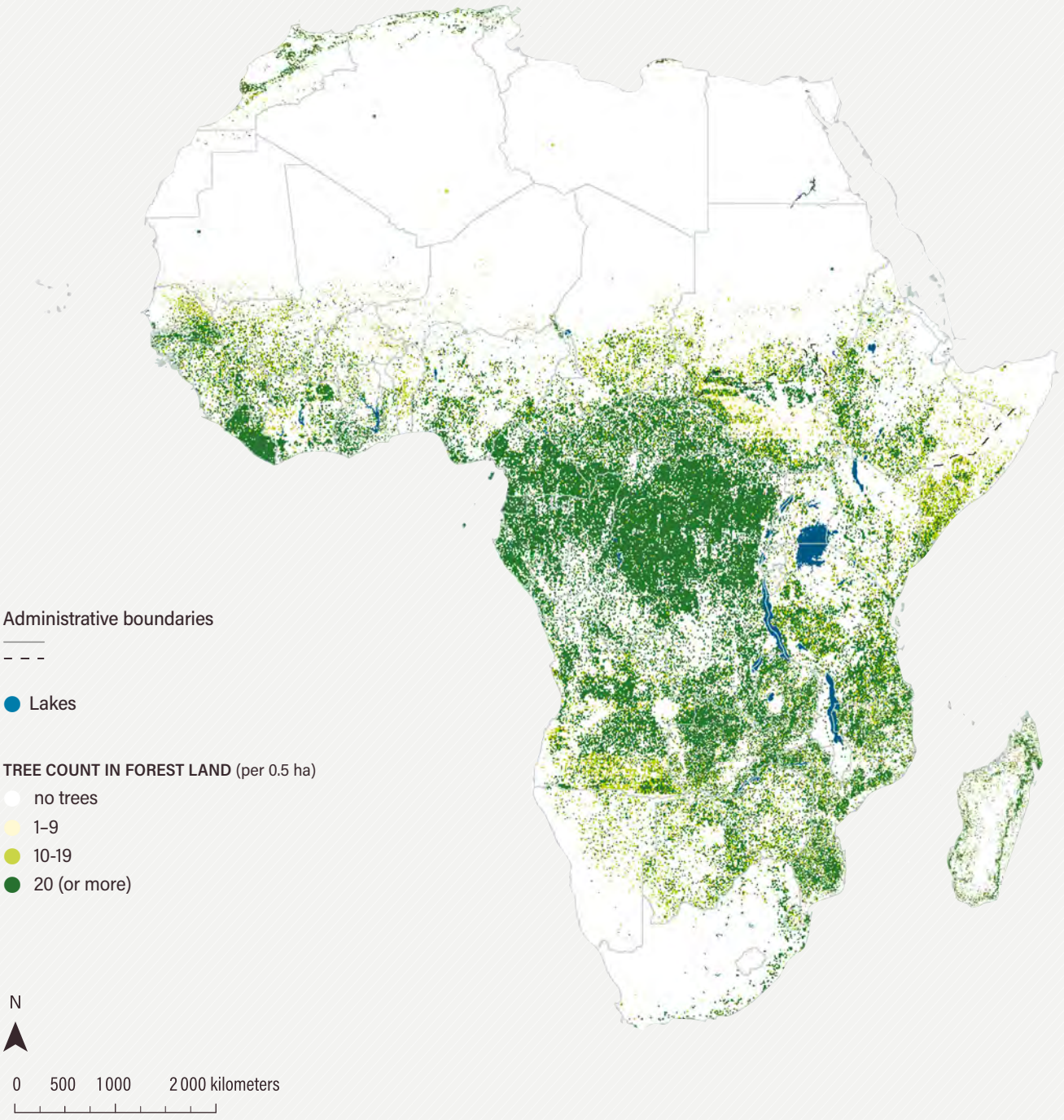
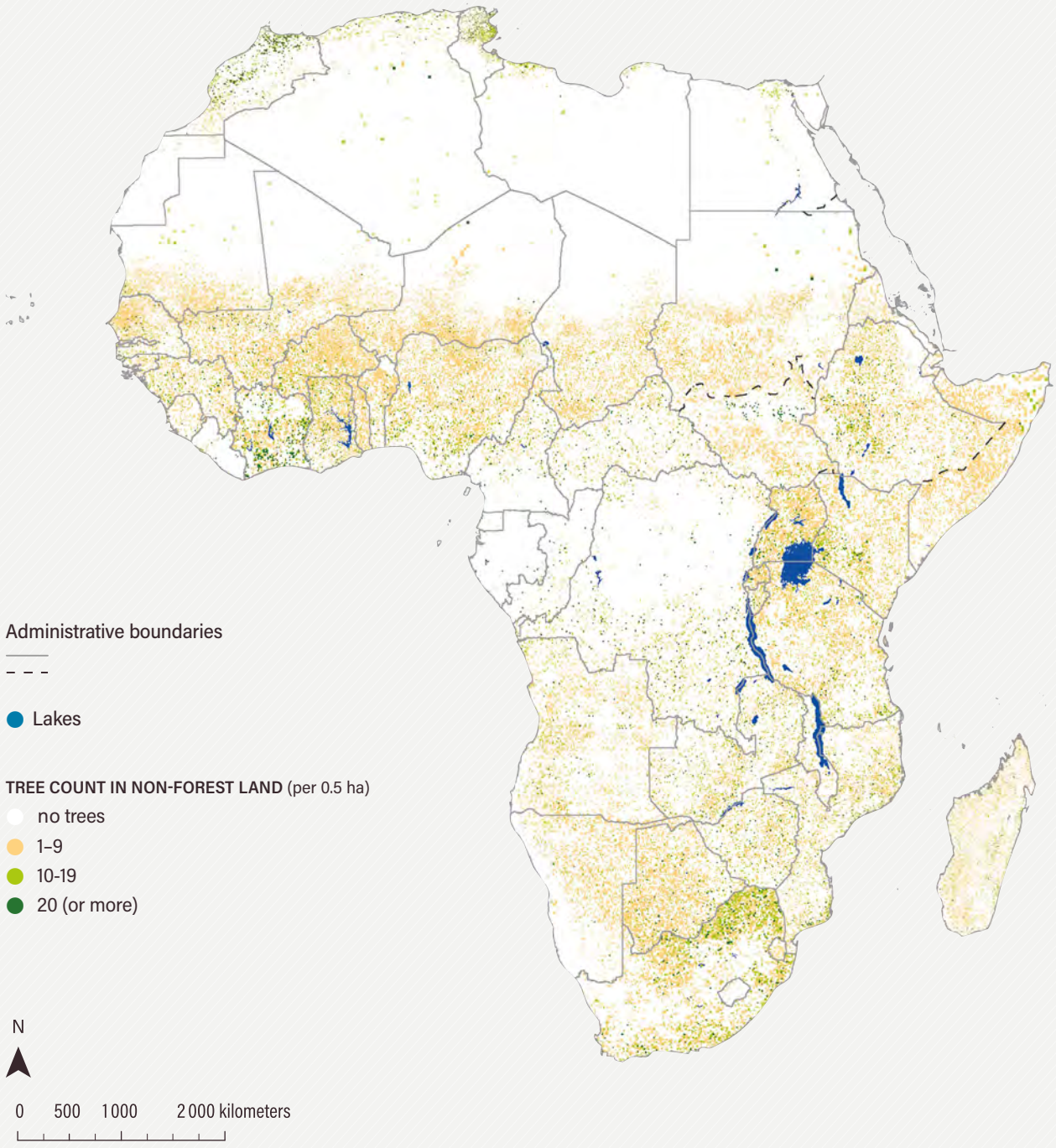


FIGURE 26. MAP OF TREE COUNT IN FOREST LAND (TREES PER 0.5HA)



Source: FAO based on Africa Open DEAL database, 2022. Adapted from United Nations World map, 2020.

FIGURE 27. MAP OF TREE COUNT IN NON-FOREST LAND (TREES PER 0.5 HA)



Source: FAO based on Africa Open DEAL database, 2022. Adapted from United Nations World map, 2020.

In Africa there are 26 countries with more than 100 million trees in non-forest land (Figure 28). The distribution of trees by country shows a very high gap between the first country, South Africa (721 million trees with an average of 6.2 trees/ha), and the others.

South Africa distributes its trees in non-forest land mainly in grassland (88 percent) (Figure 29). Ethiopia (average 5.0 trees/ha) and Nigeria (average 5.6 trees/ha) show an absolute higher total number of trees in cropland (235 and 297 million each), and also its prevalence compared to all other land uses (58 percent and 74 percent).

FIGURE 28. TREE COUNT BY COUNTRY WITH MORE THAN 100 MILLION TREES IN NON-FOREST LAND

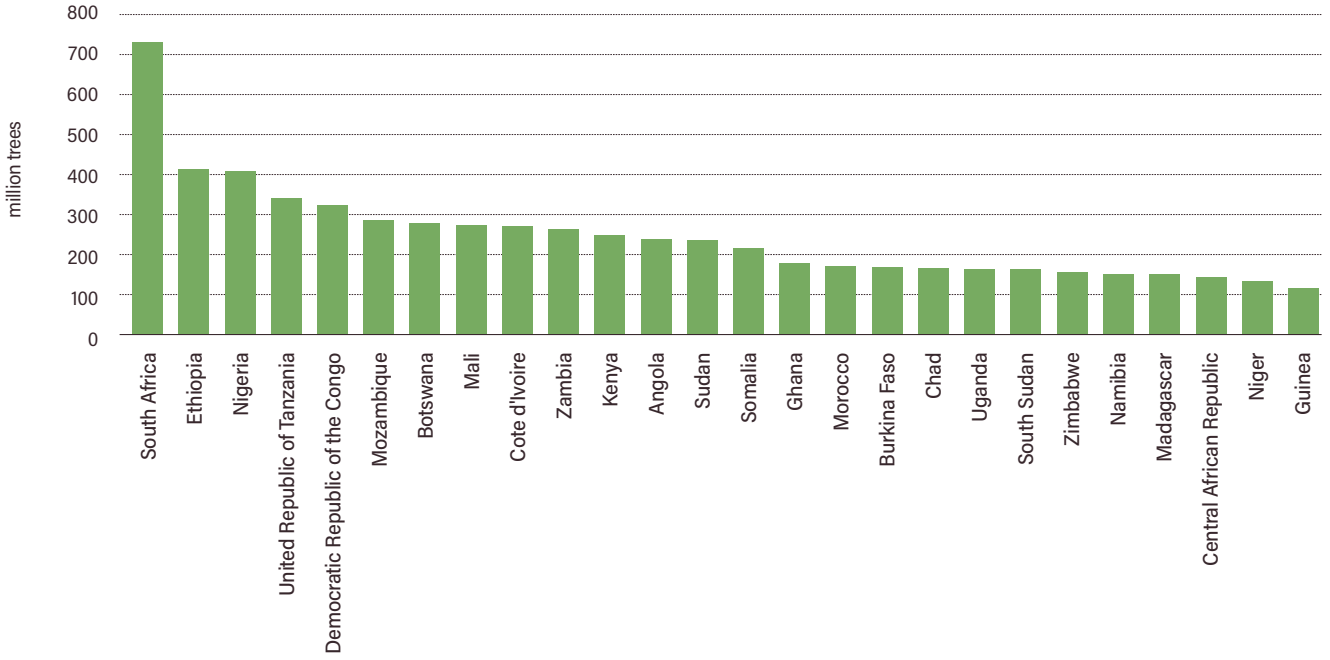
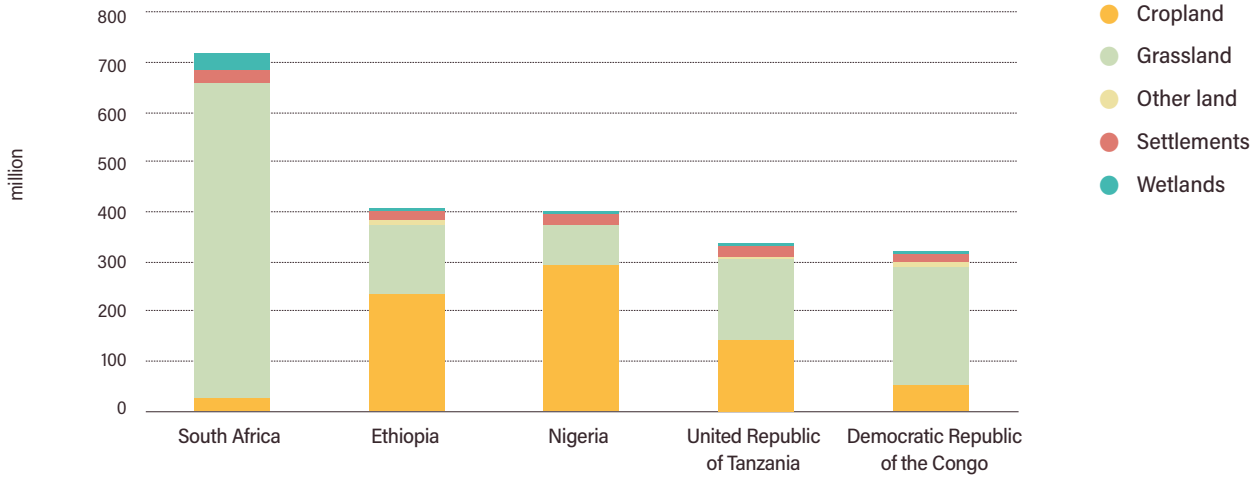


FIGURE 29. TREE COUNT (IN MILLIONS) BY LAND USE IN THE FIRST FIVE COUNTRIES (TREES IN NON-FOREST LAND)



LAND USE CHANGE IN AFRICA IN THE LAST 20 YEARS

Based on the yearly calculated attributes of land use, Figure 30 presents the area chart of temporal dynamics of land use changes in Africa between 2000–2019, showing that most losses occurred due to deforestation, mostly through conversion of forest land to cropland.

During the period 2000–2019, 1.6 percent of land has changed (48 million ha) to another land use compared to 2 937 million left unchanged (Table 16).

21 million ha of forests have been lost (44 percent of all changes, approximately 1 million ha per year during this period), while 5.5 million ha of new forest land were added through forest expansion (net change -15.6 million ha). Simultaneously, there was an agricultural expansion of 17.6 million ha (37 percent of all changes) and a settlement expansion of 4.1 million ha (9 percent). Table 17 shows that the progress of losses and gains are distributed evenly between the 2000–2010 and 2011–2019 periods.

FIGURE 30. ANNUAL LAND USE DISTRIBUTION BETWEEN 2000 AND 2019

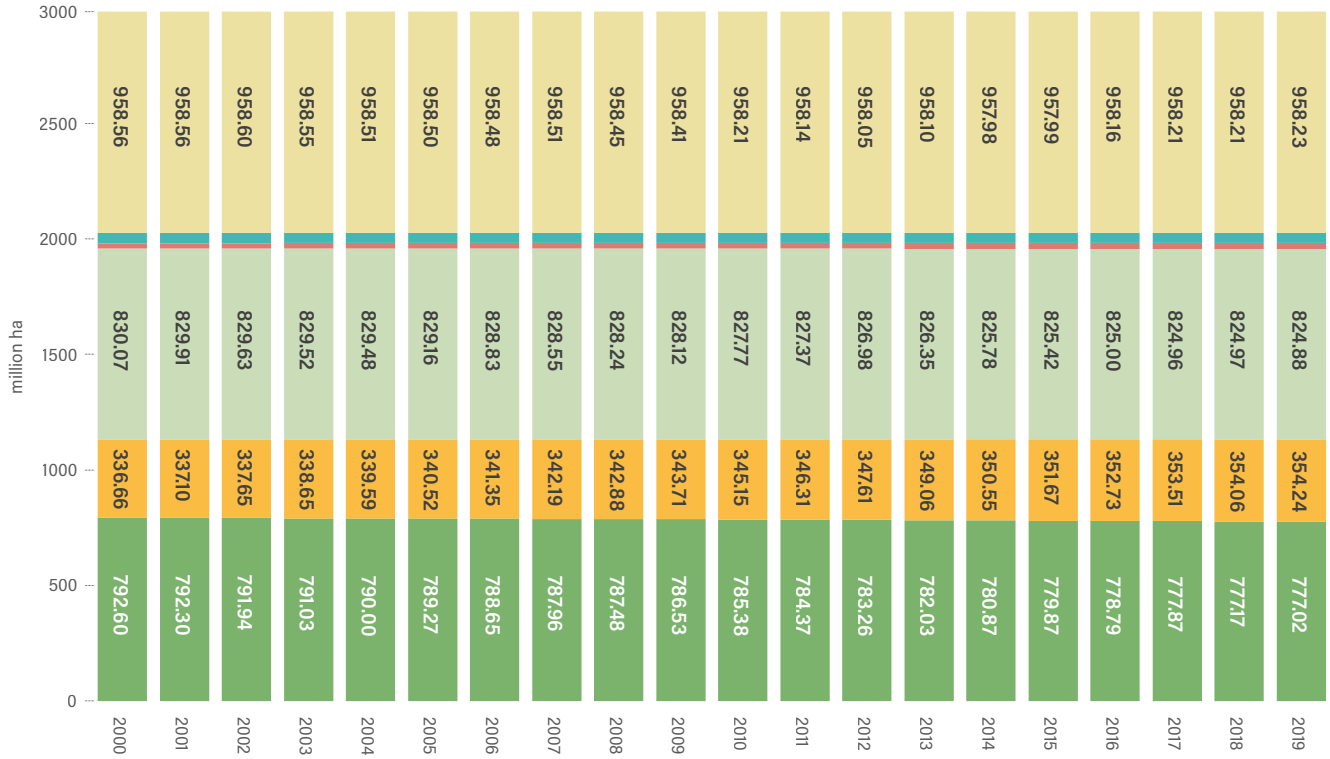


TABLE 16. LAND USE CHANGE 2000-2019

Land use *(Mha)*	Forest land	Cropland	Grassland	Settlements	Wetlands	Other land	Total 2000
Forest land	**771.49**	12.52	7.40	0.87	0.04	0.29	**792.60**
Cropland	1.72	**329.73**	3.46	1.56	0.05	0.14	**336.66**
Grassland	3.29	11.21	**813.07**	1.62	0.12	0.76	**830.07**
Settlements	0.02	0.07	0.06	**22.25**	0.00	0.01	**22.41**
Wetlands	0.33	0.10	0.24	0.02	**43.51**	0.20	**44.40**
Other land	0.18	0.61	0.65	0.24	0.05	**956.83**	**958.56**
Total 2019	**777.02**	**354.24**	**824.88**	**26.56**	**43.78**	**958.23**	**2 984.70**

TABLE 17. LAND USE NET CHANGE (LOSS AND GAIN) BETWEEN 2000, 2010 AND 2019.

Land use *(Mha)*	Area 2000	Area 2010	Area 2019	2000–2010	2010–2019	2000–2019	2000–2019 rate
Forest land	792.60	785.38	777.02	-7.22	-8.36	-15.58	-1.97%
Cropland	336.66	345.15	354.24	8.49	9.09	17.58	5.22%
Grassland	830.07	827.77	824.88	-2.30	-2.89	-5.19	-0.62%
Settlements	22.41	24.17	26.56	1.76	2.39	4.14	18.48%
Wetlands	44.40	44.02	43.78	-0.38	-0.24	-0.62	-1.39%
Other land	958.56	958.21	958.23	-0.35	0.02	-0.33	-0.03%
Total	**2 984.70**	**2 984.70**	**2 984.70**				

TABLE 18. MAIN LAND USE CHANGES AND THEIR IMPACT IN AFRICA 2000-2019.

Impact	Area	Description
	Mha	
Loss of existing forest	21.12	*Any forest land lost to other land uses between 2000 and 2019*
Gain of new forest	5.54	*Any non-forest land that became forest land between 2000 and 2019*
Net settlement expansion	4.14	*2019 minus 2000 settlement area*
Net cropland expansion	17.58	*2019 minus 2000 cropland area*

FIGURE 31. LAND USE NET CHANGE (LOSS AND GAIN, MILLION HA) IN PERIOD 2000-2019.

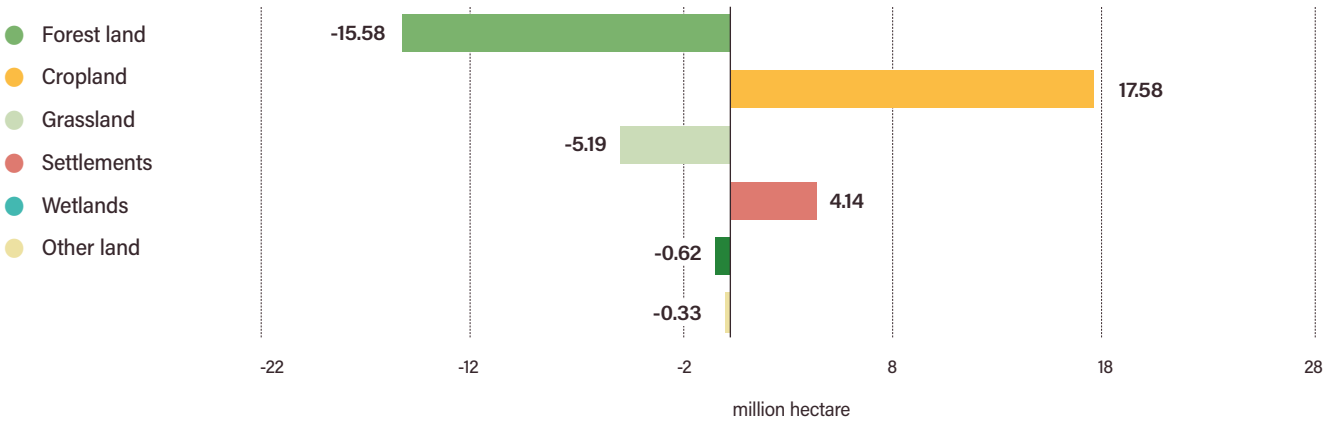


FIGURE 32. LAND USE CHANGE DIRECTIONS AND INTENSITY (HIGHER THAN 0.5 PERCENT OF TOTAL CHANGE) IN PERIOD 2000–2019

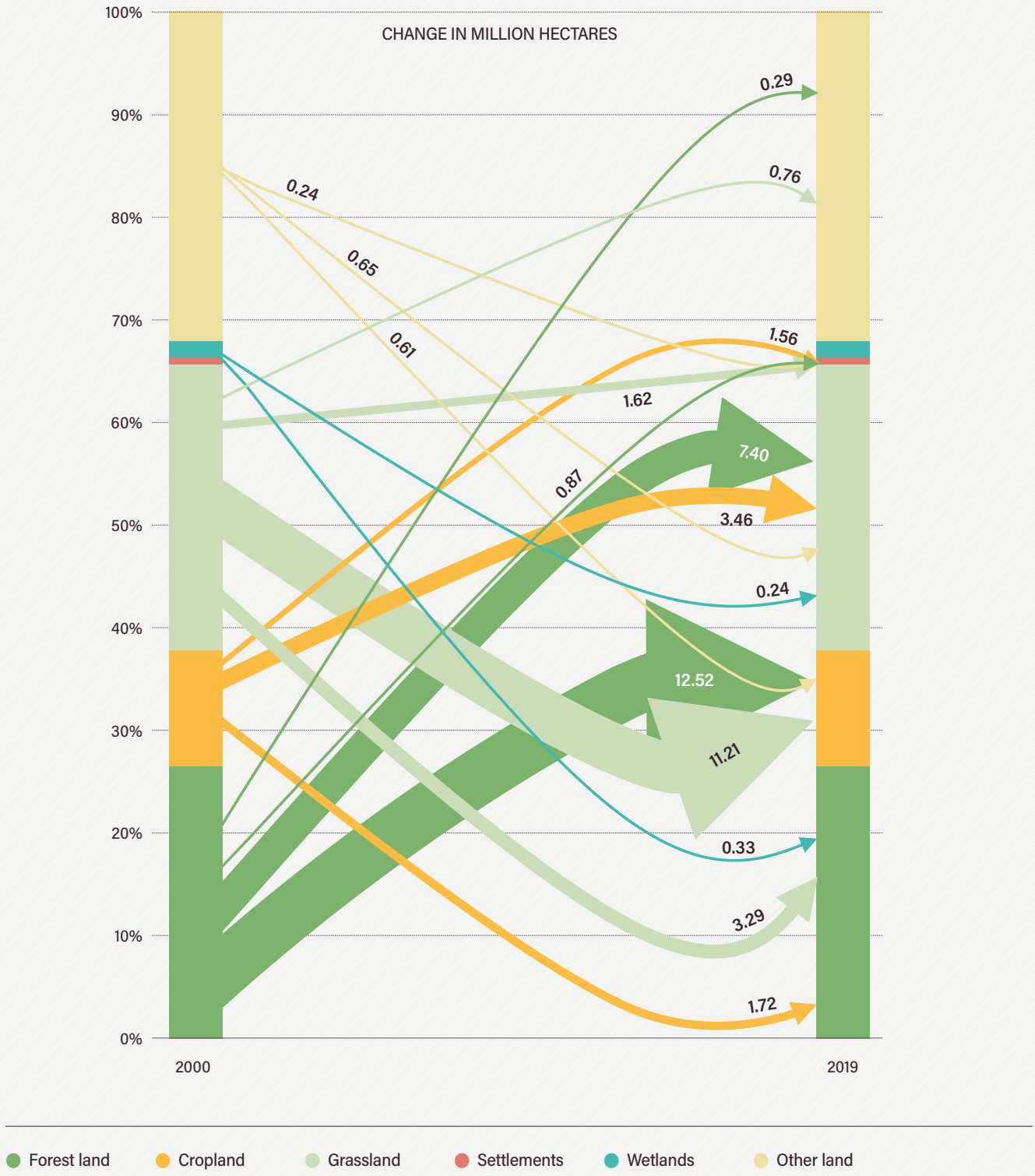


Figure 32 presents a visual interpretation of direction and intensity of land use changes between 2000 and 2019. It is clear how deforestation pertains to other changes, mostly feeding the numbers included in the crop expansion.

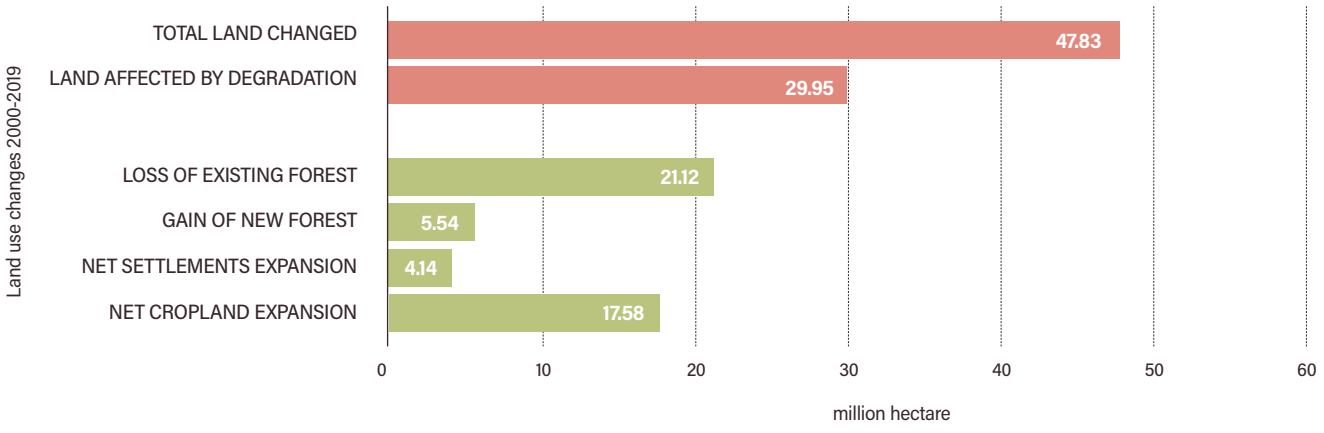
Applying the transition matrix across land covers proposed by the UNCCD (Sims *et al.*, 2021) to monitor the degradation of land (processes that are likely to reduce the biological or economic productivity and complexity of the land), we observe that nearly 30 million ha (63 percent of the changed land) was assessed as degraded by land use change (in red, Table 19), in particular due to loss of forest land or cropland and settlement expansion (Figure 33).

The vast majority of land in Africa is classified as stable. Some 30 million ha have been degraded, while almost 18 million ha have improved. The biggest number of changes have occurred in West Africa (Guinea and Sierra Leone), Angola, Zambia and the United Republic of Tanzania.

TABLE 19. LAND USE CHANGE MATRIX 2000–2019 (TRANSITIONS IN MILLION HA).

Land use	Forest land	Cropland	Grassland	Settlements	Wetlands	Other land	Total 2000
Forest land	**771.49**	12.52	7.40	0.87	0.04	0.29	**792.60**
Cropland	1.72	**329.73**	3.46	1.56	0.05	0.14	**336.66**
Grassland	3.29	11.21	**813.07**	1.62	0.12	0.76	**830.07**
Settlements	0.02	0.07	0.06	**22.25**	0.00	0.01	**22.41**
Wetlands	0.33	0.10	0.24	0.02	**43.51**	0.20	**44.40**
Other land	0.18	0.61	0.65	0.24	0.05	**956.83**	**958.56**
Total 2019	**777.02**	**354.24**	**824.88**	**26.56**	**43.78**	**958.23**	**2 984.70**

FIGURE 33. MAIN LAND USE CHANGES 2000–2019 AND THEIR IMPACT IN AFRICA



Heatmaps

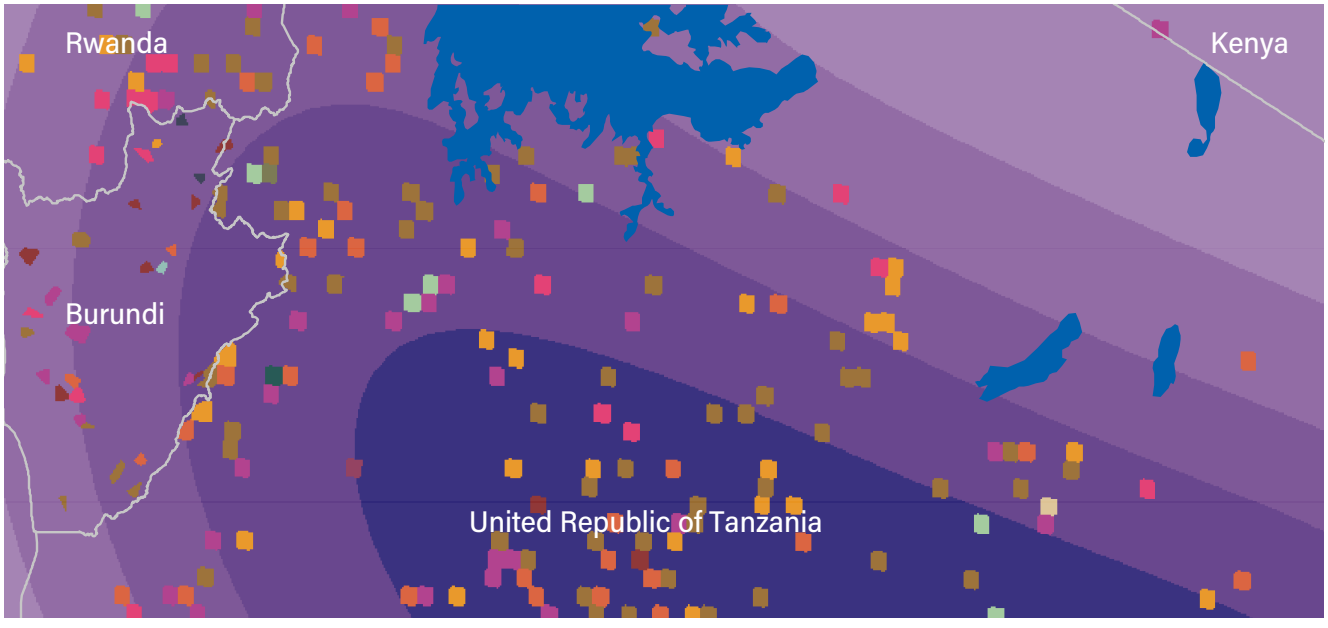
A heatmap provides a visual overview of where a point-based event occurs with higher spatial frequency, for example plots undergoing land use change. The more and closer these samples are (Figure 34) the darker the area, creating what are called "hotspots." When looking at a heatmap, one can therefore quickly see which areas of the map represent higher density of samples and which do not, by using colour-coded scales. Heatmaps are designed to be easily understood, and should be used only with the purpose of highlighting hotspots of plot density, thus avoiding misinterpretations that could lead to inaccurate conclusions.

In this section of the report, we describe all land use changes with heatmaps, as well as specific changes such as new forest land, loss of forest land, cropland expansion and settlement expansion in the period 2000–2019.[8]

The map in Figure 35 shows the clustering and variation of plots affected by land use change between 2000 and 2019. Darker colours are assigned to areas with a higher density of changed plots. This heatmap represents areas of land use change between 2000 and 2019 (47.8 million ha). Hotspots are identified in West Africa (especially in Guinea and surrounding countries), Southeast (Zambia, the United Republic of Tanzania, Mozambique, and Madagascar) and Southwest Africa (Angola).

The key hotspots denoting loss of existing forest are shown in Figure 36. This heatmap represents areas changed from any forest to other land uses between 2000 and 2019 (21.1 million ha). Zambia, the United Republic of Tanzania, Mozambique and Madagascar in Southeast Africa, Angola in Southwest, the Democratic Republic of the Congo in Central and Guinea and Côte d'Ivoire in Western Africa are the most affected.

FIGURE 34. EXAMPLE OF HEATMAP OVERLAID WITH THE SAMPLE PLOTS GENERATING THE SAME MAP (LAND USE CHANGE)



Source: FAO based on Africa Open DEAL database, 2022. Adapted from United Nations World map, 2020.

[8] The point density analysis leading to these heatmaps was performed after reassigning the nearest neighbouring point of the original database to a systematic homogeneous grid (5 km), which was necessary to overcome the different grid density (20 km, 10 km, 8 km, 4 km. etc.) and grid type (systematic or random) in the Africa Open DEAL source data set. In some countries with higher sampling density some information has been lost, but the result is more accurate at continental level.

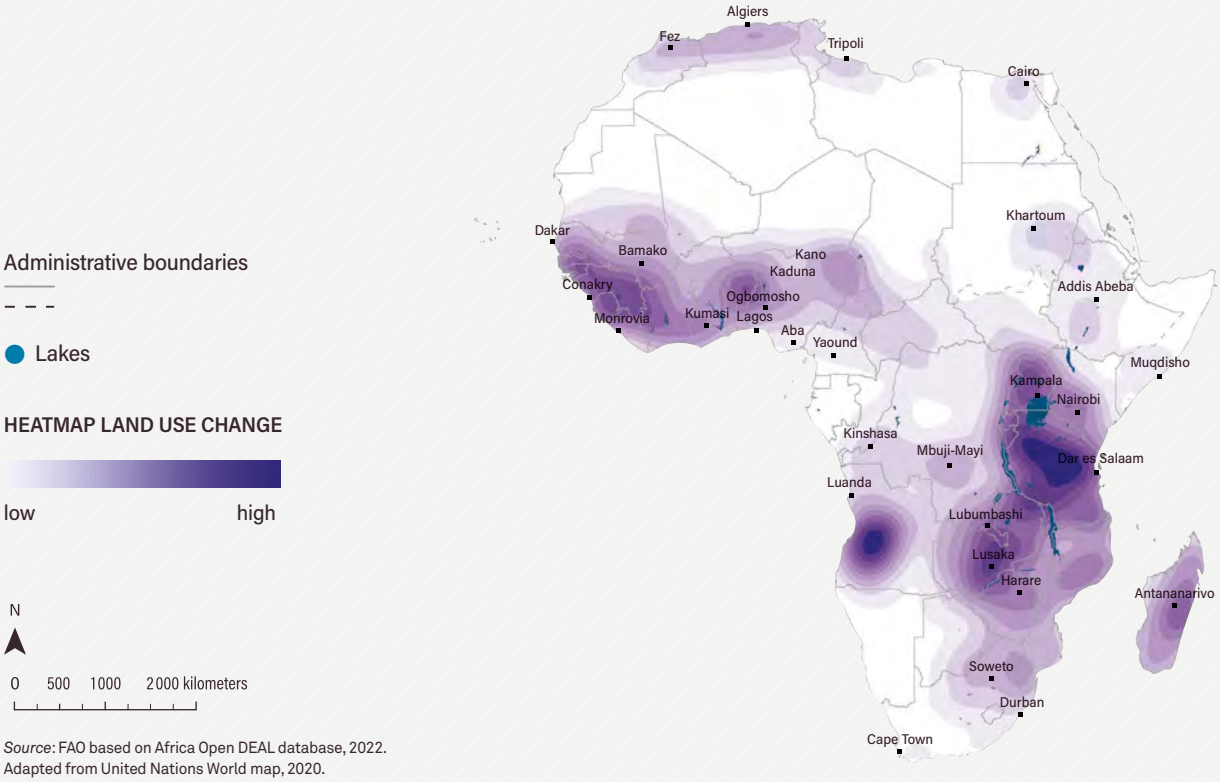
The key hotspots of gain of new forest are shown in Figure 37. This heatmap represents areas changed from non-forest land to forest land (5.5 million ha). Major hotspots are detected in Southeast Africa (mainly the United Republic of Tanzania, but also in Zambia and Madagascar), Southwest (Angola) and West Africa (mainly in Guinea and Ghana).

The key hotspots of cropland expansion are shown in Figure 38. This heatmap represents areas converted to cropland for an amount of 24.5 million ha of land, of which 51 percent converted from forest land and 46 percent from grassland. Zambia, the United Republic of Tanzania, Mozambique and Madagascar in Southeast Africa, Angola in Southwest, and Guinea, Benin and Nigeria in West Africa are the main hotspots.

The key hotspots of settlement expansion are shown in Figure 39. This heatmap represents areas converted to settlement for an amount of 4.3 million ha, of which 38 percent was converted from cropland and 36 percent from grassland. Hotspots are distributed all over the continent: Algeria and surrounding countries and Egypt in North Africa, the United Republic of Tanzania, Uganda and Kenya in East Africa, Zambia, South Africa and Angola in Southern Africa and Ghana and Nigeria in West Africa.

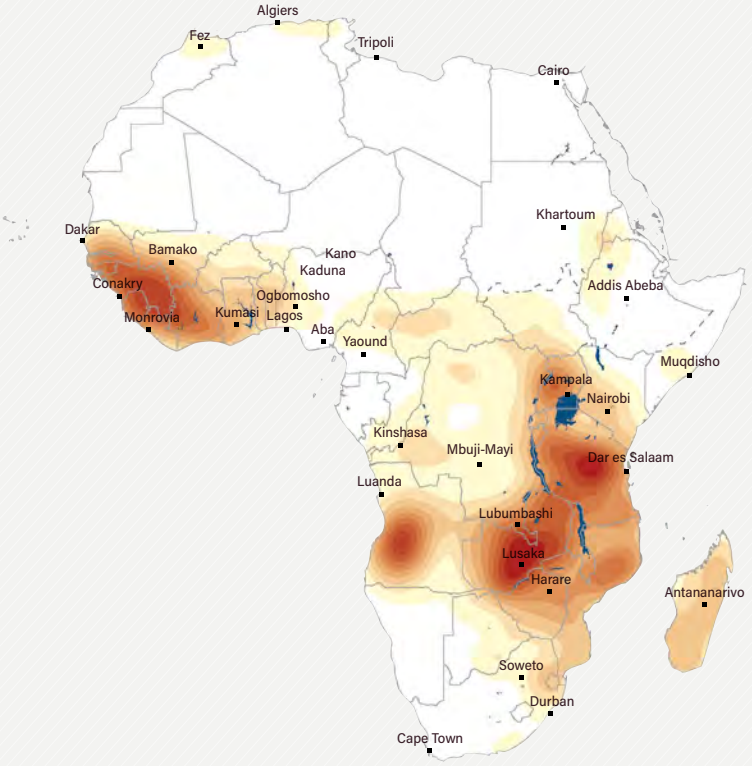
Having examined land use, cover and changes on the African continental scale, we will now look in more detail how these dynamics play out in the GGW project area.

FIGURE 35. HEATMAP OF LAND USE CHANGE HOTSPOTS 2000–2019



Source: FAO based on Africa Open DEAL database, 2022.
Adapted from United Nations World map, 2020.

FIGURE 36. HEATMAP OF FOREST LAND LOSS 2000–2019



Administrative boundaries

Lakes

HEATMAP FOREST LAND LOSS

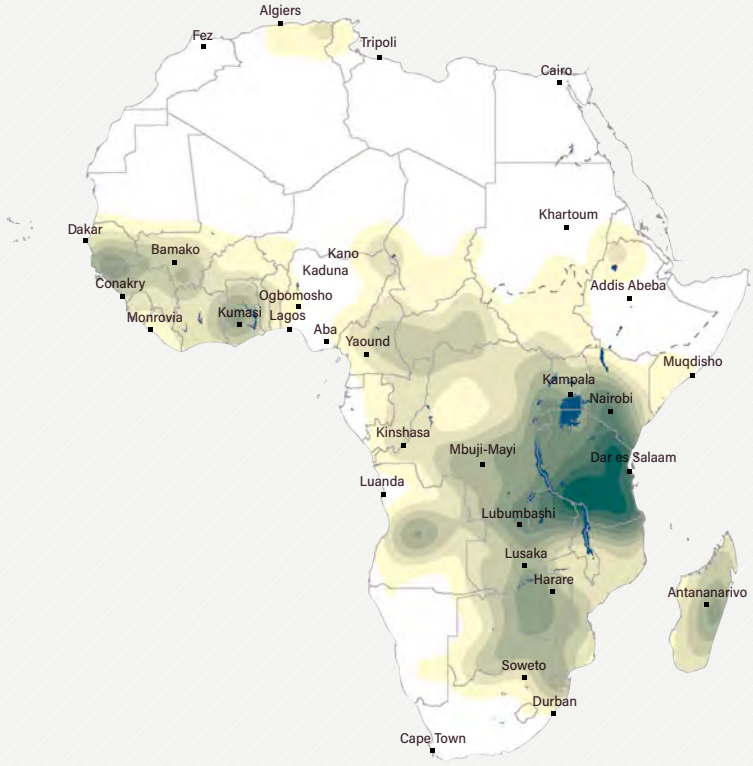
low high

N

0 500 1000 2000 kilometers

Source: FAO based on Africa Open DEAL database, 2022.
Adapted from United Nations World map, 2020.

FIGURE 37. HEATMAP OF NEW FOREST LAND 2000 2019



Administrative boundaries

Lakes

HEATMAP FOREST LAND LOSS

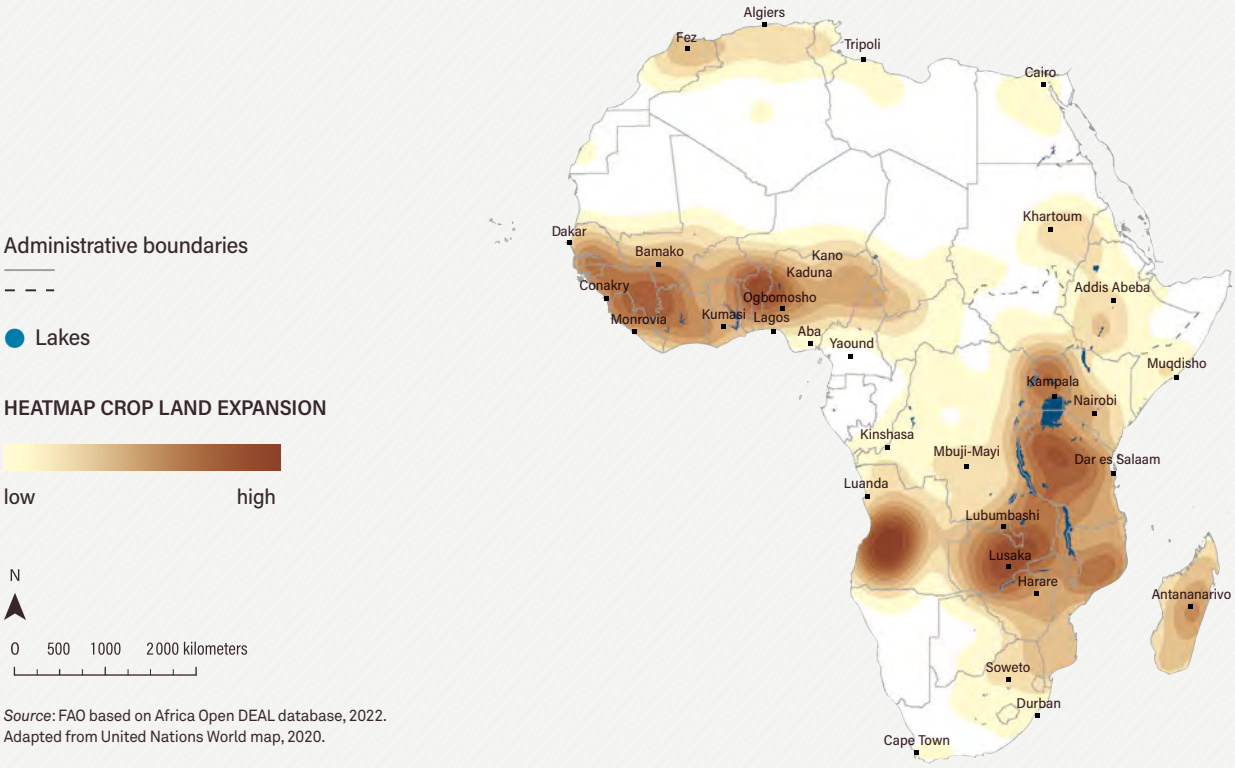
low high

N

0 500 1000 2000 kilometers

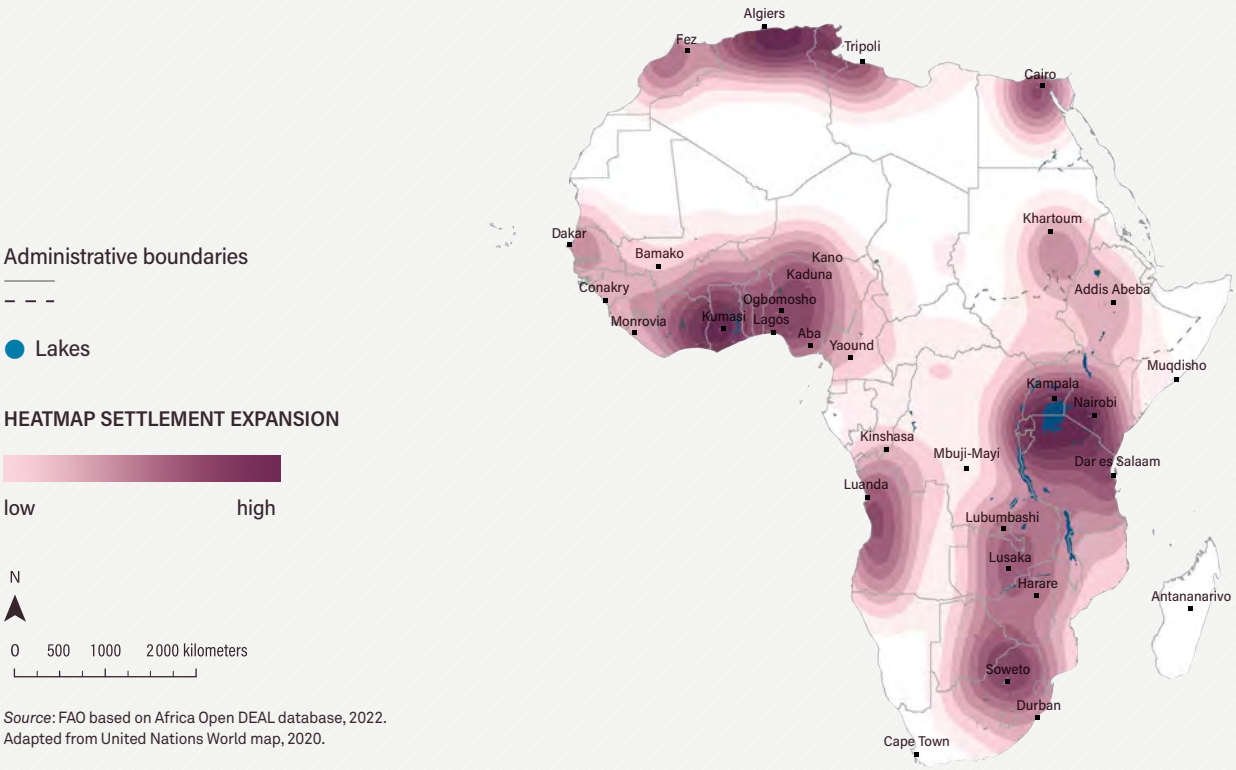
Source: FAO based on Africa Open DEAL database, 2022.
Adapted from United Nations World map, 2020.

FIGURE 38. HEATMAP OF CROPLAND EXPANSION



Source: FAO based on Africa Open DEAL database, 2022.
Adapted from United Nations World map, 2020.

FIGURE 39. HEATMAP OF SETTLEMENT EXPANSION 2000–2019



Source: FAO based on Africa Open DEAL database, 2022.
Adapted from United Nations World map, 2020.

AFRICA'S GREAT GREEN WALL

Africa's GGW is an African initiative led by the AUC to restore and sustainably manage lands in the dry areas of Sahel-Sahara and southern regions in order to address continuous land degradation, rural poverty, and climate change adaptation and mitigation.

The continental GGW area of interest is composed of three dryland regions, namely North Africa, Sahel, and Southern Africa, encompassing 25 countries. Its Sahel branch is coordinated by the Pan-African Agency of the GGW, which was first envisioned in 2005 during the seventh session of the Community of Sahel-Saharan States (CEN-SAD) , a conference for heads of state held in Ouagadougou. In 2007, the African Union approved the "Decision on the implementation of the GGW for the Sahara and Sahel Initiative". The harmonized regional strategy proposes a restoration corridor within mean annual rainfalls of 100 mm and 400 mm isohyets, from Senegal in the west to Djibouti in the east (AUC/PA-GGW, 2012) and in Northern Africa. This vision has evolved into an integrated ecosystem management approach, striving for a mosaic of different land use and production systems, including sustainable dryland management and restoration, and the regeneration of natural vegetation, as well as water retention and conservation measures. By 2030, the GGW Sahel seeks to restore 100 million ha of degraded agrosilvopastoral lands, creating 10 million green jobs and capturing 250 million of CO_2 equivalent.

In recent years, the AUC extended the initiative to Southern Africa with nine dryland countries of the Southern African Development Community (SADC). The GGW has evolved into an African-led pioneer initiative, which receives strong support from the international community, as a flagship programme to combat land degradation, desertification, drought, climate change, biodiversity loss, poverty, and food insecurity.

The initiative is well into its second decade and is receiving growing attention in the context of a new international focus on and commitments to land restoration as a global solution to improve livelihoods and address climate change adaptation and mitigation.

This section presents the key findings of the GGW regional analysis for the period 2000–2019.

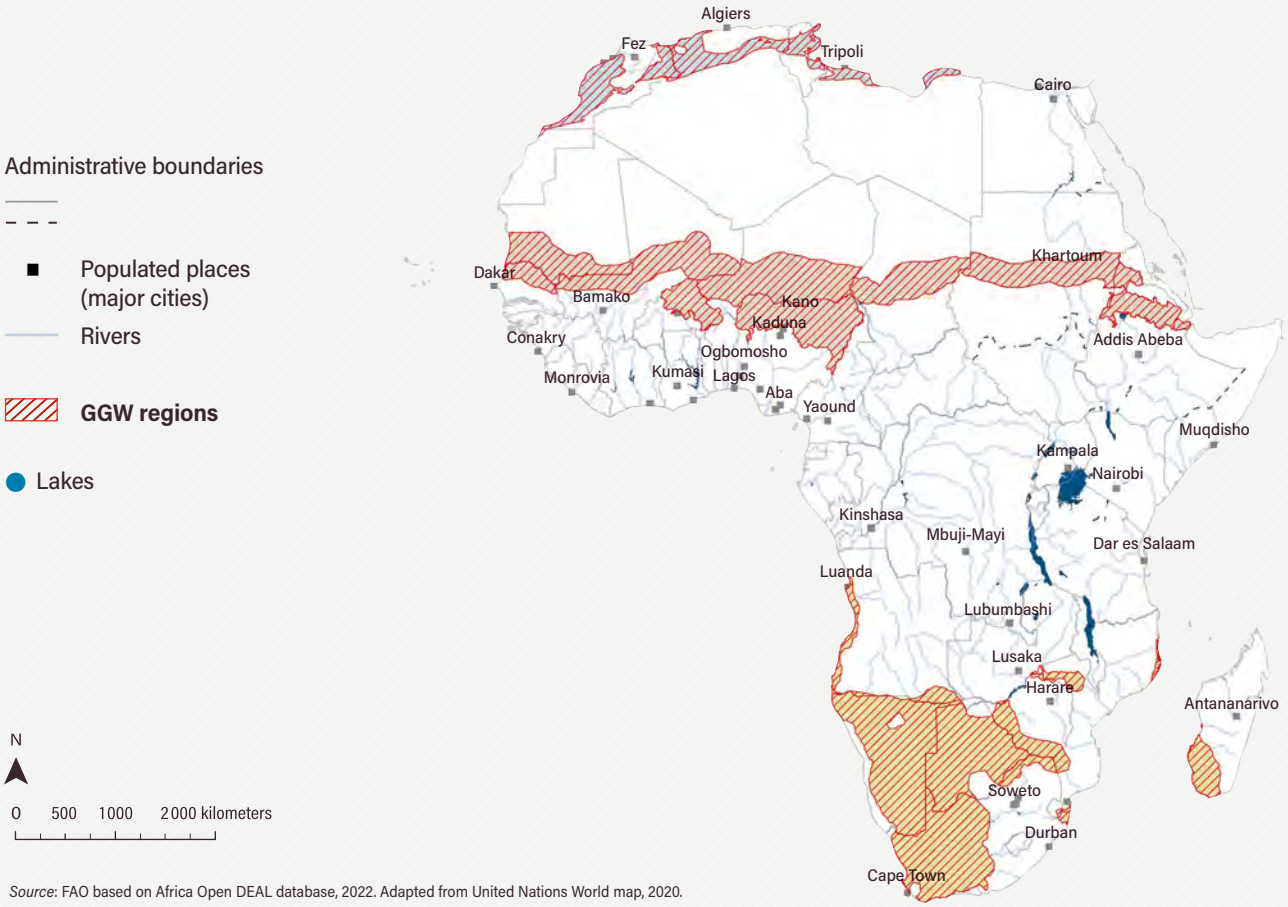
The Great Green Wall area and land use distribution

The continental GGW area of interest is composed of three dryland regions: North Africa, Sahel and Southern Africa, encompassing 25 countries (Figure 40).
The total area of interest of Africa's Great Green Wall is approximately 520 million ha, 17 percent of the African continent (Figure 42 and Figure 41), which is home to about 187 million people[9] (65 percent in GGW Sahel).
Three regions of the continental GGW have been defined by the African Union (Figure 40 and Table 20): North Africa (10 percent), Sahel and Southern Africa (45 percent each).

The North Africa region was delineated by selecting dryland areas, arid and semiarid zones from the UNEP-WCMC – Drylands database (UNEP-WCMC, 2007), refined with ecological (only four) WWF ecoregions (Olson *et al.*, 2001) and climatic variables, a combination of historical and projected precipitations of less than 400 mm (Karger *et al.*, 2017). The GGW region of Sahel was derived by using the original GGW's line of the vegetation barrier, buffered between 50 and 100 km (approximately 1 degree latitude) north/south.

[9] Source: GHSL: Global Human Settlement Layers, Population Grid 1975-1990–2000–2015 (P2016)

FIGURE 40. MAP OF GREAT GREEN WALL REGIONS: NORTH AFRICA, SAHEL, AND SOUTHERN AFRICA



Source: FAO based on Africa Open DEAL database, 2022. Adapted from United Nations World map, 2020.

FIGURE 41.
EXTENT OF GGW AREA COMPARED TO THE AFRICAN CONTINENT

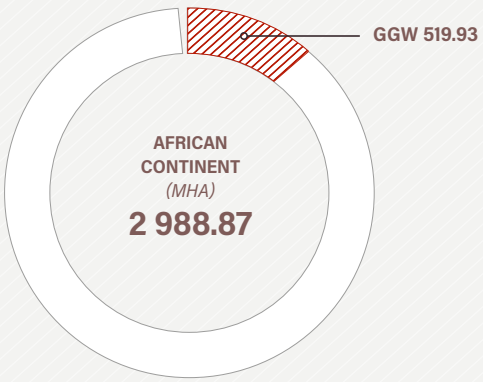
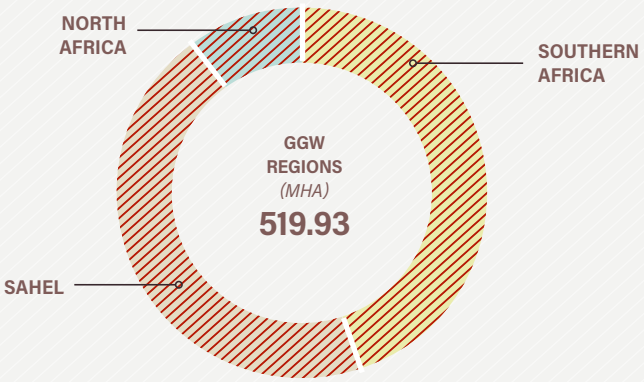


FIGURE 42.
THE AREA EXTENT OF GGW REGIONS



The Burkina Faso and Nigeria areas were identified with a set of subnational administrative units as indicated by national plans. Mauritania and Sudan also include areas of interest of the project BRIDGE.[10] The GGW region in Southern Africa was delineated by using arid and semiarid zones from the UNEP-WCMC – Drylands database.

The highest share of land in the continental GGW is grassland, approximately 51 percent (Table 20, Table 21 and Figure 42) with a lower proportion in North Africa (37 percent) and a higher proportion in Southern Africa (60 percent).

The other major three land uses in the GGW area are other land (20 percent), forest (13 percent) and cropland (14 percent).

TABLE 20. LAND USE DISTRIBUTION IN THE GGW AREA COMPARED TO THE AFRICAN CONTINENT

Land use	Total area AFRICA	Total area GGW AFRICA	GGW/AFRICA	LU/GGW total
	Mha	*Mha*		
Forest land	777.35	65.96	8.5%	13%
Cropland	356.30	74.28	20.8%	14%
Grassland	826.12	264.81	32.1%	51%
Settlements	26.93	5.62	20.9%	1%
Wetlands	43.83	7.28	16.6%	1%
Other land	958.34	101.98	10.6%	20%
Total	**2 988.87**	**519.93**	**17.4%**	**100%**

TABLE 21. LAND USE DISTRIBUTION IN THE GREAT GREEN WALL AREA BY REGION

Land use 2019	GGW North AFRICA	Share of total	GGW SAHEL	Share of total	GGW Southern Africa	Share of total
	Mha		*Mha*		*Mha*	
Forest land	4.07	8%	15.69	6%	46.20	20%
Cropland	14.58	29%	52.17	22%	7.53	3%
Grassland	18.53	37%	109.43	45%	136.85	60%
Settlements	1.47	3%	2.17	1%	1.97	1%
Wetlands	0.72	1%	2.59	1%	3.97	2%
Other land	11.08	22%	59.37	25%	31.54	14%
Total	**50.45**	**100%**	**241.42**	**100%**	**228.06**	**100%**

TABLE 22. DRYLANDS BY GGW REGION

GGW region	Hyperarid	Arid	Semiarid	Dry subhumid	TOTAL
	Mha	*Mha*	*Mha*	*Mha*	*Mha*
North Africa	0.00	18.94	31.47	0.00	50.41
Sahel	0.72	134.56	83.98	12.59	231.84
Southern Africa	0.00	56.31	171.77	0.00	228.08
Total	**0.72**	**209.81**	**287.22**	**12.59**	**510.34**

[10] www.fao.org/in-action/action-against-desertification/news-and-multimedia/detail/en/c/1051386

Africa's drylands

The United Nations Environment Programme (UNEP) identifies drylands by using an Aridity Index (AI) lower than 0.65. The AI is the ratio between average annual precipitation and potential evapotranspiration. Drylands are divided into hyperarid, arid, semiarid and dry subhumid lands based on the value of the index. Drylands are often regions of water scarcity, with higher vulnerability to degradation from climate change and direct human pressures, yet with immensely rich biodiversity (UNCCD, 2017).

The distribution of Africa's drylands in the GGW regions is presented in Table 22 and Figure 43. We can observe that most of the GGW area of interest falls into the semiarid and arid drylands regions, followed by dry subhumid and only a very small percentage in the hyperarid Sahel region.

FIGURE 43. LAND USE DISTRIBUTION IN THE GREAT GREEN WALL AREA BY REGION

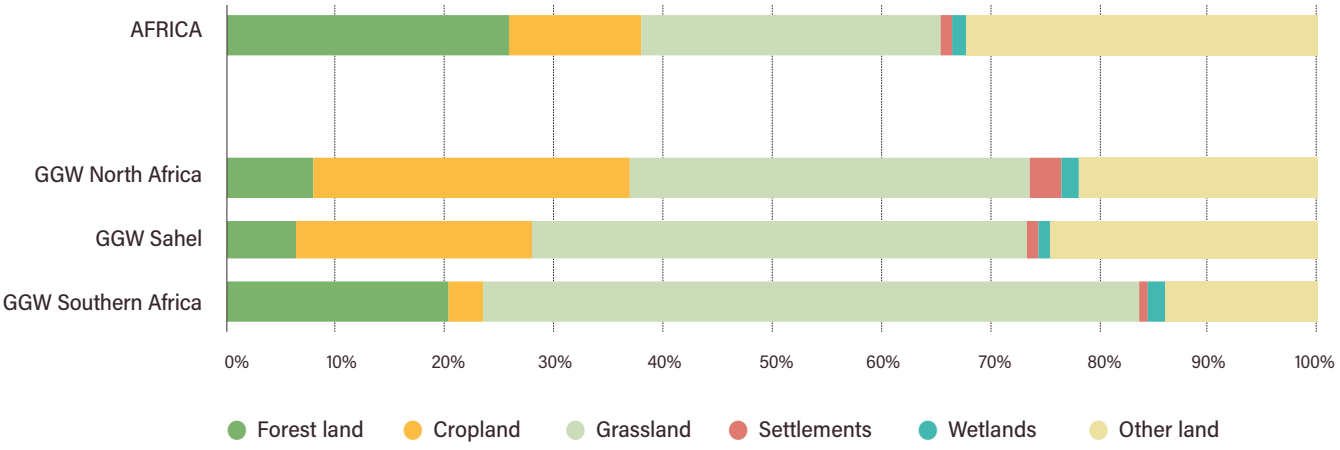
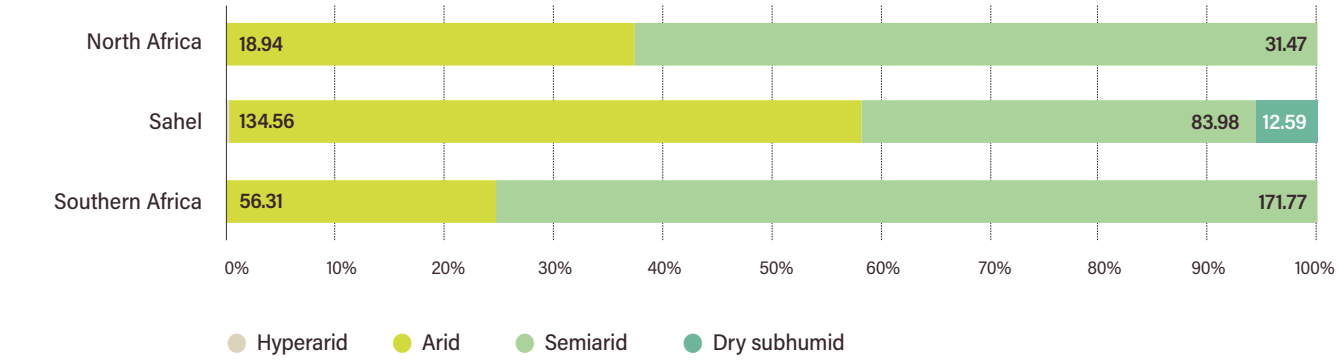


FIGURE 44. DRYLANDS BY GGW REGION



Land use change in the Great Green Wall regions

In the timeframe 2000–2019, most areas of the GGW appeared stable (98.8 percent) (Table 23), while the use of more than 6 million ha of land has changed.

Balancing losses and gains, the GGW area registers a net loss of forest of 0.8 million ha (0.4 of expansion versus 1.3 of loss) and a loss of grassland (1.5 million ha) versus expansion of cropland (1.5 million ha) and settlement (0.9 million ha) (Figure 45).

- **Loss of existing forest land**
  Any forest land lost to other land uses between 2000 and 2019
- **Gain of new forest land**
  Any non-forest land that became forest land between 2000 and 2019
- **Net settlement expansion**
  2019 minus 2000 settlement area
- **Net cropland expansion**
  2019 minus 2000 cropland area
- **Net grassland loss**
  Net loss of grassland in 2019 compared to 2000

Disaggregating data at the GGW regional scale (Figure 46), the largest forest loss is detected in Southern Africa (62 percent of total in GGW, 0.79 million ha), while the largest grassland loss is detected in Sahel (73 percent, 1.11 million ha). The total settlement expansion is nearly equally distributed across the three regions, although Northern Africa shows the largest net gained area (0.4 million ha). The largest cropland expansion is detected in the Sahel (71 percent, 1.10 million ha).

TABLE 23. LAND-USE CHANGE TRANSITION MATRIX IN THE GGW AREA BETWEEN 2000 AND 2019

Land use *(Mha)*	Forest land	Cropland	Grassland	Other land	Settlements	Wetlands	Land use 2000
Forest land	**65.46**	0.61	0.48	0.02	0.15	0.00	**66.72**
Cropland	0.10	**71.26**	0.63	0.04	0.37	0.03	**72.43**
Grassland	0.28	1.93	**263.13**	0.33	0.34	0.04	**266.05**
Other land	0.02	0.14	0.22	**101.55**	0.08	0.02	**102.03**
Settlements			0.01	0.00	**4.50**		**4.51**
Wetlands	0.05	0.03	0.06	0.02		**7.18**	**7.34**
Land use 2019	**65.91**	**73.97**	**264.53**	**101.96**	**5.44**	**7.27**	**519.08**

FIGURE 45.
IMPACT OF MAIN LAND USE CHANGES 2000–2019 IN THE GGW AREA

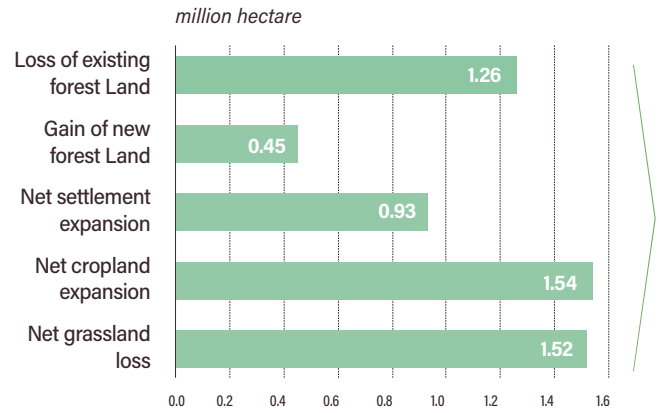
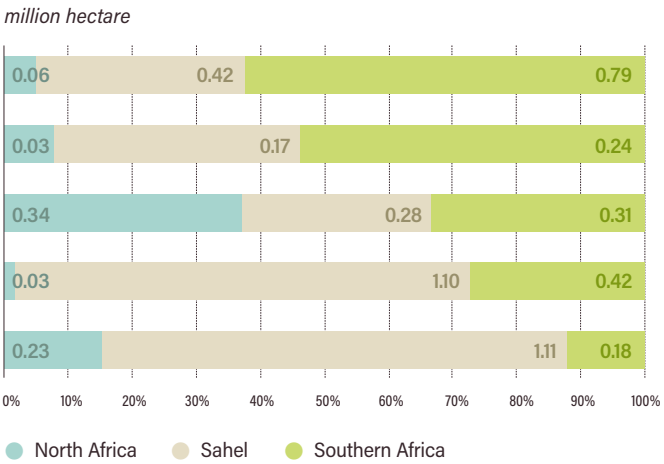


FIGURE 46.
IMPACT OF MAIN LAND USE CHANGES 2000–2019 BY GGW REGION



Trees in the Great Green Wall regions

There are approximately 4.3 billion trees in the GGW region, distributed over 217 million ha of land (Table 24). Most of these trees are in the Sahel (29 percent) and Southern Africa (63 percent) regions of the GGW (Figure 46). Trees in the GGW area represent 10 percent of the total trees in Africa. The average tree density by GGW region shows higher values in Southern Africa (12 trees/ha) and lower values in Sahel (5 trees/ha). North Africa lies between the two (7 trees/ha), mostly because of the impact of orchard systems in Tunisia and Morocco.

Excluding forest land, grassland is the land use with the most trees in the GGW area (approximately 1.1 billion trees) with an average of 4.2 trees per hectare. Cropland and settlements have a lower total number of trees but higher density (Table 25 and Figure 48).

FIGURE 47.
SHARE OF TREE COUNT BY GGW REGION

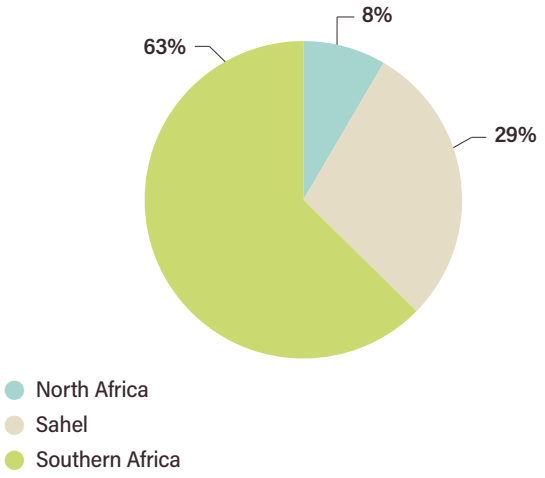


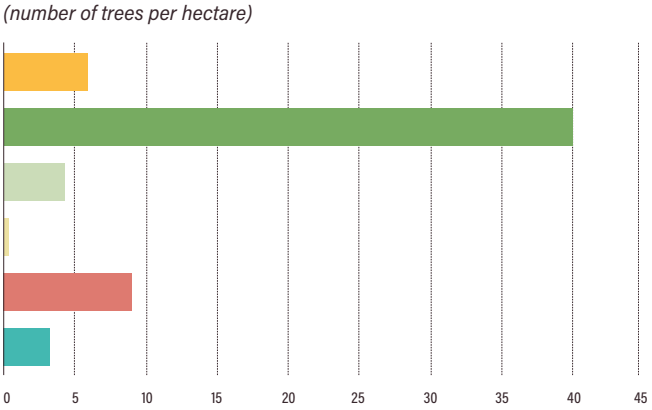
TABLE 24. TREES IN THE GGW AREA (TOTAL TREE COUNT AND TREE DENSITY) BY REGION/LAND USE

GGW region	Total land area	Land with trees	Trees	Share of total trees	Average tree density
	Mha	*Mha*	*Million*		*Trees/ha*
North Africa	50.45	12.62	363	8%	7.2
Sahel	241.42	92.76	1,243	29%	5.1
Southern Africa	228.06	111.96	2,690	63%	11.8
GGW all regions	519.93	217.34	4 296	10%	8.3
AFRICA	**2 988.87**	**1 292.38**	**42 827**	**100%**	**14.3**

TABLE 25.
TREE COUNT BY LAND USE CATEGORY IN THE GGW AREA

Land use 2019	Trees *(Million)*	Area *(Mha)*	Average tree density
Cropland	435	74.28	**5.9**
Forest land	2 635	65.96	**40.0**
Grassland	1 115	264.81	**4.2**
Other land	36	101.98	**0.3**
Settlements	50	5.62	**9.0**
Wetlands	24	7.28	**3.3**
Total	**4 296**	**519.93**	**8.3**

FIGURE 48.
AVERAGE TREE DENSITY BY LAND USE IN THE GGW AREA



The Southern Africa region boasts the highest net canopy cover (24 million ha) as well as the highest average tree cover density (10.5 percent) as opposed to the Sahel, which shows the lowest values (Table 26). The highest total net canopy cover in cropland is recorded in the Sahel (2.1 million ha) but the highest tree cover density is in North Africa (7.8 percent compared to 3.9 percent in Sahel and 4.9 percent in Southern Africa), and this likely due to the larger presence of orchard systems (olive trees and palms in Tunisia and Morocco).

Land degradation assessment in the Great Green Wall regions

FAO defines land degradation as a "*reduction in the condition of the land, which affects its ability to provide ecosystem goods and services and to assure its functions over a period of time*". Land degradation threatens entire ecosystem services and biodiversity, intensifies climate change (as a driver through the emission of greenhouse gases and reduced uptake of carbon) and presents a risk to the health and livelihoods of billions of people. The assessment of the proportion of degraded land over the total area is Indicator 3.1 of Sustainable Development Goal 15, which aims to *"protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss".*

By using the regional boundaries of the GGW, an analysis of the current state of land was conducted at national aggregation level and for the period 2001–2019, by implementing the approach (Sims *et al.*, 2021) and toolbox[11] proposed by the United Nations Convention to Combat Desertification (UNCCD) to estimate the SDG Indicator 15.3.1.

Methodology

Following the indication of the UNCCD's Good Practice Guidance (Sims *et al.*, 2021), the methodology implemented in the Trends.Earth toolbox (Trends.Earth, 2021) was used to calculate land degradation on a country basis in the boundaries of the GGW area of interest. Land degradation was quantified by analysing and then combining three land-based sub-indicators: vegetation productivity (*trajectory* [corrected for the effects of climate], *state* and *performance*); land cover change (the default matrix of land cover transitions corresponding to degradation or improvement); and the change in soil organic carbon (SOC) in the period 2001–2019. A default base data was used, in particular MODIS NDVI for vegetation productivity, and the European Space Agency-Climate Change Initiative's land cover for cover and soil carbon changes.

The output is a raster-based dataset (grid cell of 250 m resolution, Figure 49) which classifies land on a pixel basis according to three categories: degraded, stable, or improved by the target year 2019, in the reference period 2001–2019.

Results

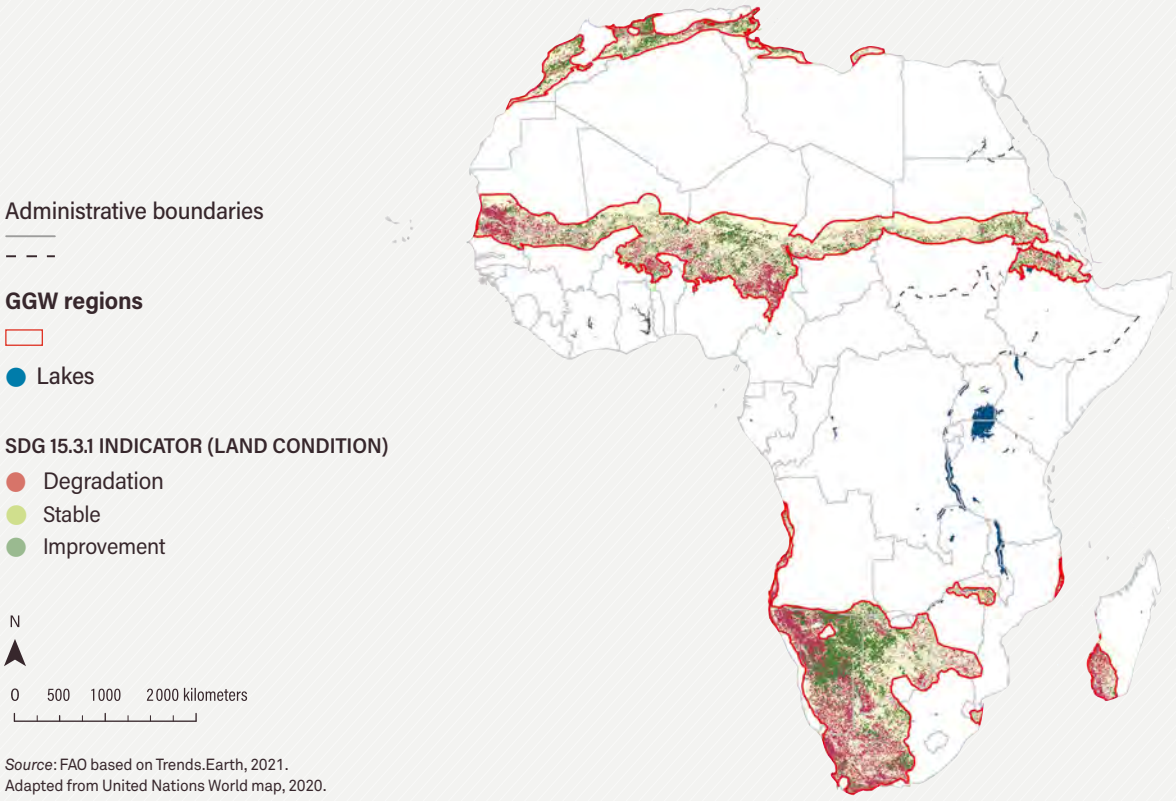
The GGW area hosts nearly 110 million ha of degraded land in 2019 (Table 27), which represents 21 percent of the total land. 60 percent of the total degraded land (66 million ha) is concentrated in the Southern Africa region (29 percent of the regional extent), while 35 percent is in the Sahel and only 5 percent in North Africa. In terms of improved land (nearly equal to the amount of degraded land), Southern Africa is the only region where the net balance inclines toward degradation (13 million ha). If we compare the extent of degraded land with the extent of improved land at regional scale, North Africa and Sahel post a net gain of improved land (9 and 4 million ha), while Southern Africa shows an overall net degradation (13 million ha) (Figure 50).

TABLE 26. TREE COVER DATA (TOTAL LAND, CUMULATED CANOPY COVER, AND AVERAGE CANOPY COVER) IN THE GGW AREA

GGW region	Land area	Land with tree cover	Cumulated canopy cover	Average density
	Mha	*Mha*	*Mha*	
North Africa	50.45	12.93	3.09	6.1%
Sahel	241.42	94.02	9.97	4.1%
Southern Africa	228.06	113.02	23.88	10.5%
Total	**519.93**	**219.97**	**36.94**	**7.1%**

[11] Trends.Earth, tracking land change. QGIS plugin, version 1.0.8. Tool to support monitoring of land degradation for reporting to the United Nations Convention to Combat Desertification, as well as tracking progress towards achievement of SDG 15.3.1.

FIGURE 49. MAP OF SDG 15.3.1 INDICATOR (LAND CONDITION) IN THE GGW AREA



Source: FAO based on Trends.Earth, 2021.
Adapted from United Nations World map, 2020.

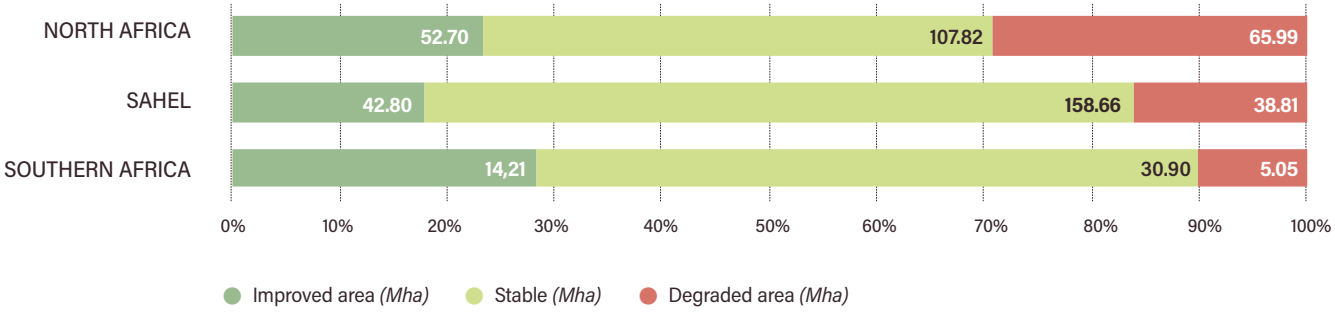
TABLE 27. SUMMARY OF LAND DEGRADATION ANALYSIS 2000–2019 IN THE GGW BY REGION

Source: FAO based on Trends.Earth, 2021.

GGW region	Total GGW area	Degraded land	Share of GGW region	Improved land	Net degradation
	Mha	*Mha*		*Mha*	*Mha*
North Africa	50.19	5.05	10%	14.21	-9.15
Sahel	240.45	38.81	16%	42.80	-3.99
Southern Africa	226.68	65.99	29%	52.70	13.28
Total	**517.33**	**109.85**	**21%**	**109.71**	**0.14**

FIGURE 50. PROPORTION OF LAND CONDITION DATA 2000–2019 BY GGW REGION

Source: FAO based on Trends.Earth, 2021.



The methodology assessing land degradation whereby these statistics are generated includes the contribution of three sub-indicators: vegetation productivity, land cover change and soil carbon change. Most of the contribution in Sahel and Southern Africa is related to the decline in vegetation (more than 90 percent). In the Southern Africa region, vegetation productivity decline represents 98 percent of the total, in Sahel 92 percent, and in North Africa 84 percent (Figure 51).

In North Africa, Algeria shows the highest proportion of total degraded land in the region (50 percent, 2.9 million ha). In the Sahel region, Nigeria and Mauritania are the countries with highest proportion of degraded land (32 percent and 18 percent) compared to the total regional degraded area (12 and 7 million ha, respectively). In the Southern Africa region, Namibia, and South Africa concentrate most of the degradation, nearly 73 percent of the total in the region (respectively 25 and 23 million ha).

FIGURE 51

CONTRIBUTION OF THE THREE SUB-INDICATORS TO OVERALL LAND DEGRADATION IN THE GGW AREA

Source: FAO based on Trends.Earth, 2021.

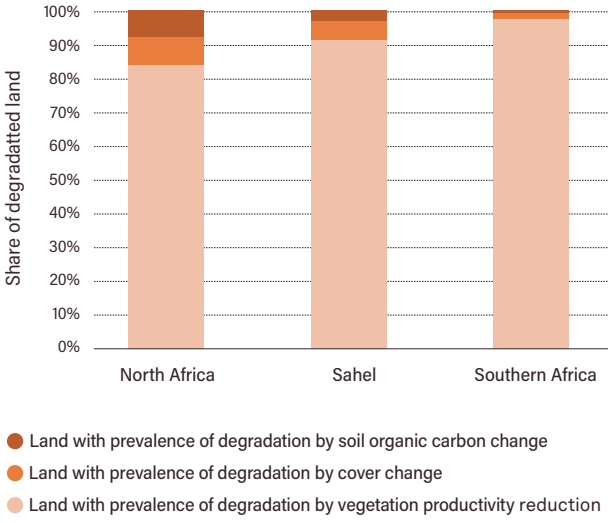


TABLE 28. DEGRADATION (INDICATED IN RED COLOUR) VERSUS IMPROVED LAND IN THE GGW REGIONS AND BY COUNTRY

Source: FAO based on Trends.Earth, 2021.

Region	Country	GGW area *(Mha)*	Degraded *(Mha)*	Improved *(Mha)*	Difference *(Mha)*
NORTH AFRICA	Morocco	20.85	1.77	5.84	-3.58
	Algeria	16.83	2.58	0.87	-3.26
	Libya	6.34	0.37	5.35	-0.50
	Tunisia	5.97	0.34	2.15	-1.81
SAHEL	Senegal	6.99	3.32	0.87	2.45
	Mauritania	23.72	6.90	2.76	4.13
	Mali	36.26	2.95	7.08	-4.13
	Burkina Faso	12.70	3.75	1.95	1.81
	Niger	46.40	3.46	10.23	-6.77
	Nigeria	38.64	12.25	7.60	4.65
	Chad	26.37	2.02	3.61	-1.59
	Sudan	31.72	0.94	5.63	-4.68
	Ethiopia	12.76	2.43	2.39	0.05
	Eritrea	3.83	0.56	0.65	-0.09
	Djibouti	1.06	0.22	0.03	0.19
SOUTHERN AFRICA	Angola	9.61	2.57	2.38	0.19
	Botswana	50.78	6.75	13.51	-6.76
	Eswatini	0.25	0.04	0.03	0.01
	Madagascar	10.94	5.10	0.57	4.53
	Mozambique	6.73	1.53	0.71	0.82
	Namibia	71.33	25.26	25.45	-0.19
	South Africa	65.20	22.76	9.12	13.64
	Zambia	0.52	0.06	0.06	0.00
	Zimbabwe	11.31	1.91	0.87	1.04

If we consider the national level of aggregation for balancing degraded versus improved land (Table 28), Nigeria, Mauritania and Senegal show a prevalence of degradation in the Sahel region (11 million ha net loss) while Sudan shows a net gain of improved land of 5 million ha. South Africa and Madagascar show the largest net increase in degraded land in the region (18 million ha). Namibia has the largest degraded portion (25 million ha) concentrated in the north-west part of the country (Figure 48), but also the largest improved area (25 million ha), which compensates for the loss of productivity in an overall balance. Botswana shows the highest net gain in improved land in the region. North Africa shows general improvement: Algeria, Morocco and Tunisia show an overall net gain of 9 million ha in improved land.

The knowledge of where degradation is and of the drivers leading to it are essential to learning lessons, promoting adaptive management, and supporting programmes reversing the loss of land productivity, for example through restoration, which is discussed below.

Carbon stocks in the Great Green Wall regions

The estimate of terrestrial carbon stocks in the GGW area, as a baseline for evaluating the impact of future restoration efforts, is based on available consolidated and spatially explicit datasets depicting the status of vegetation carbon (above-ground biomass, AGB and below ground biomass, BGB) and SOC (1 m depth).[12] These data provide a picture at one point in time (2010) of how carbon stocks vary across the GGW regions. Biomass carbon stocks in the GGW regions are higher in Southern Africa, while the carbon stock density (tonnes of carbon per hectare) is higher in North Africa (Table 29). The highest value of soil carbon stock is found in the Sahel region, closely followed by the Southern Africa region, but the soil carbon density is higher in North Africa.

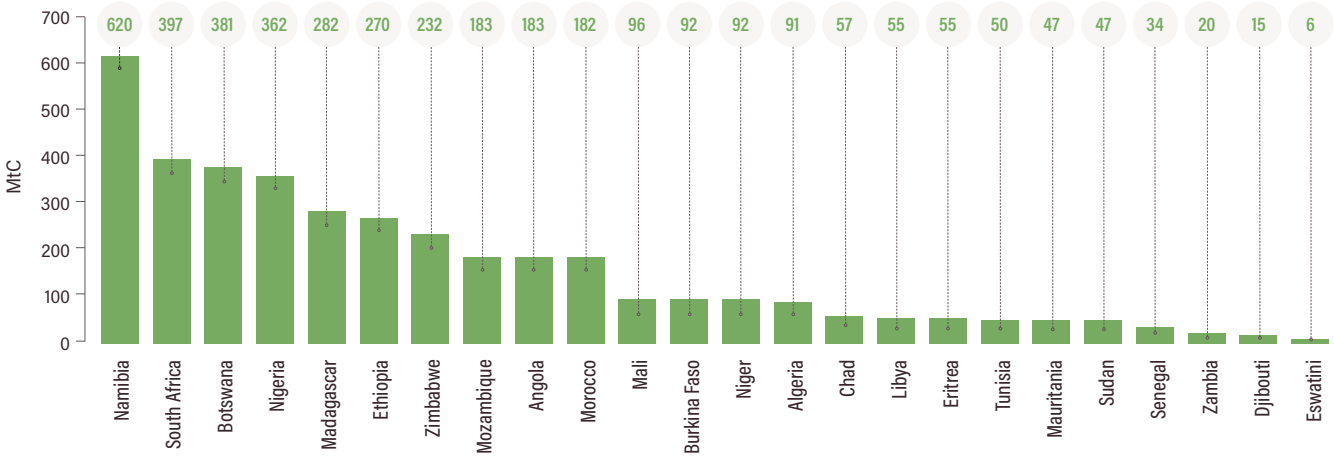
TABLE 29. BIOMASS CARBON AND SOIL CARBON STOCKS FOR THE YEAR 2010, BY GGW REGION

Source: FAO based on Soto-Navarro *et al.*, 2020.

GGW region	AGB-BGB carbon stocks	AGB-BGB carbon density	Soil (1 m depth) carbon stock	Soil (1 m depth) carbon density
	GtC[13]	*tC/ha*	*GtC*	*tC/ha*
North Africa	0.377	10.9	2 307	66.8
Sahel	1.166	6.3	9 865	53.2
Southern Africa	2.305	10.2	9 592	42.4
Total	**3.849**		**21 764**	

FIGURE 52. AGB-BGB CARBON STOCKS IN THE GGW AREA BY COUNTRY, REFERENCE YEAR 2010

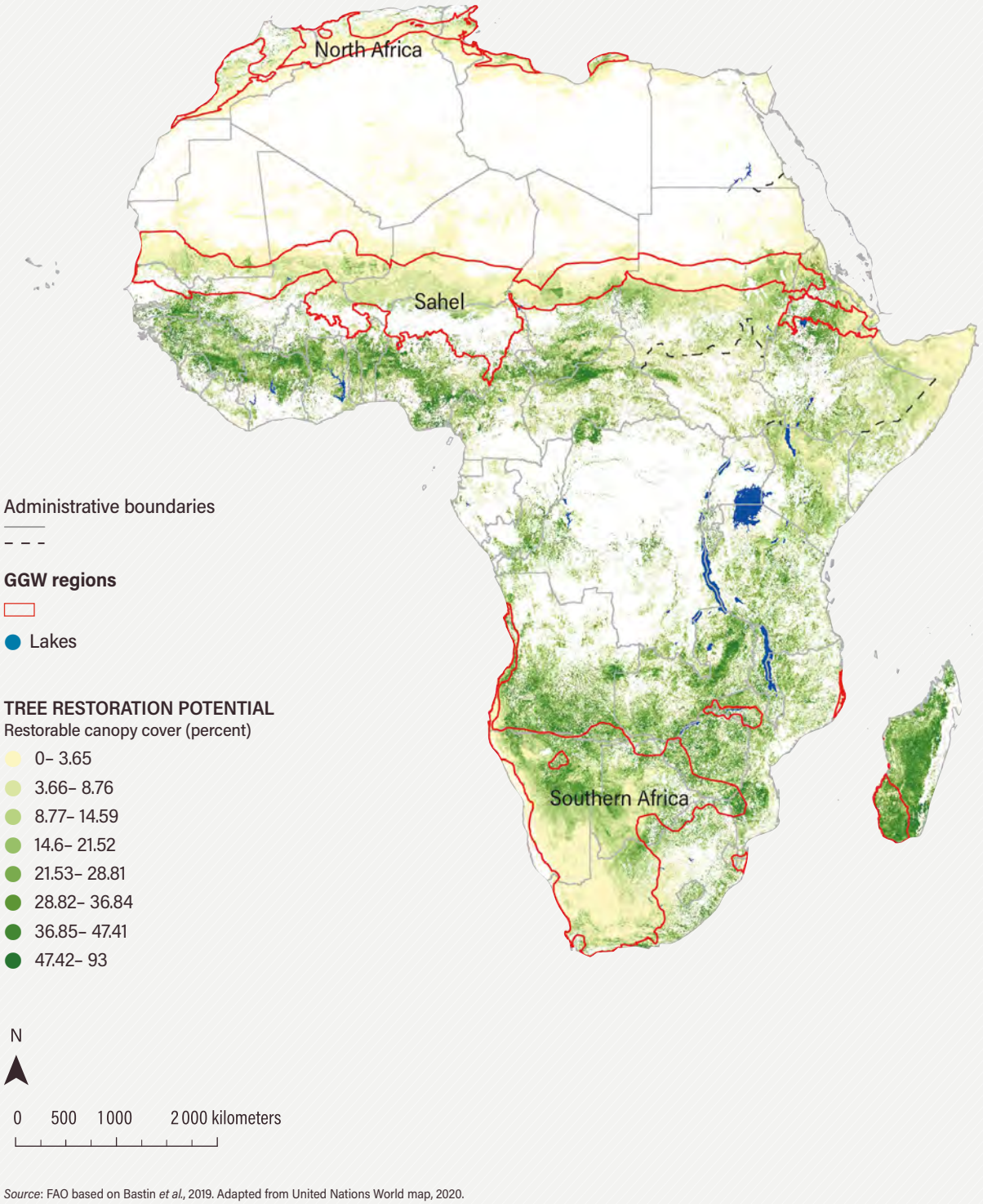
Source: FAO based on Soto-Navarro *et al.*, 2020.



[12] Harmonized global map of above- and belowground terrestrial carbon storage (tonnes (t) of C per hectare (ha)) in biomass and soil for the reference year 2010 (Soto-Navarro *et al.*, 2020).

[13] GtC (gigatonnes of carbon). 1 GtC is equal to 109 tonnes of carbon or 1012 kg. 3.7 Gt carbon dioxide will give 1 GtCO2.

FIGURE 53. MAP OF TREE RESTORATION POTENTIAL IN AFRICA



Source: FAO based on Bastin *et al.*, 2019. Adapted from United Nations World map, 2020.

In the GGW area of interest, Namibia, South Africa, and Botswana occupy the first three places in AGB-BGB Carbon stock values (1.4 GtCO2 together, 36 percent of the total carbon stock in the GGW); Nigeria has the highest value of the Sahel countries (0.36 GtCO2) and Morocco has the highest value of North Africa countries (0.18 GtCO2) (Figure 52).

Tree restoration potential in the Great Green Wall regions

Land restoration is a way of reversing degradation processes and increasing the contributions of ecosystems and landscapes to livelihoods, land productivity, environmental services, and the resilience of human and natural systems. The concept of "restoration" involves a wide range of conservation, sustainable management and active restoration practices that increase the quality and diversity of land resources, enhancing ecological integrity and human well-being.

In July 2019 the Crowther Lab[14] and FAO[15] published a report on the global tree restoration potential (Bastin *et al.*, 2019), which provided the first quantitative assessment of the Earth's current and future carrying capacity to host trees: this section presents the findings of the analysis of tree restoration potential in the GGW area based on data released with the publication, and aims to estimate the distribution and extent of restoration potential in support of planning activities in the regions such as tree planting, reforestation, establishment of agroforestry systems and assisted natural regeneration through fencing/enclosures (Figure 53).

The analysis estimates the restorable areas based on the difference between the carrying capacity of trees by the land (climatic, edaphic and absence of human disturbances conditions) and the current tree cover. The cumulated canopy cover (CCC)[16] is the sum of all projected canopy areas occupied by the restored trees. Canopy cover means the extent of the canopy for an individual tree, or the cumulative areal extent of the canopy of all trees on a site (the area that could be entirely covered by trees). Its use as parameter is independent by the density of trees restored in a specified area (restorable land in Sahel has a much lower accumulated restorable canopy cover than in Zambia, given the same extent).

In the GGW regions, the potential restorable land (including any land that has the potential to increase its current tree cover) is approximately 393 million ha, which in terms of restorable canopy area is 37 million ha (Table 30, Figure 53 and Figure 54).

FIGURE 54.
SHARE OF NET CANOPY COVER GAIN FROM RESTORATION IN GGW REGIONS

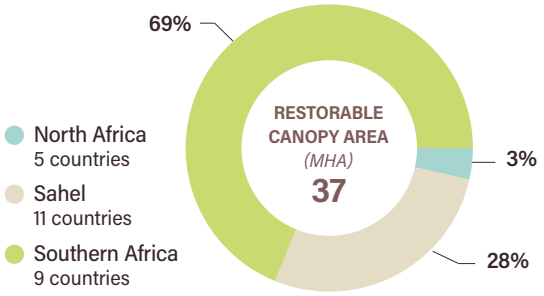


TABLE 30. TREE RESTORATION POTENTIAL AREA AND NET CANOPY COVER GAIN FROM RESTORATION BY GGW REGION

GGW region	GGW Biophysical area *(Mha)*	Restorable land *(Mha)*	Share of GGW area	Restorable canopy area *(Mha)*	Average tree cover increase with restoration
	Mha	*Mha*		*Mha*	
North Africa	50.45	33.26	66%	1.31	3.9%
Sahel	241.42	161.73	67%	10.23	6.3%
Southern Africa	228.06	198.48	87%	25.50	12.8%
Total	**519.93**	**393.47**	**76%**	**37.05**	**9.4%**

[14] crowtherlab.com
[15] www.fao.org/home/en
[16] The cumulated or continuous canopy cover is the sum of tree crown area vertically projected to the ground (e.g. 1 percent of tree cover over 1 ha corresponding to a canopy cover of 0.01 ha, and 100 percent to 1 ha).

By using an average multiplication factor of 400 mature trees per ha of restored canopy cover, the estimate of the potential additional trees that could be restored is close to 15 billion.

The availability of data on restorable land in the GGW regions has allowed for the implementation of an algorithm[17] to estimate the change in carbon stocks due to restoration by calculating the sequestration of carbon in biomass (above and below ground, vegetation only) from which it is subtracted the soil carbon removal determined by the restoration (Grace *et al.*, 2006).[18]

At maturity of planted trees, the additional total potential net gain of carbon in the restorable GGW area (approximately 393 million ha) ranges between 1.05 and 3.45 GtCO2. The highest potential net gain of carbon occurs in the Southern Africa region (range between 0.8 and 2.4 GtCO2), while the lowest net gain occurs in the Northern Africa region (0.03-0.11 GtCO2) (Table 31 and Figure 55).

Tree cover restoration potential in the GGW North Africa region

The largest GGW area is located in Morocco which is also where the largest cropland and grassland areas in the region are located. is the largest cropland and grassland areas in the region. Morocco is the country with the highest estimated presence of trees. Tunisia has the highest tree density in the region with 14.2 trees per hectare (Figure 56 and Table 32) mainly due to the large presence of orchard systems in cropland.

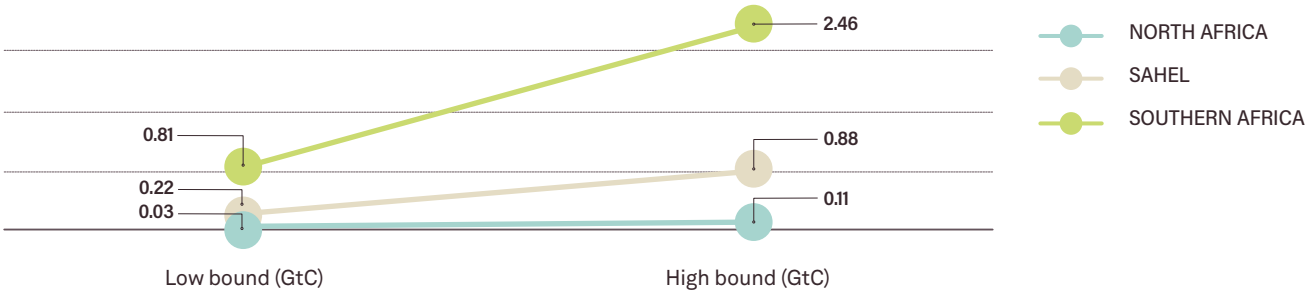
Tree cover restoration potential in the GGW Sahel region

The largest GGW area is in Niger where also is the largest grassland portion and the most restorable land in the region (41 million ha), 25 percent of the total restorable land in the region (Figure 57 and Table 33).

TABLE 31. POTENTIAL CARBON GAIN AND LOSS FROM RESTORATION BY GGW REGION

GGW region	Total gross carbon sequestration		SOC loss
	Low bound (GtCO2)	*High bound (GtCO2)*	*GtCO2*
North Africa	0.07	0.15	-0.04
Sahel	0.54	1.21	-0.32
Southern Africa	1.35	3.00	-0.55
Total	**1.96**	**4.36**	**-0.91**

FIGURE 55. RANGES OF NET CARBON GAIN FROM RESTORATION BY GGW REGION



[18] According to Grace *et al.*, 2006, the average carbon density associated to live biomass from vegetation only is 27.94 (above ground) + 25.06 (below ground) tonnes of C per hectare of canopy cover, which means that an increase of 1 percent net tree canopy cover leads to an increase of carbon of (1/100)* (53.00). A range of lower and higher limits is considered: Lower limit: 100 percent tree cover net gain is equivalent to 27.94 t (ACD) + 25.06 t (BCS) of carbon. Higher limit: 45 percent tree cover net gain is equivalent to 27.94 t (ACD) + 25.06 t (BCS) of carbon. Through the quantification of the potential restorable cumulated canopy cover in an area, the equivalent carbon gain (from vegetation) or loss (from soil) was estimated.

[17] The Google Earth Engine script, developed by Jean-François Bastin, Associate Professor, Gembloux Agro Bio-Tech, University of Liège.

FIGURE 56. TREE COVER RESTORATION POTENTIAL IN NORTH AFRICA REGION OF THE GGW AREA

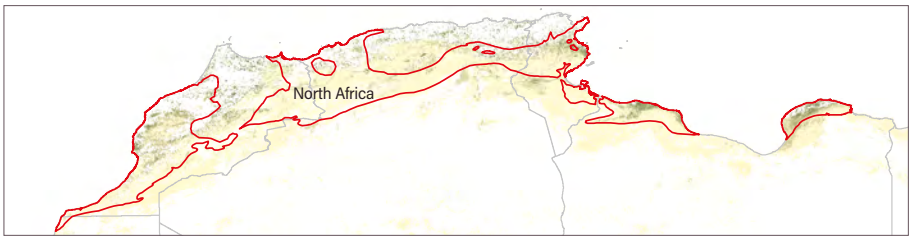
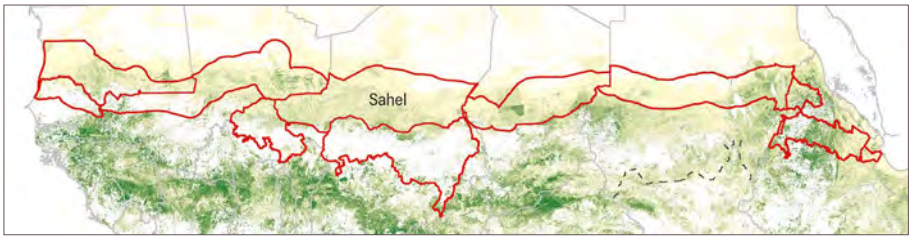


FIGURE 57. TREE COVER RESTORATION POTENTIAL IN SAHEL REGION OF THE GGW AREA



Administrative boundaries

GGW regions

Lakes

TREE RESTORATION POTENTIAL

Restorable canopy cover (percent)

- 0– 3.65
- 3.66– 8.76
- 8.77– 14.59
- 14.6– 21.52
- 21.53– 28.81
- 28.82– 36.84
- 36.85– 47.41
- 47.42– 93

N

0 245 490 980 kilometers

Source: FAO based on Bastin *et al.*, 2019.
Adapted from United Nations World map, 2020.

TABLE 32. GGW NORTH AFRICA REGION SUMMARY BY COUNTRY: LAND USE, TREE COUNT/DENSITY, RESTORATION POTENTIAL

Country	Total land	Forest land	Cropland	Grassland	Settlements	Wetlands	Other land	Tree count	Tree density	Restoration potential
	Mha	*Mha*	*Mha*	*Mha*	*Mha*	*Mha*	*Mha*	*Million*	*Trees/ha*	*Mha*
Algeria	16.89	0.69	3.03	5.76	0.29	0.36	6.76	46.1	2.7	11.48
Libya	6.42	0.31	1.39	2.27	0.34	0.10	2.01	33.3	5.2	5.37
Morocco	21.15	2.78	6.83	8.72	0.60	0.12	2.10	198.14	9.4	11.72
Tunisia	5.99	0.29	3.33	1.77	0.24	0.14	0.20	85.3	14.2	4.69
Total	**50.45**	**4.07**	**14.58**	**18.53**	**1.47**	**0.72**	**11.08**	**362.8**		**33.26**

TABLE 33. GGW SAHEL REGION SUMMARY BY COUNTRY: LAND USE, TREE COUNT/DENSITY, RESTORATION POTENTIAL

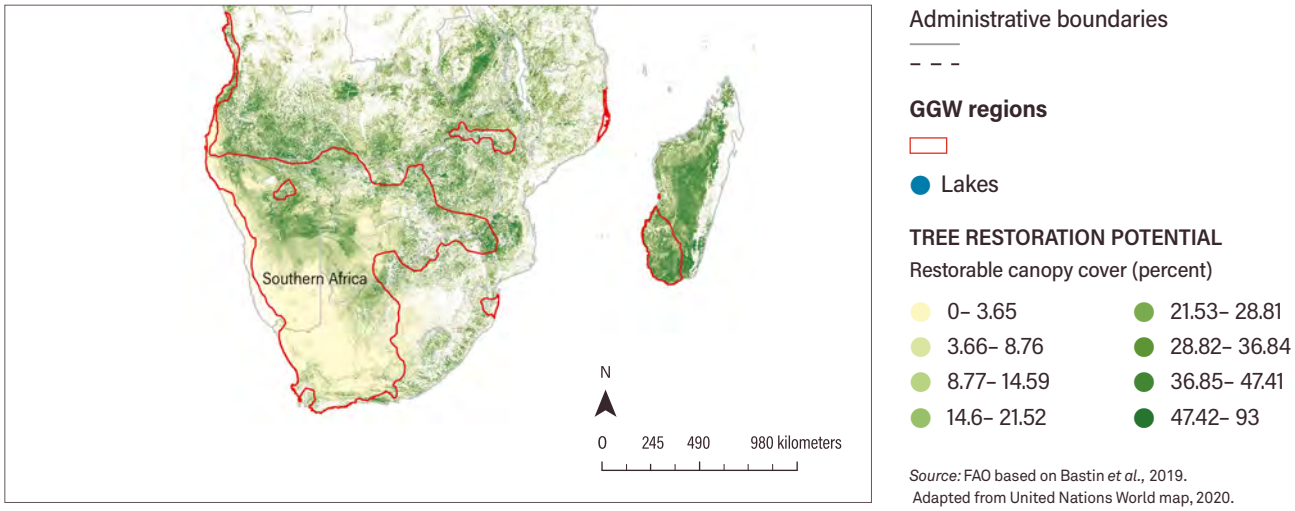
Country	Total land	Forest land	Cropland	Grassland	Settlements	Wetlands	Other land	Tree count	Tree density	Restoration potential
	Mha	*Mha*	*Mha*	*Mha*	*Mha*	*Mha*	*Mha*	*Million*	*Trees /ha*	*Mha*
Burkina Faso	12.73	2.11	5.40	5.03	0.11	0.05	0.02	109.5	8.6	4.85
Chad	26.50	0.70	0.54	15.63	0.12	0.31	9.20	40.3	1.5	22.16
Djibouti	1.08	0.02	0.00	0.68	0.01	0.03	0.34	3.2	3.0	1.06
Eritrea	3.84	0.31	0.65	2.53	0.01	0.05	0.29	23.1	6.0	2.96
Ethiopia	12.82	1.32	3.46	4.61	0.22	0.32	2.89	99.2	7.7	9.57
Mali	36.42	2.63	3.22	17.98	0.11	0.42	12.06	229.6	6.3	24.68
Mauritania	23.83	0.91	0.52	14.53	0.15	0.21	7.51	103.2	4.3	19.1
Niger	46.44	1.15	11.28	23.14	0.29	0.19	10.38	152.3	3.3	41.23
Nigeria	38.88	3.35	22.49	11.36	0.76	0.66	0.25	297.5	7.7	8.52
Senegal	7.03	2.62	1.05	2.97	0.11	0.23	0.06	105.9	15.1	2.13
Sudan	31.83	0.56	3.54	10.97	0.28	0.12	16.37	78.8	2.5	25.47
Total	**241.42**	**15.69**	**52.17**	**109.43**	**2.17**	**2.59**	**59.37**	**1 242.5**		**161.73**

Nigeria shows the largest cropland portion and the largest total number of trees (300 million, 24 percent of total trees in the region). Although the total restorable land is prevalent in Nigeria, Sudan, Nigeria and Chad (all together cover 70 percent of the restorable land in the region), Ethiopia, Eritrea and Nigeria share the highest average potential tree cover increase from restoration (15 percent). Senegal has the highest tree density in the region with 15.1 trees per hectare.

Tree cover restoration potential in the GGW Southern Africa region

The largest GGW area is in South Africa where also is the largest grassland and cropland portions, but Namibia has the largest restoration potential in the region (67 million ha) 34 percent of the total restorable land in the region (Figure 58 and Table 34). Botswana has the largest portion of forest and consequently the highest number of trees (37 percent of total trees in the region).

FIGURE 58. TREE COVER RESTORATION POTENTIAL IN SOUTHERN AFRICA REGION OF THE GGW AREA

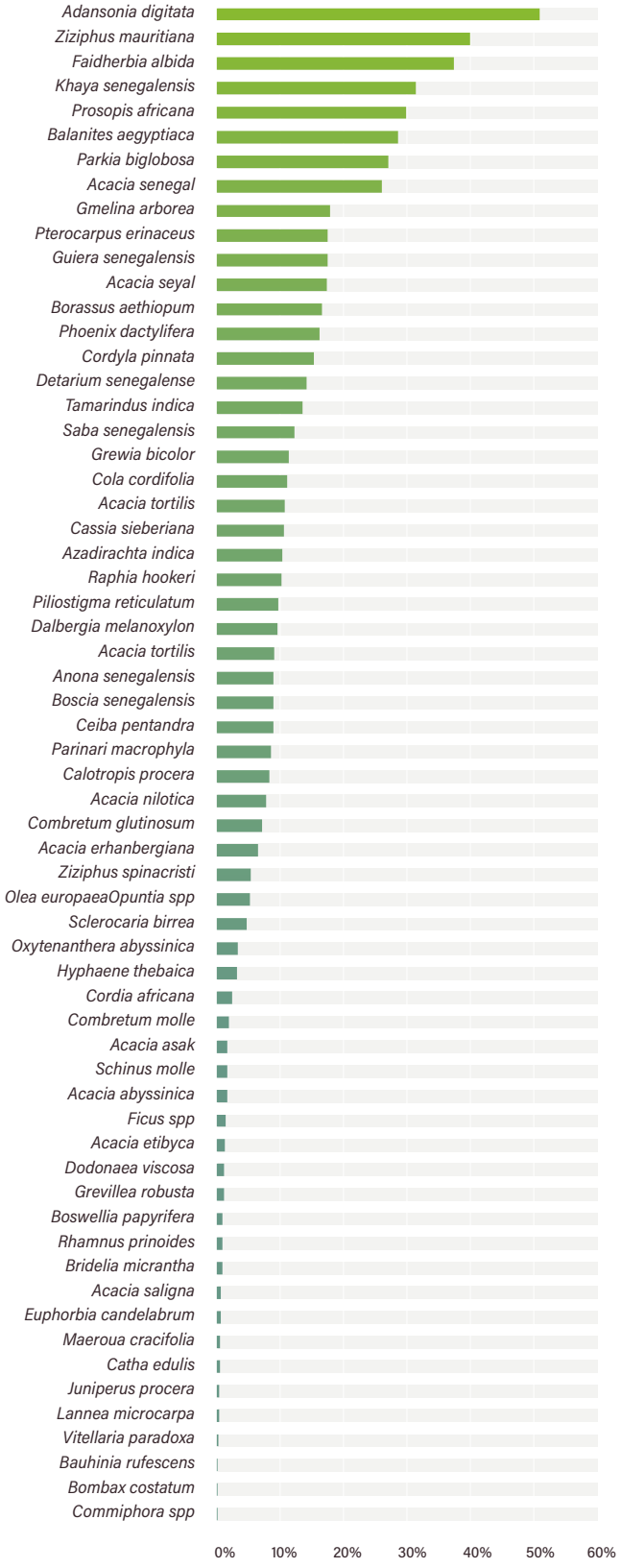


Source: FAO based on Bastin *et al.*, 2019.
Adapted from United Nations World map, 2020.

TABLE 34. GGW SOUTHERN AFRICA REGION SUMMARY BY COUNTRY: LAND USE, TREE COUNT/DENSITY, RESTORATION POTENTIAL

Country	Total land	Forest land	Cropland	Grassland	Settlements	Wetlands	Other land	Tree count	Tree density	Restoration potential
	Mha	*Mha*	*Mha*	*Mha*	*Mha*	*Mha*	*Mha*	*million*	*trees/ha*	*Mha*
Angola	9.67	5.25	0.18	2.66	0.18	0.02	1.39	209.2	21.63	7.80
Botswana	50.82	18.35	0.57	29.58	0.36	0.90	1.06	1 003.3	19.74	41.86
Eswatini	0.27	0.13	0.08	0.05	0.01	0.00	0.00	6.3	23.56	0.17
Madagascar	11.21	2.99	1.27	6.64	0.03					
Mozambique	7.31	4.54	0.51	1.85	0.06	0.11	0.16	153.7	13.71	10.54
Namibia	71.75	7.34	0.71	38.18	0.78	0.32	0.05	235.3	32.17	4.66
South Africa	65.16	1.35	2.97	54.01	0.52	0.86	23.87	399.0	5.56	67.22
Zambia	0.52	0.40	0.02	0.09	0.00	1.67	4.63	381.2	5.85	57.32
Zimbabwe	11.35	5.85	1.22	3.79	0.03	0.08	0.38	282.6	24.90	8.50
Total	**228.06**	**46.20**	**7.53**	**136.85**	**1.97**	**3.97**	**31.54**	**2 690.4**		**198.48**

FIGURE 59. LIST OF NATIVE SPECIES: PREFERRED RATING



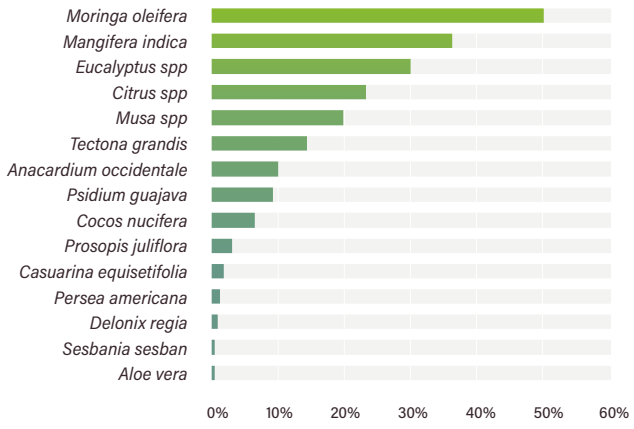
Although restorable land is prevalent in Botswana, Namibia and South Africa (which together represent 84 percent of the restorable land in the region), Mozambique and Madagascar register the highest average potential tree cover increase from restoration (29 percent). Zambia and Mozambique have the highest tree density in the region with 38.4 and 32.2 trees per hectare, respectively.

Beyond counting trees

Africa Open DEAL has revealed the global numbers of trees in and outside forest lands. Trees have vast economic, social and environmental significance and provide many benefits. Beyond counting trees and estimating tree cover, the survey's findings resonate beyond forestry sector, informing and providing important inputs into broader natural resource and land use planning and management. Africa Open DEAL thus helps ensure informed decisions on exploitation and the allocation of natural resources and provides opportunities for targeting actions designed to sustainably and equitably restore degraded lands through tree planting, increase biodiversity, and combat climate change.

In recent years, tree-based restoration has attracted particular attention due to the multiple benefits of trees beyond carbon sequestration, such as providing habitats for pollinators, improving soil fertility, and for improving nutrition and livelihoods. For example, in support of the implementation of GGW, FAO's Action Against Desertification has recorded most trees and over 200 species as useful to communities following

FIGURE 60. LIST OF INTRODUCED SPECIES: PREFERRED RATING



consultations and 110 of these native species were planted to initiate degraded land restoration and increase tree diversity (Figure 59). Non-native species were also planted (mostly in home gardens) for other purposes (Figure 60), though in general, species with multiple uses and high market value are usually preferred, mostly utilised for food, feed or human and veterinary health. Plant knowledge and new land preparation technologies complement field work conducted with communities on what and where to plant well-adapted species (Sacande *et al.* 2020).

Recognizing the interdependence between people and the biosphere, and the need for restoration to include not only ecological criteria for success but also consider human benefits is a key challenge for restoration, yet not a new one for conservation. The main message is that local land and natural resource users, and their perceptions, preferences and actions, will ultimately make or break restoration interventions. Restoration actions must thus consider the broader context in which they take place. What we plant and when hence becomes a key determinant not only of restoration interventions, but future nutrition outcomes, alongside being one of the most effective strategies for adaptation and climate change mitigation. Coordinating multiple land uses across large scales in particular is inherently complex, not least as it requires collaboration between different levels of government, communities and other local stakeholders across different agroecological zones and towards "shared landscapes" (Wilson and Cagalanan, 2016). The key challenge for the UN Decade for Ecosystem Restoration (2021–2030) will be to carefully manage the balance between multiple needs and benefits, with an eye on a vision of future landscapes that cannot not only restore biodiversity and contribute to combatting climate change, but also nourish and sustain communities (Sacande and Muir, 2022).

Economic costs and benefits of land restoration in the GGW Sahel region

It is important to assess the economic costs and benefits of restoration interventions in the ecosystems of a region like the Sahel, which is heavily affected by a land degradation that threatens livelihoods, productive agrosilvopastoral systems and food security. FAO's Action Against Desertification recently led a study (Mirzabaev *et al.,* 2022) to evaluate the economic costs and benefits of land restoration activities in support of the GGW. Various scenarios were tested, including the impact of violent conflicts in the region, which are estimated to reduce the accessibility to these degraded ecosystems from 27.9 million to 14.1 million hectares. The results also show that the costs of land restoration are lower than the costs of inaction in all scenarios tested at the regional level, providing a strong economic justification for land restoration interventions. For every US dollar injected into the massive effort across the Sahel region from Senegal in the west to Djibouti in the east, investors can expect an average return of USD 1.2, with outcomes ranging between USD 1.1 and USD 4.4 (Table 35).

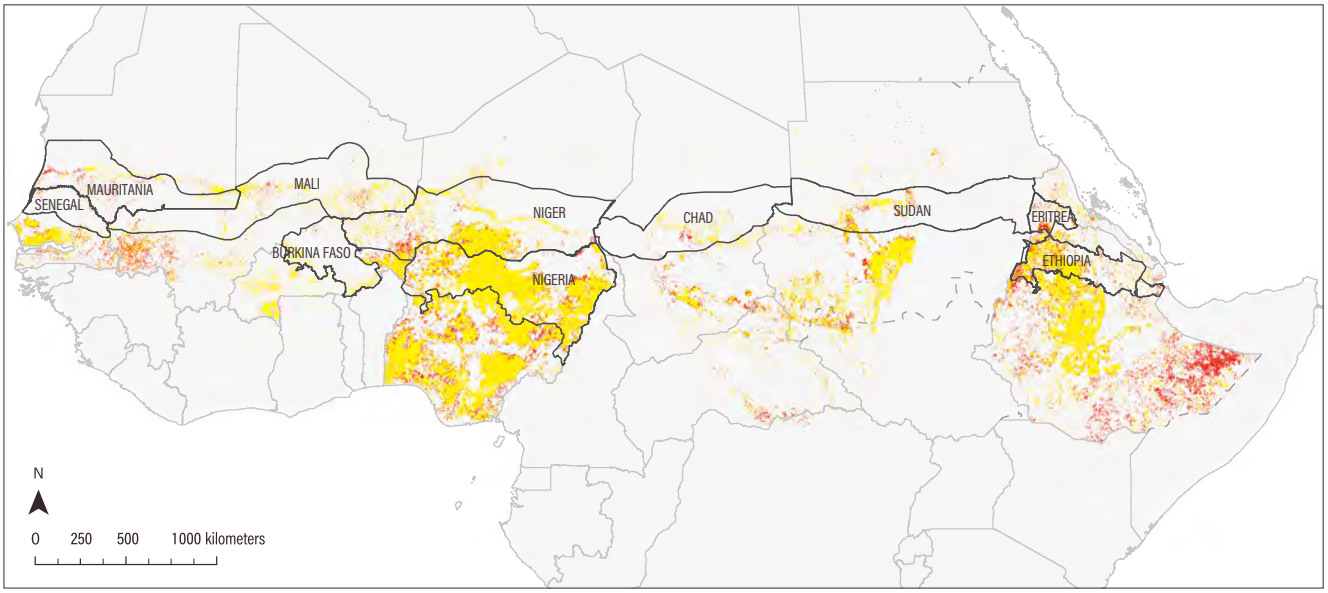
Although conflicts and climate change are big barriers to restoration interventions, GGW provides viable return on investments and makes economic sense. This research will increase the efficiency of targeting future land restoration activities in localities where interventions are both economically attractive and ecologically sustainable (Figure 61).

TABLE 35. COST/BENEFIT ANALYSIS OF LAND RESTORATION IN THE SAHEL

Source: Mirzabaev *et al.,* 2022.

Country	Benefit from land restoration *(million USD)*		Cost of land restoration *(million USD)*		Return from each US dollar invested in land restoration *(USD)*
	base scenario[19]	*min/max across all scenarios*	*base scenario*	*min/max across all scenarios*	
Burkina Faso	254	(250–2 416)	535	(357–647)	0.5 (0.5–4.2)
Chad	1 207	(1 104–6 854)	1,317	(901–1 619)	0.9 (0.6–4.8)
Djibouti	276	(42–904)	146	(68–209)	1.9 (0.6–5.6)
Eritrea	549	(141–1 756)	340	(190–490)	1.6 (0.7–4.8)
Ethiopia	39 335	(8 040–87 961)	23,536	(6 626-37 674)	1.7 (0.9–3.5)
Mali	1 384	(1 292 –9 054)	1,589	(963–2,100)	0.9 (0.7–4.3)
Mauritania	712	(148–3 075)	710	(342–965)	1.0 (0.4–3.9)
Niger	1148	(533–6 452)	1,110	(851–1 387)	1.0 (0.6–5.0)
Nigeria	26 514	(18 087 –70 661)	11 194	(5 742–20 212)	2.4 (1.4–5.5)
Sudan	2 348	(2 163 –12 706)	2 902	(1 818–3,627)	0.8 (0.7–4.4)
Senegal	587	(539–4 248)	767	(438–1 117)	0.8 (0.6–3.8)
The Sahel	**74 314**	**(35 326–205 425)**	**44 146**	**(18 292 –69 658)**	**1.2 (1.1-4.4)**

FIGURE 61. MAP OF COST/BENEFIT ANALYSIS OF LAND RESTORATION IN THE SAHEL (ANNUAL USD/HA IN 2001–2018)



Administrative boundaries

GGW region (Sahel)

Lakes

2001-2018 COST/BENEFIT (USD/ha/y)

- Costs higher than benefits (-80,000 - 0)
- Benefits higher than costs (0 - 80,000)

Source: FAO based on Mirzabaev *et al.*, 2022. Adapted from United Nations World map, 2020.

[19] Scenario for the analysis which includes a planning horizon equal to the years required to have the ecosystem fully restored.

CLIMATE ANALYSIS AT CONTINENTAL SCALE

Climate analysis facilitates better understanding of the past and present climate, and helps to predict and plan future responses to changes in natural factors and human coping efforts for adaptation. This section presents major changes in Africa's climate in the past 40 years (between 1979 and 2020), taking into account parameters such as temperature and precipitation and their impact on biomass and vegetation production.

Using maps and statistics generated with the Earth Map tool,[20] the assessments of climatic changes cover the whole African continent, with a specific focus on the three GGW regions and the Congo Basin. The changes are investigated looking at annual and monthly mean temperature and precipitation values. The frequencies of extreme events are described using heat stress days (HSD) with temperatures > 32°C and extreme rain days (ERD) with precipitation records >50mm (Salack *et al.*, 2018). The analyses consider the implications of changes in these parameters on biomass driven by photosynthesis or net primary production (NPP).

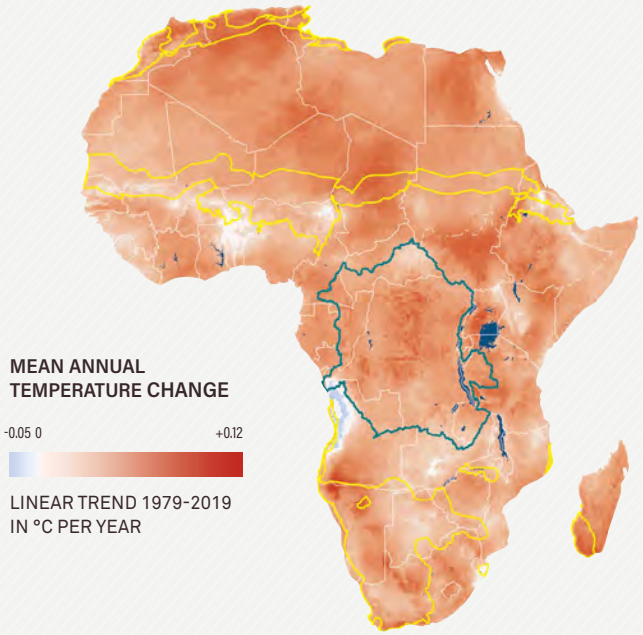
Climate changes in Africa in the last 40 years

Changes in annual temperatures Africa's mean annual temperature has experienced a significant increase (1.2 °C) between 1979 and 2019 (Figure 62, 63). In fact, the latest IPCC Sixth Assessment Report (AR6, 2022) for Africa acknowledges that the rate of surface temperature increase has generally been more rapid in Africa than the global average.[21] The most vulnerable to and directly affected by these climatic changes are African natural capital and livelihoods such as farming, fishing, forestry, herding of livestock and biodiversity. Subsequently, Africa's agricultural croplands have expanded in the last 20 years, with 81 percent of its 12 percent territory assessed as temporary croplands, reaching 356 million ha of cultivated lands (see *Trees in Africa* section at page 16). AR6 suggest that drought mortality together with forest clearing have been drivers for localized loss of tree cover in the Miombo woodlands and forest loss in the Congo Basin. Increased temperature negatively affects crop production and is expected to expose human and livestock population to water stress, especially in the driest areas.[22] This highlights how rural population livelihoods are especially vulnerable in Africa; in particular, the highly vulnerable populations in the Sahel region with its extreme conditions, which are seen as 'ground zero' for climate change.

Changes in annual precipitation - Most studies suggest that it is difficult to draw conclusions about trends in annual precipitation over the past century (Funk *et al.*, 2015) due the lack of sufficient observational data in most areas of the African continent and discrepancies between different observed precipitation data sets.[23] However, in the last 40 years,[24] diminished rainfall patterns have been noted in the Congo Basin and in some areas in the SADC GGW region, while positive trends appear throughout the whole Sahel region, especially in the rainy seasons (Figures 64, 65). Considering extreme rain days (ERD) with precipitation of > 50 mm, a positive trend appears for both the Sahel and the Congo Basin for the past 20 years. Changes in rainfall patterns affect both the Sahel and Congo Basin regions. In the Congo Basin ERD are occurring more often throughout the year, but in the Sahel ERD appear mainly in the wet season.

[20] openforis.org/tools/collect-earth
[21] www.ipcc.ch/report/ar6/wg1/downloads/factsheets/IPCC_AR6_WGI_Regional_Fact_Sheet_Africa.pdf
[22] www.ipcc.ch/site/assets/uploads/sites/2/2019/06/SR15_Chapter3_Low_Res.pdf
[23] www.ipcc.ch/report/ar5/wg2/africa
[24] The source of this dataset is the CHIRPS (Climate Hazards Group InfraRed Precipitation with Station) quasi-global rainfall dataset. We selected the CHIRPS database for our analysis due to its spatial resolution (5*5km) in comparison to ECMWF (28*28km).

FIGURE 62. MAP OF AFRICA'S MEAN ANNUAL TEMPERATURE CHANGE



Source: Copernicus Climate Change Service (C3S), 2017.
Adapted from United Nations World map, 2020.

FIGURE 63. GRAPH OF MEAN ANNUAL TEMPERATURE CHANGE IN THE GGW (DRYLAND) REGIONS AND THE CONGO BASIN (HUMID AREAS)

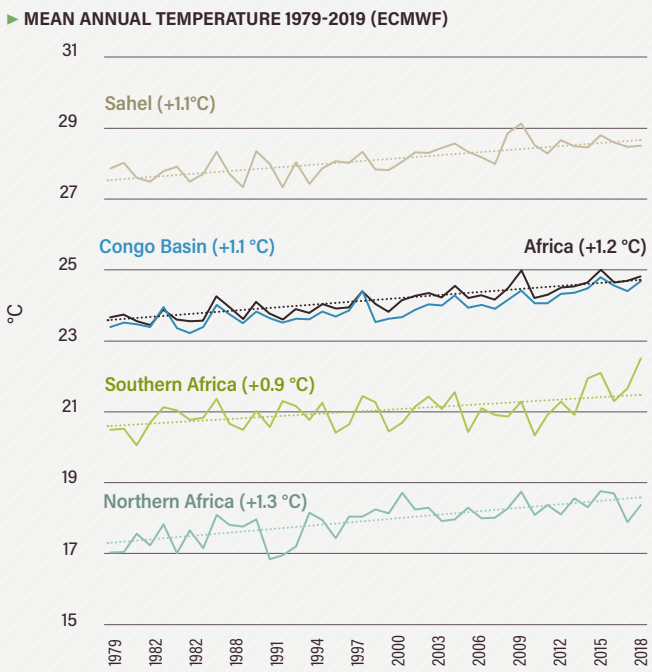
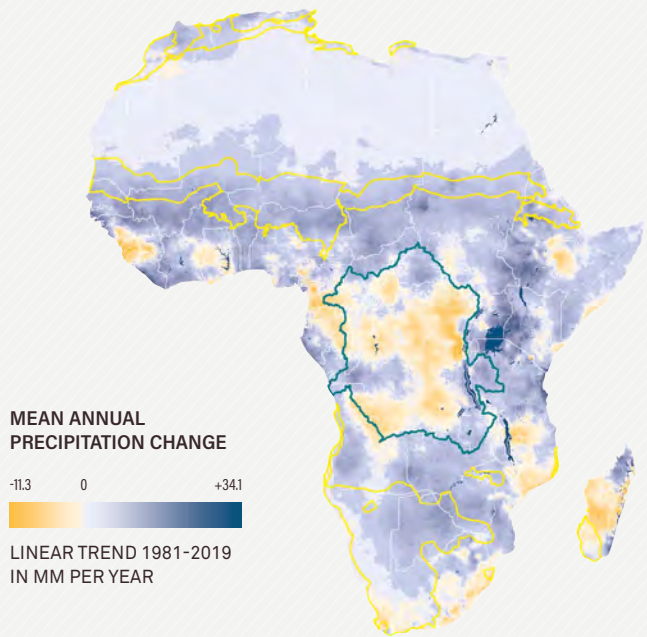
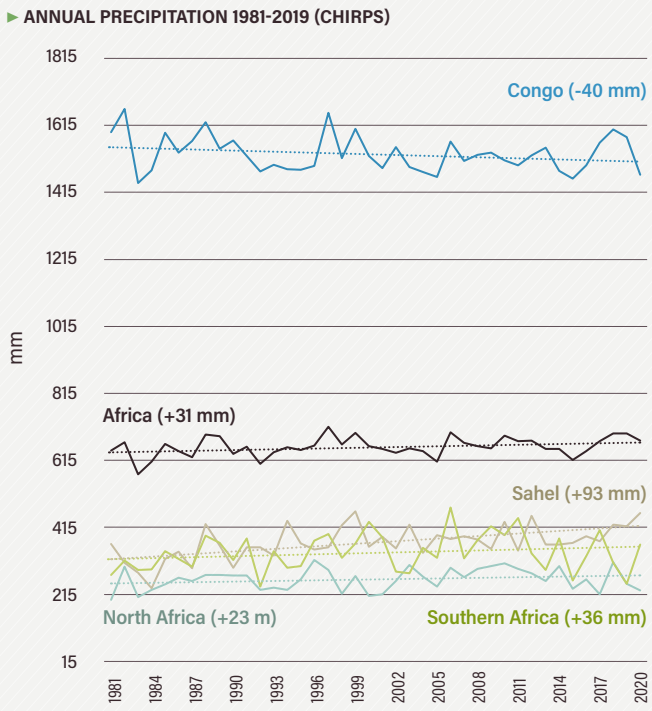


FIGURE 64. MAP OF AFRICA'S TOTAL ANNUAL PRECIPITATION CHANGE



Source: Funk, C. *et al.*, 2015.
Adapted from United Nations World map, 2020.

FIGURE 65. GRAPH OF VARIATIONS IN PRECIPITATION IN THE THREE GGW (DRYLAND) REGIONS AND CONGO BASIN (WETLANDS)



Administrative boundaries

GGW regions
Congo basin

Lakes

Africa
North Africa
Southern Africa
Congo Basin
Sahel

The frequency and intensity of heavy precipitation events are projected to increase almost everywhere in Africa with additional global warming.[25] The monsoon[26] season is also projected to have a delayed onset and a delayed retreat,[27] with prominent consequences for the livelihoods (mainly livestock and agriculture) of the local population.

Drylands in Africa's North, Sahel and Southern Africa regions are more adversely affected by reduced rainfall or extreme precipitation events than wetter areas, such as the Congo Basin.[28] Land restoration and rehabilitation represent an important mitigation action to increase vegetation and land cover and surface drainage. Studies have projected that a successful GGW restoration of 100 million hectares of restored lands in the Sahel would have a profound positive effect on the climate of the whole region including northern Africa. These changes could as much as double rainfall within the Sahel or decrease average summer temperatures throughout much of Northern Africa and into the Mediterranean.[29]

Impacts of climatic changes on vegetation in Africa

There are direct linkages – cause-and-effect relationships – between climatic changes and the natural capital, specifically the vegetation production (NPP), driven by photosynthesis and vegetation intensity, measured by the NDVI. Statistics show declining NPP in a big extent of areas in the African continent in the last 10 years, coinciding with decreased precipitation patterns and increased HSD (FAO, 2020). Differences observed between regions highlight a strong decline in NPP in the Congo Basin, in western Sahel (but stable in the rest of the region) and in the Southern Africa GGW region (Figures 66, 67).

Considering that the Congo Basin is amongst the largest and highest-density irrecoverable carbon reserves (ca. 8.2 GtCO2 eq.), important conservation efforts should be rolled out and implemented to preserve this area of critical importance that we cannot afford to lose.[30] On the other hand, restoration efforts should urgently be carried out particularly through the GGW in order to regreen and rehabilitate the Sahel region.

Multi-parameter analysis of climate, vegetation and land use change

The following multi-parameter analysis will assist the reader in better understanding the interaction of climate-related hazards (including extreme weather or climate events) and changes in aridity with vegetation parameters and land cover dynamics to emphasize the potentially adverse consequences for humans and socio-ecological systems (Table 36).

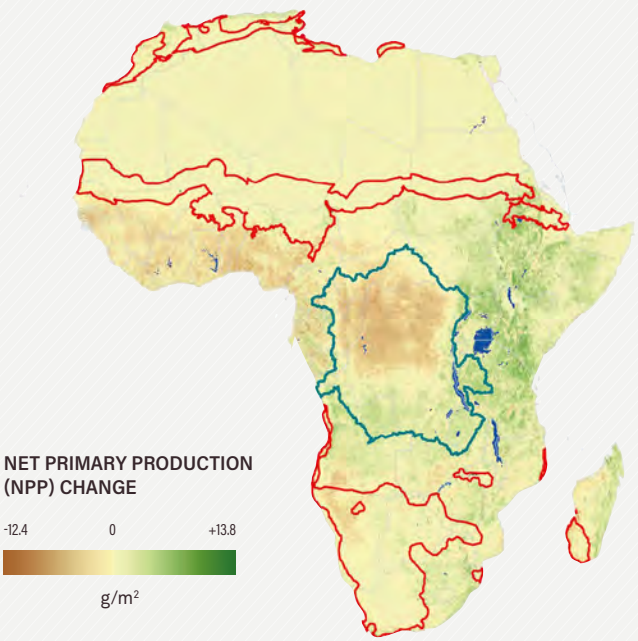
Even if in general terms climate and vegetation changes in the Sahel are on a smaller scale in comparison to the Southern/North Africa GGW region or the Congo Basin, every climatic change will profoundly affect the region due to its extreme climate baseline conditions. The Sahel GGW is covered by around 50 percent of hyperarid drylands and extreme temperatures are part of the daily lives of its population. HSD > 32°C only increased by one day on average in the Sahel region, HSD > 40 °C increased by 12 days on average. This demonstrates its extreme baseline condition. In terms of relative changes in land use the Sahel has lost more forest land (2.61 percent) and grassland (1.01 percent) than the other regions, while expanding its croplands substantially (2.15 percent).

[25] www.ipcc.ch/report/ar6/wg1/downloads/factsheets/IPCC_AR6_WGI_Regional_Fact_Sheet_Africa.pdf
[26] Africa's precipitation patterns are driven by the West African Monsoon (WAfriM) Monsoon.
[27] www.ipcc.ch/site/assets/uploads/2018/02/WGIIAR5-Chap22_FINAL.pdf
[28] www.ipcc.ch/site/assets/uploads/2018/02/WGIIAR5-Chap22_FINAL.pdf
[29] www.sciencenews.org/article/africa-great-green-wall-trees-sahel-climate-change
[30] www.nature.com/articles/s41893-021-00803-6

Overall, the Northern Africa and Southern Africa GGW regions have experienced similar changes in climate and vegetation variables, with respectively 4.76 percent and 11.09 percent drier aridity land conversions in contrast to the Sahel, which only experienced 2.08 percent of land conversion into a drier aridity category. Nevertheless, Northern Africa and Southern African GGW areas have witnessed smaller increases in ERD > 50mm than the Sahel. This emphasizes its exposure to extreme precipitation events. In terms of relative land use change, we note the biggest settlement expansion (35.16 percent) and net grassland loss (1.23 percent) in the northern African GGW and an important cropland expansion in the Southern Africa region (6.03 percent).

When contextualizing the changes in the Congo Basin, its non-dryland nature, and the fact that it is home to the biggest tropical forest in Africa with important reserves in carbon stocks must be considered. The Congo Basin has experienced profound changes in all its climatic variables HSD, ERD and decrease in NPP together with most significant cropland expansion (8.68 percent) and smallest gain of new forest (0.56 percent).

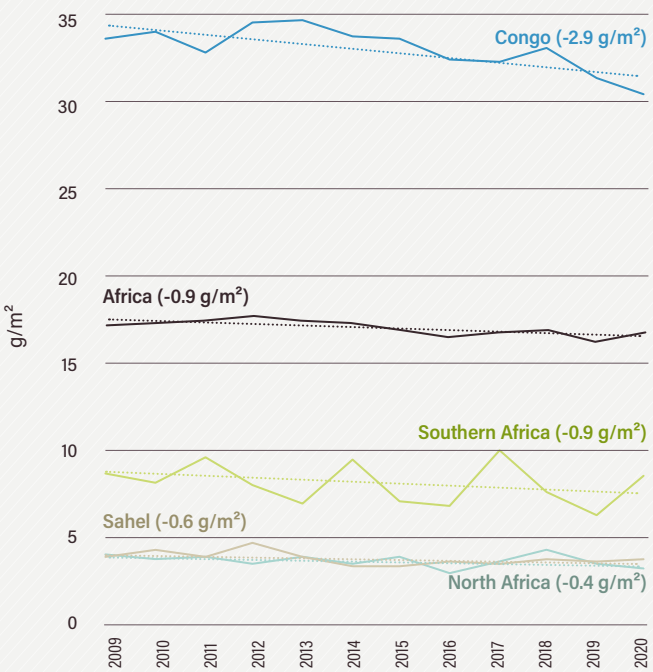
FIGURE 66. MAP OF AFRICA'S VEGETATION CHANGE (NPP)



Source: FAO WaPOR database, 2020.
Adapted from United Nations World map, 2020.

FIGURE 67. GRAPH OF VARIATIONS OF NPP AND NDVI IN THE THREE GGW (DRYLAND) REGIONS AND THE CONGO BASIN (WETLAND)

► NET PRIMARY PRODUCTION -FAO 2009-2020



Administrative boundaries
GGW regions
Congo basin
Lakes
Africa
North Africa
Southern Africa
Congo Basin
Sahel

TABLE 36. MULTI-PARAMETER ANALYSIS SUMMARIZING CHANGES IN LAND USE AND CLIMATE VARIABLES DURING THE LAST 40 YEARS

Changes in variables	Type of change	Africa	GGW North Africa	GGW Sahel	GGW Southern Africa	Congo Basin
Total area (Mha)		**3 000.57**	**50.39**	**241.98**	**228.35**	**370.52**
Changes in Climate/ Vegetation Parameters						
Mean annual temperature 1979–2019 (ECMWF)	Slow onset	↑1.2 °C	↑1.3 °C	↑ 1.1 °C	↑ 0.9 °C	↑ 1.1 °C
Heat stress days > 32° c (HSD) 2000–2020 (ECMWF)	Extreme events	↑ 14 days	↑ 7 days	↑ 1 day	↑ 31 days	↑ 39 days
Annual precipitation sum 1981–2020 (CHIRPS)	Slow onset	↑ 31 mm	↑ 23 mm	↑ 93mm	↑ 36 mm	↓ 40 mm
Extreme rain days > 50mm (ERD) 2000–2020 (ECMWF ERA5)	Extreme events	↑ 0.17 days	↓ 0.01 days	↑ 0.12 days	↑ 0.03 days	↑ 0.19 days
Net primary production (NPP) 2009–2020 (FAO)	Slow onset	↓ 0.9 g/m²	↓ 0.4 g/m²	↓ 0.6 g/m²	↓ 0.9 g/m²	↓ 2.9 g/m²
Changes in aridity 2000–2020 (ECMWF/MODIS)	Slow onset		4.76 % drier 1.4 % wetter	2.08 % drier 10.07 % wetter	11.09 % drier 2.03 % wetter	2.72 % drier 4.19 % wetter
Changes in land use/ land cover - Change in percentage[31]						
Loss of existing forest 2000–2019		↓2.66%	↓ 1.23%	↓2.61%	↓1.69%	↓ 1.35%
Gain of new forest 2000–2019		↑ 0.70%	↑ 0.85%	↑ 1.07%	↑ 0.51%	↑ 0.56%
Net settlement expansion 2000–2019		↑ 18.48%	↑ 35.16%	↑ 14.58%	↑ 19.02%	↑ 22.61%
Net cropland expansion 2000–2019		↑ 5.22%	↑ 0.18%	↑2.15%	↑ 6.03%	↑ 8.68%
Net grassland loss 2000–2019		↓ 0.62%	↓ 1.23%	↓ 1.01%	↓ 0.13%	↑ 0.09%

Low Middle High

[31] The changes in percentage have been calculated compared to initial conditions in each region.

03

LAND USE DATA OUTLOOK FOR THE FUTURE

CONCLUDING REMARKS ON MAJOR FINDINGS

By investing in the capacity development of experts, Africa has taken advantage of digital technologies and been a pioneer in producing a continental digital and comprehensive database on the biophysical environment, agriculture and land use.

Africa Open DEAL and the continent's GGW mapathons have proved that mobilizing expertise is possible at national and regional levels and collective efforts ensure timely responses, sustainability, and data ownership for decision-making. International partnership can be said to be successful when international services are no longer needed. The landmark new study combining the expertise of African scientists and practitioners, high-resolution land use imagery and the knowledge of local people has generated the most accurate estimate yet of Africa's tree resources. Among its key findings, the study estimates that **the continent supports 43 billion trees** – constituting an asset of immense value to its people, land and biodiversity. The study has also enabled the identification of vast areas of degraded lands in need of restoration.

A global first for Africa

Implemented on a previously unattained scale, the science-based analytical survey known as the Africa Open DEAL involved 30 African countries, and was supported by the Pan-African Agency of the GGW and the SADC. FAO and the AUC provided technical support and continent-wide engagement respectively. Africa is the first continent to complete the collection of such an accurate, comprehensive, and harmonized set of data on land use and land use change.

The detailed panorama of Africa's tree cover is the product of 350 African experts, who spent two years between 2018 and 2020 capturing 300 000 sampling points of approximately 0.5 hectares in size from very-high-resolution satellite imagery. Measuring 100 parameters at each point, the raw data produced by the project was subsequently reviewed by local analysts trained in the use of Collect Earth, an open-source tool developed by FAO with the support of Google. 2021 was used to check, complete gaps and validate the collected raw data, which were then analysed to tease out the key findings.

African tree numbers revealed

The study found that:

- 26 percent of land in Africa is forested.
- The continent supports a total of 43 billion trees.
- There are almost 7 billion previously unrecorded trees outside forests (16 percent of the total) distributed over 537 million ha.
- Forests contain 36 billion trees (84 percent of the total).
- Africa has more restorable lands than any other region; the area of the continent-wide GGW initiative has 393 million ha of land with restoration potential and opportunities.
- The GGW is the essential core area of the 1 billion ha of the continent's drylands, comprising 780 million ha in the Sahara and the Sahel and 228 million ha in Southern Africa.
- 350 million ha of cropland is cultivated in Africa, more than double that of the European Union.
- Between 2000 and 2019, land use change involved mostly a reduction of forests (-2 percent) and grassland, other lands and wetland (-1 percent) in favour of settlement (+18 percent) and cropland (+5 percent). The estimated annual rate of deforestation between 2000–2019 is 1 million ha.

Why do these data matter?

For African countries and most of its peoples, trees have vast economic, environmental, and social significance and benefits. Used judiciously, the information, data and analyses generated by Africa Open DEAL could lead to transformative benefits for Africa's rural communities, particularly those living in arid and semiarid drylands – which cover a billion hectares of Africa's land area and are estimated to meet a large part of the socioeconomic needs of 320 million people. Sustainable natural capital management can be improved by informed policy and decision-making through identifying areas of increased human expansion, settlements and also key factors propelling greater deforestation and the loss of crop-grass- and wet- lands, and alterations in wildlife habitats.

The interconnectedness of the land sector means that the findings will resonate beyond actions related solely to trees and agriculture. They provide critical data and inputs for more sustainable and equitable natural resource, biodiversity and land use planning and management, particularly in consultations and decisions on targeting of programme resources and action to sustainably increase and improve Africa's tree stock, restore its degraded lands, reduce poverty and hunger, increase biodiversity and combat climate change.

Similarly, the data will have a huge bearing on and significance for actions in international bodies, including the three Rio Conventions, which collate and compile aggregated global data, and for global natural resource conventions and monitoring and reporting, such as the SDGs. The data can be used to help increase Africa's preparedness for climate change and improve reporting on progress towards international land use targets and goals. The survey's findings will also resonate beyond forestry, informing and providing important inputs into broader natural resource and land use planning and management. Africa Open DEAL will thus help ensure informed decisions on the allocation of natural resources and provide opportunities for targeting actions designed to sustainably and equitably restore degraded lands, reduce poverty and hunger, increase biodiversity, and combat climate change.

Other benefits from Africa Open DEAL

Africa Open DEAL provides a powerful opportunity to train national experts in accessing, interpreting and analysing land use data and information, thus increasing the continent's capacity for the application of geospatial technologies. The success of the project shows the importance of investment in the science, research and agriculture sectors and of encouraging young Africans to pursue careers in these fields. Not to be underestimated, thanks to Africa Open DEAL, Africa's natural-resource policymakers, experts and practitioners can gain greater confidence in planning holistic strategies and policies to attenuate the impact of forest degradation and loss on hunger, malnutrition and poverty, desertification and climate change.

The significance of Africa Open DEAL for large-scale land restoration in Africa

African governments have made ambitious restoration commitments, which illustrate the extent of the political will for restoration, though they overlap in some areas. In 2015, the African Forest Landscape Restoration Initiative (AFR100) was launched to restore 100 million ha by 2030. Three years later, the Pan-African Agenda on Ecosystem Restoration for building resilience led to the commitment to restore 200 million ha. And the GGW for the Sahara and Sahel, launched in 2007, also led to a commitment to restore a 100-million ha zone of degraded lands across the Sahel by 2030. Nevertheless, Africa has continued to lose forest in the last decade, with a net annual forest loss of 3.94 million ha during the 2010–2020 period. Estimates suggest that the continent also has 660 million ha of degraded land and 132 million ha of degraded cropland. However, reversing forest loss and land degradation first and foremost requires addressing the drivers behind that loss and degradation, but also requires scaling up restoration.

Africa's total drylands are around 2 billion ha. The continental GGW is the essential core area of a 1 billion ha arid and semiarid zones of this total. It provides an estimated 393 millions ha of restorable land in its three regions. Africa's GGW is a model transnational restoration initiative for meeting the land restoration goal of 1 billion hectares by 2030, as set by the UN Decade on Ecosystem Restoration (2021–2030). The defining feature of GGW success is continuous, operational-level consultation with local communities within a holistic regional strategy of country-designed and -led national action plans. Such consultations include obtaining first-hand understanding of local community planting preferences and restoration objectives, which led to a recording of over 200 species in 13 countries in the Sahel that local people consider essential for medicine, food, fuel and other important uses.

Comprising the three dryland regions – North Africa, the Sahel and Southern Africa – and encompassing 25 countries and 520 million ha of land, the GGW contains more than 4.3 billion of the continent's 43 billion trees and would benefit from restoration (Bastin *et al*., 2019). The Africa Open DEAL findings further facilitate measuring and reporting on the GGW objectives to develop an 8 000 km corridor of productive, sustainable landscapes across the Sahel, with the specific targets to restore 100 million ha of degraded lands by 2030, sequestering 250 million tCO_2eq and creating 10 million green jobs (UNCCD, 2020).

UPCOMING OUTPUTS

Under Earth Map as the major landing platform, Africa Open DEAL data are incorporated in FAO's Hand-in-Hand Geospatial Platform. Experts from various countries continue to receive support to further populate their national data and information through this platform, which is hosted and maintained by FAO (with free training if and when required), though countries can freely agree or not to openly contribute and share their national data. Some of the planned activities to be developed in partnerships with countries and experts are listed below:

- → **FAO, PA-GGW and SADC** will continue will continue to work together to prepare reports on biophysical assessments of Africa's GGW and other restoration initiatives, which will feed into the Green Climate Fund, the UN Decade on Ecosystem Restoration and other national reports on various commitments.

- → **FAO and Africa Union Commission** will continue to lead the preparation of comprehensive reports about the new knowledge on land use, environment, agriculture, water and climate change. The scope of these reports is to identify policy relevant questions and scientific and technical topics to be addressed at continental level.

- → **National assessments and submissions under UNFCCC.** Countries will be supported in feeding the activity data generated through the Collect Earth assessment into their national GHG inventories for the AFOLU sector, to improve their Biennial Update Report, Forest Reference Levels and National Communication. New features in FAO's Collect Earth – now connected with the IPCC's own inventory software – allow countries to access and interpret land use data for GHG inventories.

- → **National assessments and submissions under UNCCD.** Each country will be able to use the data generated through Africa Open DEAL to set its baseline for land degradation neutrality and review progress on its national LDN targets.

- → **National reporting under CBD.** Data will be made available for each country to support its National Report related to four Aichi Biodiversity Targets (Targets 5, 7, 11 and 15) and to set the baseline and measure progress in implementation of the post-2020 CBD Framework Targets.

- → **National submissions to FAO STAT.** Countries will receive data to support their submissions for a large set of country indicators related to agriculture production, emission, land use and forestry sections of the FAOSTAT database.

- → **Wetland and water resources data under the Ramsar Convention.** Countries will receive data to improve their National Reports on the Ramsar Convention goals and targets.

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FUTURE RESEARCH AND REGULAR UPDATING DATA

(2025 – 2027 – 2030)

The intention is to review and regularly update the Africa Open DEAL data,as a baseline data set, at least every two years. The proposed timelines are in 2025, 2027 and in 2030. The plan is to produce a number of technical and scientific publication products deriving from Africa Open DEAL in order to validate the database and maps created, to better communicate on land potentials in Africa, accessible to wider audiences. The themes to feature in these publications include, but are not limited to, the following:

- **Scientific data –** a paper of Africa Open DEAL presenting and sharing the photo-interpreted data, with a description of the methodology and summary statistics.

- **The land cover of Africa,** featuring the most detailed land cover map (not with classes but with quantitative cover). This allows a more detailed understanding as compared to classic land cover maps. It will show the tree cover, shrub cover, grass cover, bare ground cover, crop cover, and built-up cover. Each pixel reaches a maximum of 100 percent of cover when combining all types of cover (except tree cover, which can have several layers).

- **Potential natural ecosystems of Africa,** featuring a map of natural coverage and land use change including tree cover, shrub cover, grass cover, bare ground cover and the potential co-existence of several ecosystems. This will link cover types with species composition with a spatial kriging analysis and a distance matrix, and information on functional traits/ecosystem services. Species composition will be associated with future cover types (using a climate dissimilarity matrix as in Bastin *et al.*, 2019).

- **Thematic reports on Africa's GGW –** to combat desertification, biodiversity loss and climate change will be produced on these three most important challenges occurring in the drylands of Africa. Defining priority regions that maximize the outcomes regarding desertification, biodiversity, climate change, that is, the three Rio Conventions (UNCCD, CBD and UNFCCC), these technical reports will provide biophysical details on the continental GGW in the three regions of North Africa, the Sahel and the Kalahari-Namib of Southern Africa, highlighting issues related to environmental and climate processes and defining restoration opportunities and carbon sequestration potentials.

- **Drivers of degradation of African natural ecosystems –** to better identify the link between fire frequency and different land cover (tree cover, shrub cover, etc.) and better define when a fire is actually a source of degradation. For some natural ecosystems, fire might be a positive driver while it would be a negative driver for other. This would be of particular interest in regions with multiple natural ecosystem states.

→ **Status of shrub cover on the African continent** – to provide information on the spatial distribution of shrub cover at a continental scale. The research will apply a normalized frequency distribution and spatial correlations of shrub (>50 percent cover) and tree (>50 percent cover) as a function of various bioclimatic variables such as precipitation and daily temperature differences. This information should make it possible to propose a map of the ecological niche potential of the shrub distribution and could help to improve the assessment of carbon stocks.

→ **Influence of land cover changes (forest conversion) on temperature** – to improve our understanding of the influence of land cover changes within particular forest changes on temperature patterns across the whole continent. In drylands, different land use conversions forest to grassland, forest to cropland or forest to settlement might have different effects on temperature patterns, as recently showed in the semiarid agroecosystems of East Africa.

→ **Distribution of Africa's largest trees outside forests** – to improve our understanding of the distribution of those large trees outside forested areas and estimate their prevalence across the whole continent. An assessment will be conducted of the global distribution of the largest trees outside forests over Africa through kriging. The largest trees will be determined as the ones belonging to plots with a mean crown area[32] in the top 90th percentile of their respective ecoregions, i.e., the largest 10 percent per ecoregion. This enhanced knowledge of the distribution of those trees could help target further conservation policies and expand their focus to non-forested landscapes, as well as drawing attention to the threat of global change on the key links which large trees are in the global landscape matrix.

→ **Understanding of tree biodiversity in the regions and outside forest lands** – to provide information on the increasing improvement of trees outside forests in farming systems, agro-ecological and sylvo-pastoral systems, in home-gardens, parks and settlements (e.g. trees in/green cities). Increasingly, parts of such land use change contribute to and improve not only climate mitigation but also the conservation of certain tree biodiversity.

[32] Mean crown area (MCA) as a proxy of tree size. MCA is retrieved for each plot from the AOD dataset using the following formula: $\frac{(plot_{area}.treecover/100)}{(tree\ count)}$ with plot area in square meters and tree cover in percentage terms.

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ANNEXES

ANNEX 01
GLOSSARY

Agrosilvopastoral system: Multiple land use including agricultural crop production, livestock herding/ breeding, forestry and woodland conservation.

Aridity Index: The Aridity Index is the ratio between average annual precipitation and total annual potential evapotranspiration.

Biomass: Organic material both above ground and below ground, and both living and dead, for example, trees, crops, grasses, tree litter, roots, and so on. **Above-ground biomass (AGB)** is all living biomass above the soil including the stem, stump, branches, bark, seeds, and foliage; **below-ground biomass (BGB)** is all living biomass of live roots. Fine roots of less than (suggested) 2 mm diameter are sometimes excluded because these cannot often be distinguished empirically from soil organic matter or litter. It may include the below-ground part of the stump.

Biophysical area: The total area surveyed in the Africa Open DEAL initiative, including inland water bodies.

Canopy cover: The percentage of the ground covered by a vertical projection of the outermost perimeter of the natural spread of plant foliage (crown closure).

Carbon pool: A reservoir or system which has the capacity to accumulate or release carbon. Examples of carbon pools are living biomass (including AGB and BGB); dead organic matter (including dead wood and litter); soils (soil organic matter).

Carbon stock: The quantity of carbon in a "pool".

Cropland: Agriculture land including rice fields, and agroforestry systems where the vegetation structure falls below the thresholds used for the forest land category.

Cumulated Canopy Cover (ACC): Cumulated or continuous canopy cover is the sum of tree crown area vertically projected to the ground (e.g., 1 percent of tree cover over 1ha corresponding to a canopy cover of 0.01 ha, and 100 percent to 1 ha). This simple metric is independent of any tree cover threshold or forest definition and includes all levels of tree cover of a given region while more appropriately balancing the importance of tree density. Note that the quantification of the forest cover and of the cumulated or 'continuous canopy cover' can differ significantly, often leading to an overestimation in forest cover area).

Earth Map: Earth Map is a free software designed in the framework of the FAO-Google partnership, which facilitates the visualization, processing and analysis of land and climate data (EarthMap.org), thanks to the processing power of Google Earth Engine.

Forest land: Land with woody vegetation consistent with thresholds used to define forest land in the national greenhouse gas inventory. This also includes systems with a vegetation structure that currently fall below, but could potentially reach the threshold values used by a country to define the forest land category.

Grassland: This includes rangelands and pastures that are not considered cropland. It also includes systems with woody vegetation and other non-grass vegetation, such as herbs and brushes that fall below the threshold values used in the forest land category. The category also includes all grassland from wild lands to recreational areas as well as agricultural and silvopastoral systems, consistent with national definitions

IPCC Land Use Categories: The six top-level land categories for greenhouse gas inventory reporting.

Land cover versus land use: Land cover is the type of vegetation covering the Earth's surface. Land use is the type of activity being carried out on a unit of land. The IPCC land categories here adopted are a mixture of land cover (forest, grassland, wetland) and land use (cropland, settlement) classes.

Land degradation: FAO defines land degradation as a "reduction in the condition of the land, which affects its ability to provide ecosystem goods and services and to assure its functions over a period of time". UNCCD defines **land degradation neutrality (LDN)** as "a state whereby the amount and quality of land resources necessary to support ecosystem functions and services and enhance food security remain stable or increase within specified temporal and spatial scales and ecosystems".

Land restoration: A way of reversing degradation processes and increasing the contributions of ecosystems and landscapes to livelihoods, land productivity, environmental services and the resilience of human and natural systems. **Restorable land** is the land that has the potential to increase its current tree cover according to the global tree restoration potential study (Bastin *et al*., 2019).

Linear trend: The trend of a quantity measures its change over a time period, with a positive trend value indicating growth in the quantity, and a negative value indicating a decrease. It is defined as the ratio of the change in the quantity over the time period, divided by the initial value of the quantity.

Other land: Bare soil, rock, ice, and all land areas that do not fall into any of the other five categories. It allows the total of identified land areas to match the national area, where data are available.

Sampling approach: Sampling infers information about an entire population by observing a fraction of it. In the Africa Open DEAL survey, 317 000 square-shaped (half-hectare) sample plots over the whole continent were analysed for a large number of variables, and then spatially extrapolated to produce statistics at different scales of aggregation (continental, regional, national, and subnational).

Settlements: All developed land, including transportation infrastructure and human settlement of any size, unless they are already included under other categories. This should be consistent with national definitions.

Time series: Series of observations at successive (usually equidistant) points in time. Examples are climatic parameters (precipitations, temperatures) or remotely sensed indices (normalized difference vegetation index), analysed at annual, monthly, or daily intervals.

Tree: A woody perennial with a single main stem, or in the case of coppice with several stems, having a more or less definite crown. Includes bamboos, palms, and other woody plants meeting the above criteria.

Wetland: Areas of peat extraction and land that are covered or saturated by water for all or part of the year (e.g. peatlands) and that do not fall into the forest land, cropland, grassland or settlement categories. This includes reservoirs as a managed subdivision and natural rivers and lakes as unmanaged subdivisions.

ANNEX 02
DATA COLLECTION METHODOLOGY

A sample-based approach

The Africa Open DEAL database is derived from an assessment of land cover, land use and land use change based on a sampling approach and visual interpretation of high resolution satellite images, implemented through **Collect Earth.**[33]

Collect Earth is an open-source tool for land monitoring from the FAO's Open Foris suite,[34] developed in partnership between FAO and Google.

In total, the initiative draws on information from more than **300 000 sampling plots** in Africa. A **plot** is a square of 70-by-70 meters, covering an area of about 0.5 hectares. The distance between plots varies according to the sampling design. The expansion[35] of the plots allows real statistics to be generated from the Collect Earth database.

Around 80 percent of the AOD plots were assessed during *mapathons,* or group data collections, involving more than 350 African experts with knowledge of the landscapes, GIS, and land uses. The interpretation was made throughout 2019–2020 in 16 nationally and regionally focused workshops,[37] convened by FAO in collaboration with government and regional institutions including the PA-GGW and SADC.

Around 20 percent of the overall sample, was imported from surveys created in the framework of other programs, using random or systematic sampling grids.

The AOD plots were distributed over stratified systematic grids (see Table 38). The sample was designed according to specific interest in the area (e.g. the GGW regions) and/or to the heterogeneity of the landscape:

- → The **hyper-arid zones** (4 percent of the sample), were sampled at the lowest intensity (20-by–20 km) because of the relative homogeneity of the landscape, mainly desert-
- → The **non-hyper arid zones** (53 percent of the sample) (arid, semi-arid, dry-subhumid, and non-drylands categories), were sampled with a 10-by-10 km grid.
- → The **Great Green Wall area of interest** (16 percent of the sample) was covered by a denser grid: 6.5-by-6.5 km, to monitor restoration progress and generate the baseline situation for some areas where activities are planned to start soon.
- → At the **local level**, some countries opted for a higher sampling density (e.g. Senegal, Zambia, Rwanda, Lesotho chose an 8x8 km grid, Tunisia 4x4 km, etc).

TABLE 37.
AFRICA OPEN DEAL SAMPLING PLAN, DISTRIBUTION OF PLOTS BY STRATUM

Grid type (Distance between sample plots)	Number of plots	Share of total
	000 plots	
GGW (6.5x6.5 km)	50.7	16 %
Non-hyperarid (10x10 km)	168.9	53 %
Hyperarid (20x20 km)	13.6	4 %
Local (mixed, <10x10 km)	84,8	27 %
TOTAL	**318**	**100 %**

Source: FAO based on Africa Open DEAL database, 2022.

[33] openforis.org/tools/collect
[34] openforis.org
[35] The plot expansion factor is the ratio between the area of the region to be assessed (in ha) and the number of plots inside it. When the sampling plan is stratified, the plot expansion must be calculated for each stratum.
[36] Coordinated group mapping workshops where local experts are invited to collect data collectively and intensively for a specific area.
[37] The training workshops were structured in two parts: first, a Collect Earth training was conducted by FAO trainers on the use of the tool, followed by the group data collection, which was supervised by FAO trainers for the first days, then coordinated by country technical focal point(s). A small team of Collect Earth experts was usually previously trained on the whole process through advanced capacity building.

For the assessment of the data accuracy, 3 200 plots (or 1 percent of the total sampling plots) were randomly selected throughout the continent, checked, and re-interpreted by FAO experts in case of any errors made by local interpreters.

Tools for interpretation

Collect Earth supported African operators in the visual interpretation of time series of satellite images to facilitate the detection of vegetation seasonality and land dynamics over 2000–2019. The operator photo-interpreted very high spatial resolution (pixel size 30 cm to 3 m) satellite images made freely accessible for visualization on Google Earth and/or Bing Map, and in parallel controlled his measurements with spectral information,[38] automatically compiled from 2000 onwards, from medium-to-high resolution satellite images (MODIS, Landsat7/8, and Sentinel 2).

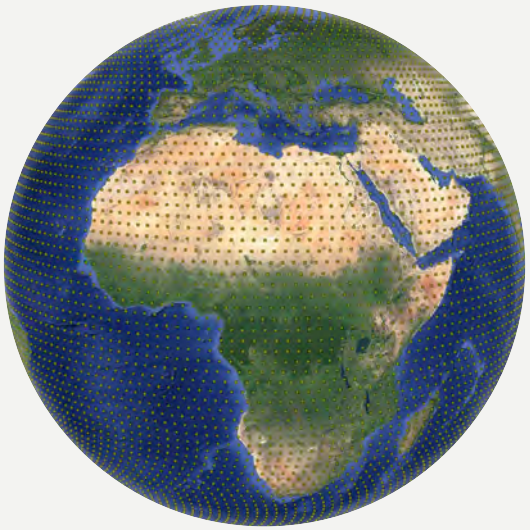
This free and geo-synchronized access to multi-temporal imagery sources, integrated with satellite remote sensing derived time series of vegetation indices (such as NDVI and NDFI) and chart of possible fires (from MODIS Burned Area), provided better representation of spatial and temporal dynamics of vegetation and enabled the collection of an unparalleled amount of information on land cover, land use and land use changes for the whole of Africa.

BOX 1. SIGRID, THE SYSTEMATIC ITERATIVE GRID

To allow for easy customization of the sampling plan, the FAO LUMI (Land Use Monitoring and Innovation) team developed **SIGRID,** a global systematic Equal Area grid of points at 1x1 km with sub-nested grids at various intervals. SIGRID was designed in such a way that the latitude for each row of plots remains constant and the distance in degrees that equates to 1 000 meters at that latitude is calculated and applied sequentially to each plot. This guarantees that the distance is very close to 1 000 meters at any latitude and the expansion factor is the same everywhere (≈ 1 km^2)

SIGRID aims to provide a global multi-purpose grid for improved data harmonization (the same location can be used for multiple surveys sharing the same plot IDs).
SIGRID is an open-source project at:

- **https://github.com/herrtunante/SIGRID.git**



Visualization of SIGRID at 200 km

[38] Collect Earth, through its Google Earth Engine App, gives quick access to real and false colour multi-temporal mosaics and composites and allows to generate on-the-fly interactive vegetation and fires charts (from MODIS, Landsat 7/8 and Sentinel 2). The user can click on any points of Landsat 7/8 and Sentinel 2 NDVI charts to visualize the corresponding mosaic at the specific date: e.g. by clicking on a pic high value of NDVI, the related false colour image will appear bright orange over the plot (the band combination is NIR-SWIR-Red).

Figure 68 shows a land use change from forest land to cropland in Angola, occurred in 2016. In this example, the vegetation indices enabled the correct detection of forest loss and the year of change (confirmed by the Landsat 8 yearly mosaic), despite the quick recover of the vegetation (crops). The MODIS Burned Area chart shows frequent fires on the plot land and its surroundings.

The harmonized classification scheme

The AOD initiative developed a land-use classification system in line with the IPCC's harmonized framework for consistent representation of land, flexible enough to accommodate differences in national land use classification systems. Within each **land use category** (see Box 1 for short description) are a number of more detailed

FIGURE 68. AUGMENTED VISUAL INTERPRETATION IN COLLECT EARTH

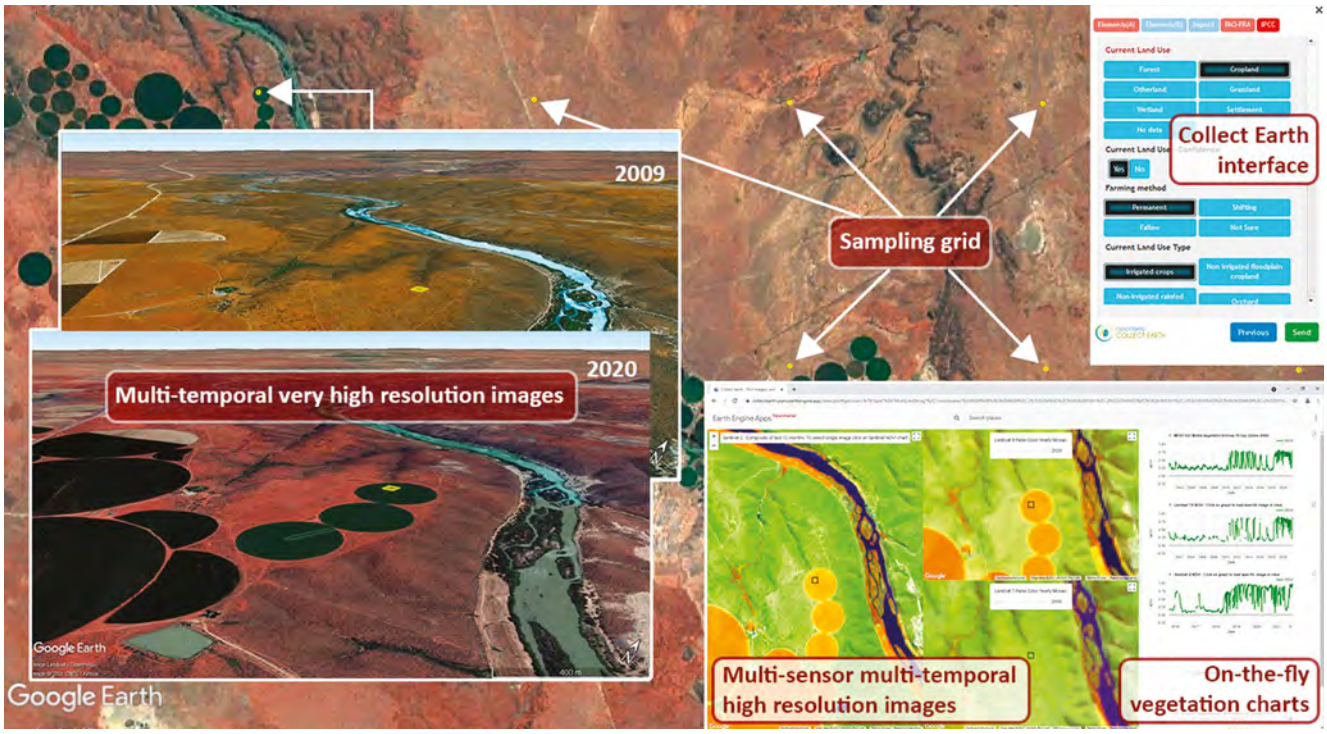
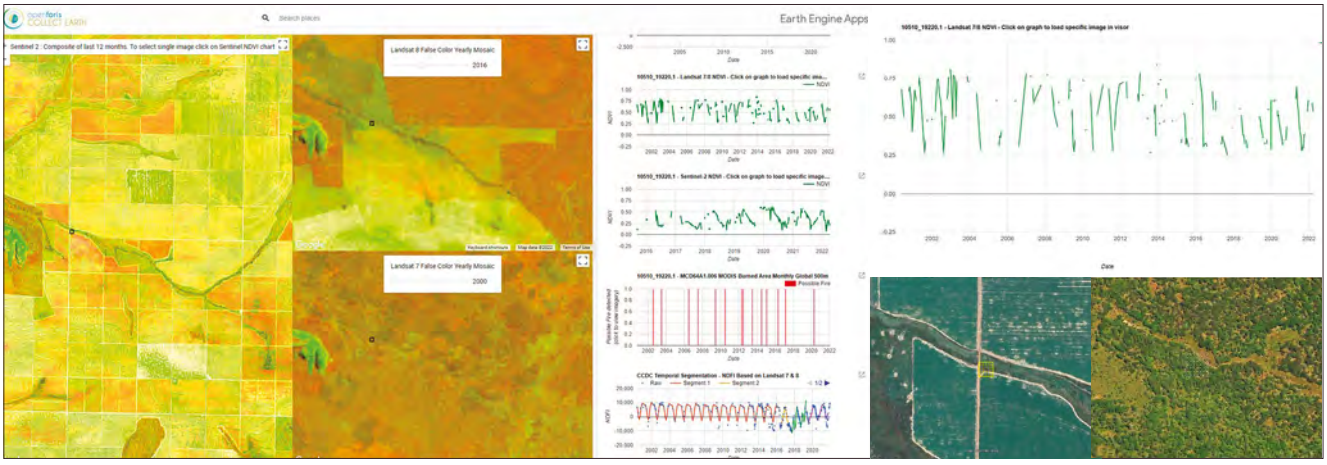


FIGURE 69. THE GEE APP OF COLLECT EARTH SHOWING A LAND USE CHANGE (FOREST->CROPLAND) IN ANGOLA, PLUS NDVI, NDFI AND FIRE TIME SERIES



BOX 2. LAND USE CATEGORIES OF THE INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE

Top-level categories for representing all land use areas:

FOREST LAND - This category includes all land with woody vegetation consistent with thresholds used to define forest land in the national greenhouse gas inventory. It also includes systems with a vegetation structure that currently fall below, but in situ could potentially reach the threshold values used by a country to define the forest land category.

CROPLAND - This category includes cropped land, including rice fields, and agroforestry systems where the vegetation structure falls below the thresholds used for the forest land category.

GRASSLAND - This category includes rangelands and pastures that are not considered cropland. It also includes systems with woody vegetation and other non-grass vegetation such as herbs and brushes that fall below the threshold values used in the forest land category. The category also includes all grassland from wild lands to recreational areas as well as agricultural and silvipastural systems, consistent with national definitions.

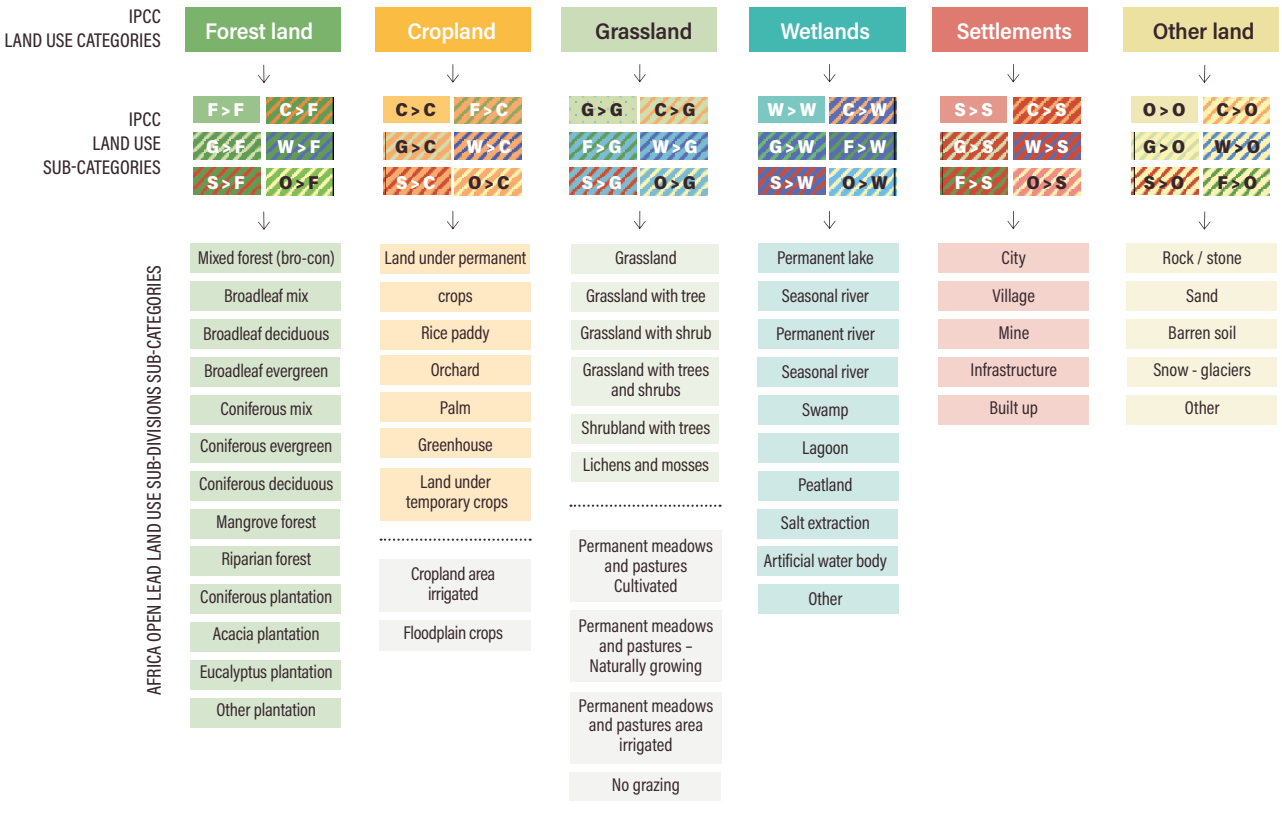
WETLAND - This category includes areas of peat extraction and land that is covered or saturated by water for all or part of the year (e.g. peatlands) and that does not fall into the forest land, cropland, grassland or settlement categories. It includes reservoirs as a managed sub-division and natural rivers and lakes as unmanaged sub-divisions.

SETTLEMENT - This category includes all developed land, including transportation infrastructure and human settlement of any size, unless they are already included under other categories. This should be consistent with national definitions.

OTHER LAND - This category includes bare soil, rock, ice, and all land areas that do not fall into any of the other five categories. It allows the total of identified land areas to match the national area, where data are available.

Source: 2006 IPCC Guidelines for National Greenhouse Gas Inventories

FIGURE 70. AFRICA OPEN DEAL CLASSIFICATION SCHEME SHOWING SIX LAND USE CATEGORIES, 36 SUB-CATEGORIES AND 46 SUBDIVISIONS



land use and land cover classes – the **subdivisions**, which describe specific circumstances significant to the estimation of emissions. For example, the 'settlement' category includes, 'city,' 'mine', 'infrastructure', 'built-up' and 'village' subdivisions. The AOD classification system proposed harmonized subdivisions classes within each category (see Figure 70), that are mutually exclusive and exhaustive. That is, each plot within the mapped area could be classified into one and only one subdivision. It is worth nothing that several countries (Morocco, Tunisia, Niger, Algeria, Zambia, Ghana, Rwanda, and Mauritania) opted for national land use classification scheme, which was integrated within the AOD survey. Thirty-six **sub-categories** (six for each land use category) were introduced following the IPCC guidelines; they show the possible land use changes over the assessment period (the IPCC guidelines recommend a 20-year evaluation period, which can be adjusted according to the national specific needs).

The collected variables

Using the system described above, more than 100 environmental variables and land parameters were collected:

- Variables regarding the **land cover**: tree cover and number, crop cover, grass cover, bush/shrub cover, palm cover and number, built-up cover, infrastructure cover, water cover, bare soil cover, presence of linear vegetation, presence of seasonal floods.
- Variables regarding the **land use** category and subdivision (see Box 2): presence of single/multiple land use(s) within the plot; coverage of each land use within the plot; land use category; land use subdivision
- Variables regarding **management options**: irrigated/floodplain crops; presence of grazing: naturally growing, cultivated or irrigated meadow and pasture.
- Variables regarding forest land and grassland **disturbances** (primary, secondary, and tertiary): fire (and related year), logging (and related year), grazing, crops, shifting cultivation, flooding, paths, settlement, other.
- Variables regarding the **land use change**: up to two land use changes (three possible land uses) for each plot, between 2000 and 2019; 36 subcategories, changes in land use subdivision within the same land use category; year of each change (to allow yearly consistent representation of land).[39]
- **Climate and terrain** related parameters: Table 38 shows a list of supplementary data collected for each plot not by the user through visual interpretation but through automatic algorithms within the Google Earth Engine platform.[40]

TABLE 38. EXTRA DATA AUTOMATICALLY INCLUDED IN THE AOD DATABASE

Supplementary data added to the AOD grid	Data source
Elevation	USGS SRTM, 2000
Slope	USGS SRTM (derived from DEM)
Aspect	USGS SRTM (derived from DEM)
Global ecological zone (GEZ)	FAO, 2010
Land productivity	UNCCD, 2015
Climate zone	IPCC, 2006
Soil type	IPCC, 2006
Dryland category	UNEP, 2010
Biome	RESOLVE, 2017
Ecoregion	RESOLVE, 2017

[39] In case of land use change, it was mandatory to select the year of change, previous land use category and previous subdivision. This allowed the system to produce the year-by-year sequence of LUs, which is needed to generate the Activity Data for AFOLU GHG national inventories.

[40] The Grid Generator is a Google Earth Engine App that allows the generation of point grids in a fast and easy manner. It is possible to customize the fields to be included in the grid. It can be freely accessed at collectearth.users.earthengine.app/view/collect-earth-grid-generator

Table 39 lists the main international conventions whose reporting could be improved using AOD collected data.

Tree-related and other measurements in the AOD survey

Thanks to Collect Earth and ad hoc survey forms designed in Open Foris Collect,[41] it was possible to record not only the presence of trees, but also the tree canopy cover (ranging from 0 to 100 percent), the number of trees, the type of trees, their distribution in the plot, and the related land use category, by making it possible to analyse, among many other parameters, the number of trees outside forest land, the tree cover distribution by any variable in the database, the conversion from a specific forest type to any other land use or subdivision, and so on.

Specific validation rules[42] helped improving the accuracy of collected data. A subset of the most important rules is presented in Table 40.

The operators entered and saved qualitative and quantitative information about land attributes in the forms that open within Google Earth as a hypertext markup language (HTML) balloon. Figure 71 shows an example of the AOD survey forms interface and the Google Earth VHR image that enabled the land cover assessment with the support of control points.[43]

TABLE 39.

A SUMMARY COMPENDIUM OF THE DATA COLLECTED WITHIN THE AFRICA OPEN DEAL INITIATIVE AND RELATED ADDRESSED REPORTING PROCESS

Data category	Data variables and parameters (direct or derived)	Main reporting process
Land cover 2019	Tree/palm cover and number, shrub cover, water cover, crop cover, grass cover, bare soil cover, built-up cover, infrastructure cover.	UNCCD LDN SDG 15.2.1 SDG 15.3.1 REDD+
Land use 2000–2019	Land use and land use change distribution according to IPCC, land use and land use change distribution according to a regional harmonized African classification, land use and land use change distribution according to eight national classification schemes.	UNFCCC AFOLU SDG 15.1.1 SDG 15.4.2 REDD+
Agriculture 2000–2019	Distribution of crop types and crop management, arable land, grassland/pasture types and management, agrosilvopastoral systems, etc.	FAO STAT
Land degradation and disturbances 2000–2019	Occurrence and distribution of fire, flooding, mining, logging, etc. Changes in land productivity, changes in carbon stocks above and below ground, (from time series of LU and vegetation changes and disturbances).	UNCCD LDN SDG 15.3.1 UNFCCC AFOLU Aichi Target 14 REDD+
Landscape biodiversity 2019	Presence of trees outside forests, presence of linear vegetation elements, land cover heterogeneity.	CBD national reports Aichi Biodiversity Targets 5, 7, 10, 14
Water 2000–2019	Water bodies distribution and changes.	Ramsar

[41] https://openforis.org/tools/collect

[42] The Survey Designer in OF Collect allows to create validation controls to prevent users from saving the plots unless they follow the rules. If there is conflicting information, the card marks it as error.

[43] Each plot presents a systematic grid of 7-by-7 points (49 control points) allowing easy and direct measurements of tree canopy cover and other land cover elements, with each point representing 2 percent of the plot.

TABLE 40. MAIN CONDITIONAL RULES IN THE AFRICA OPEN DEAL SURVEY

Validation rules in the AOD survey	Comments
If tree cover >0, then number of trees >0	The survey allows the operator to differentiate between tree cover in forest or grassland (or wetland) and tree cover in settlement or croplands. This rule applies in both cases.
If tree cover (in forest or grassland) > 10 %, then final LU = forest land[44]	Following the FAO definition of forest land.[45]
If Infrastructures or Housing cover >=20 %, then final LU = settlement	Even with multiple land uses within the plot.
If LU subdivision = grassland, then grass cover > 0.	Subdivisions are the possible classes under a specific land use, in this case grassland.
If LU subdivision = grassland with trees, then grass cover > 0 AND tree cover (0.10) % **If LU subdivision = grassland with shrubs, then grass cover > 0 AND shrub cover (0.10)% AND grass cover > 0.** **If LU subdivision = grassland with trees and shrubs, then shrub cover (0.10) %, AND tree cover (0.10) %** **If LU subdivision = shrubland, then shrub cover >= 10 %** **If LU subdivision = shrubland with trees, then shrus cover >= 10 %, tree cover (0.10) %** **If LU = cropland, then crop cover >0**	(0.10)% means any values between 1% and 9%.
If LU change is true, then year of change and previous LU must be specified	This allowed the system to produce the year-by-year sequence of LUs, which is needed to generate the activity data for AFOLU GHG national inventories.

[44] Trees must be distributed throughout the plot. In case of multiple land uses within the plot (trees grouped in one part of the plot), the operator must specify a forest land use coverage at least equal to the tree canopy coverage. The final LU is then assigned according to hierarchical rules.
[45] Forests refer to land with a tree canopy cover of more than 10 percent and area of more than 0.5 ha.

In Figure 71, five control dots (in red) are counted on *trees in agriculture* (the shadow of trees is black and does not contribute to the coverage) and 44 control dots (circled in blue) on *Crops*. This corresponds to 10 percent of tree cover (in agriculture) and 80 percent of crop cover in the plot. The land use is homogeneous cropland.

Figure 72 shows an example of plot with two distinct land uses. The method allowed to easily measure the coverage of each land use. Dedicated algorithms in the survey design automatically calculated the final land use of each plot (in this case, forest land).

FIGURE 71. PLOT VISUALIZATION HIGHLIGHTING THE LAND COVER/LAND USE ASSESSMENT IN A HOMOGENEOUS PLOT

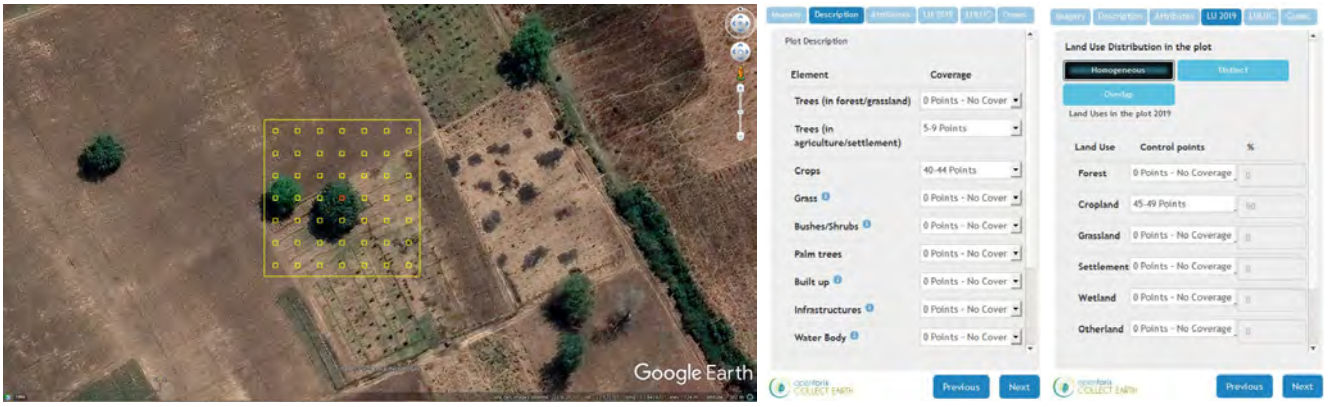
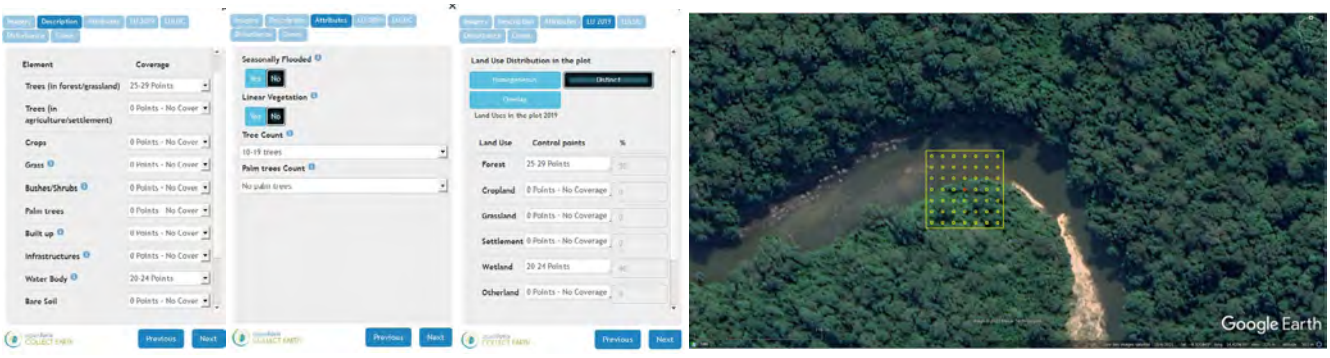
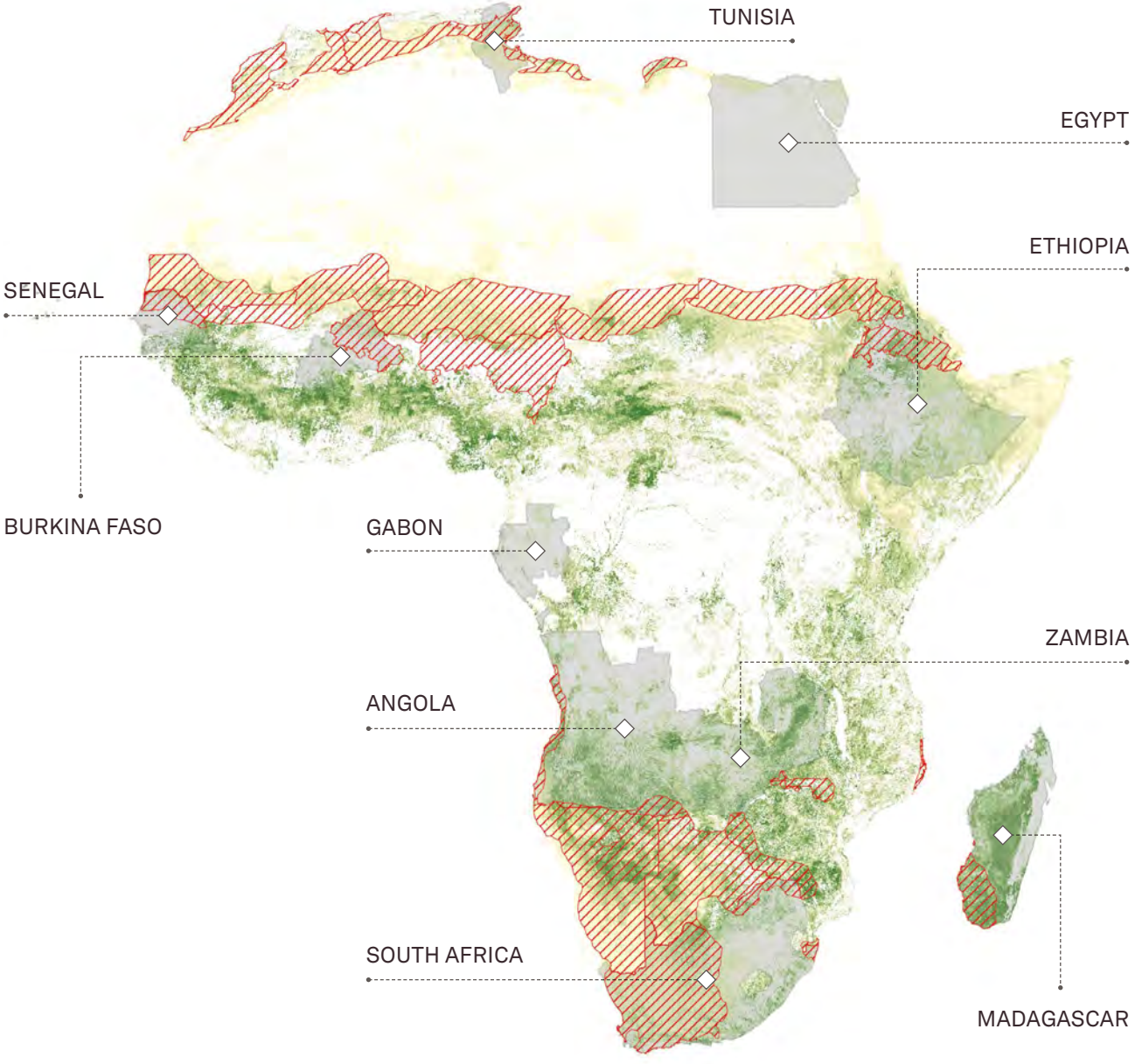


FIGURE 72. PLOT VISUALIZATION HIGHLIGHTING THE LAND COVER/LAND USE ASSESSMENT IN A PLOT WITH DISTINCT LAND USES



ANNEX 03
COUNTRY PROFILES

This section provides national disaggregated data and information from the Africa Open DEAL survey as well as other sources for a selection of ten countries: Angola, Burkina Faso, Egypt, Ethiopia, Gabon, Madagascar, Senegal, South Africa, Tunisia, and Zambia, selected by geographical distribution and environmental representativeness in the African continent.



Source: FAO based on Bastin *et al.*, 2019. Adapted from United Nations World map, 2020.

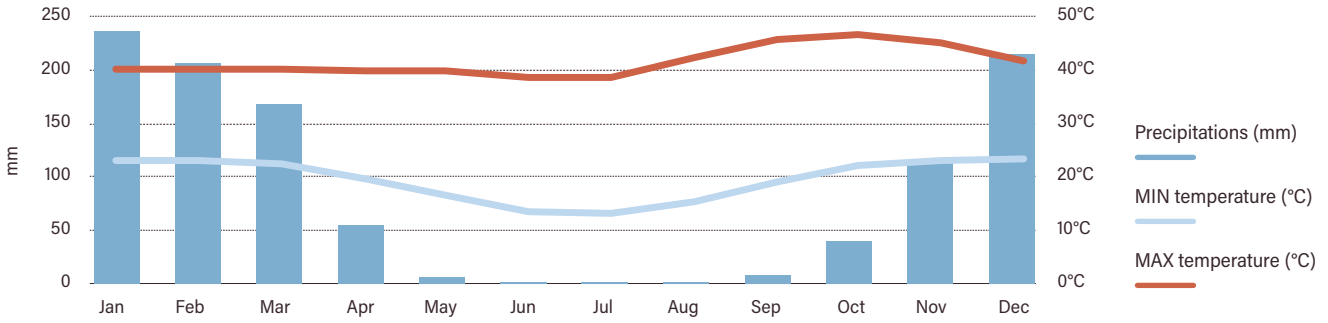
ANGOLA

GEOGRAPHICAL CONTEXT (Red hatched zone=GGW area)	
Administrative area (million ha)	**124.67**
Biophysical area (million ha)	**124.67**
Regions (number)	**18**
GGW area (million ha)	**9.67** (7.8 percent of total land)
Systematic sampling units	**12 471**

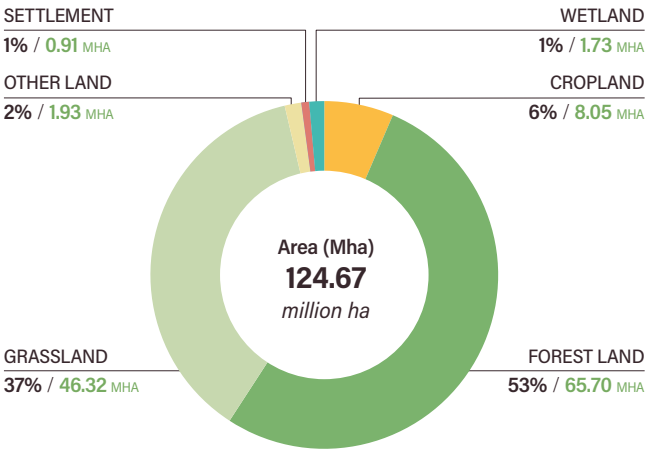
Source: All tables and figures of Angola are FAO based on Africa Open DEAL database, 2019, unless referenced differently.

► CLIMATE CHART MONTHLY AVERAGES 1991-2019

Source: FAO based on Earth Map platform.



► LAND USE DISTRIBUTION (IPCC categories), 2019 (million ha)

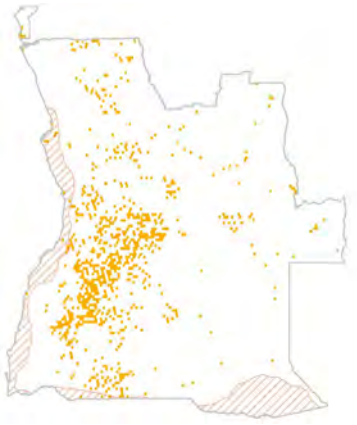


Angola's climate is tropical. Depending on the season, the average daytime temperatures range between 25 °C and 30 °C, with high peaks (hotter months) of 34 °C and low peaks (colder months) of 16 **°C in some parts of the country. The annual rainfalls average from 1100 mm to 950 mm in the period of observation, with a tendency to a reduction.**

According to the Global Climate Risk Index (CRI), which focuses on the occurrence of extreme weather events, Angola scored medium-low (class 51-100) in the period 2000–2019.

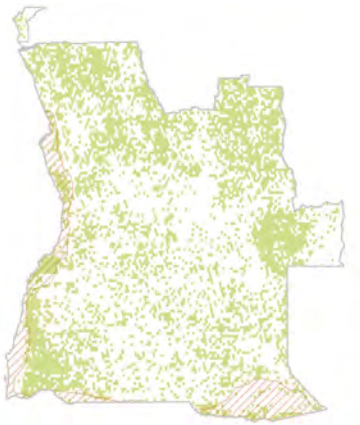
Angola is covered by 66 million ha of forest, 53 percent of the total area, and 46 million ha of grassland, 37 percent of the total area. Of the 124.6 million ha representing the national biophysical area, 9.7 million ha are of interest for the GGW initiative.

► LAND USE MAPS



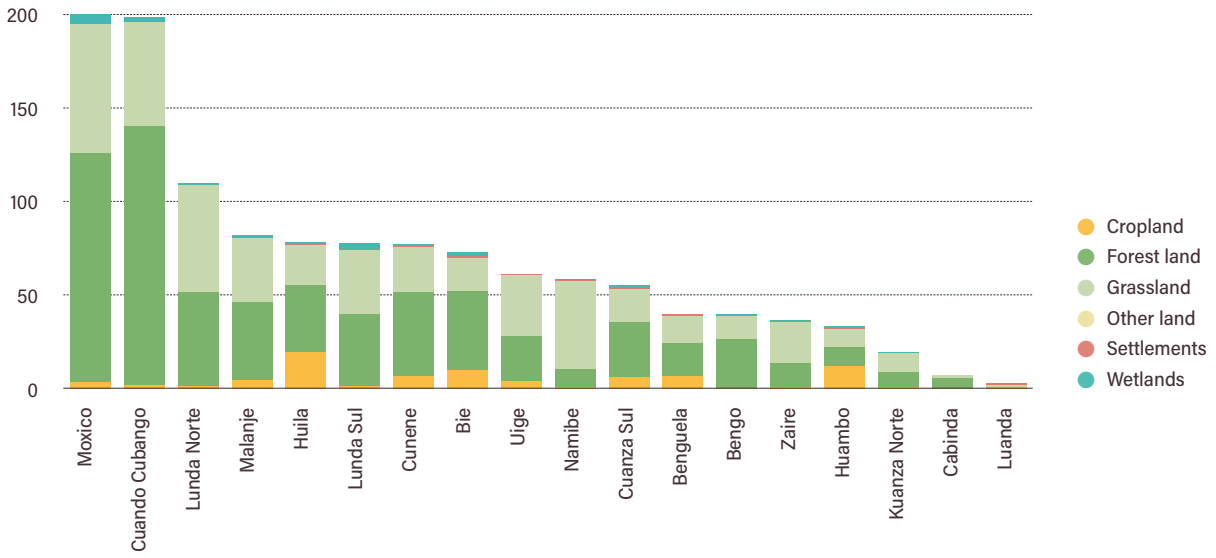
Cropland (6 percent)

Forest land (53 percent)



Grassland (37 percent)

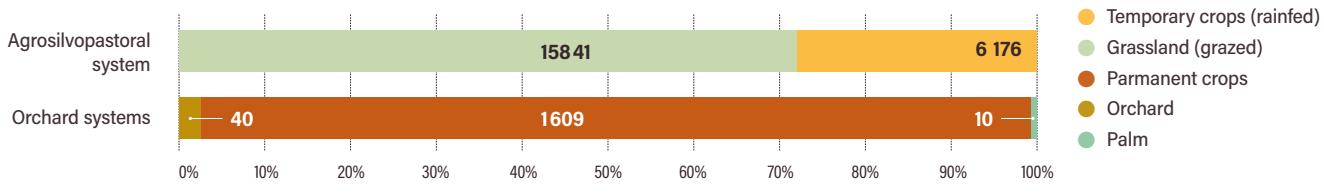
► LAND USE DISTRIBUTION BY REGION, 2019 (MILLION HA)



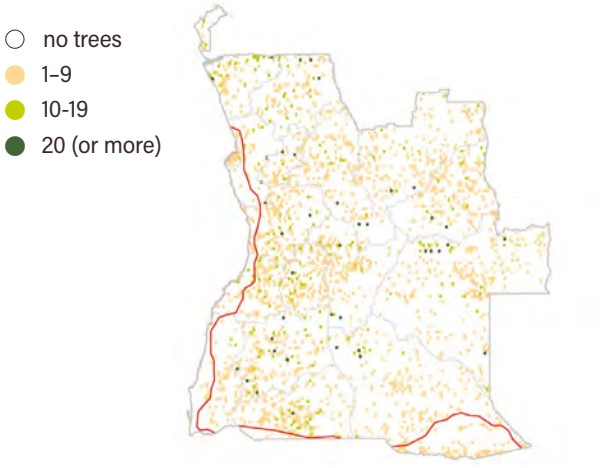
The largest province is Moxico but Cuando Cubango has the largest forest land. Huila has the largest cropland portion.

18 percent of total land is agrosilvopastoral, with a prevalence of grazed grassland (72 percent). Almost all orchard systems are permanent crops (97 percent).

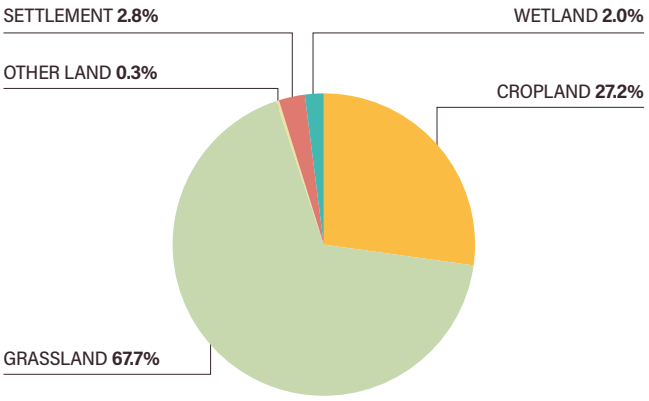
► AGROFORESTRY SYSTEMS, 2019 (000 HA)



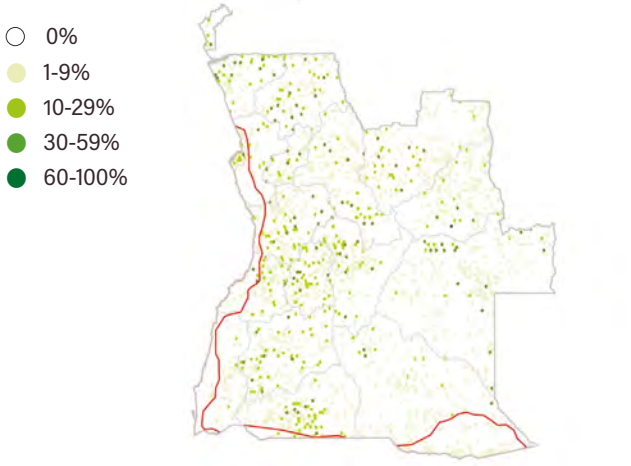
► TREE COUNT (/0.5 HA) IN NON-FOREST LAND, 2019



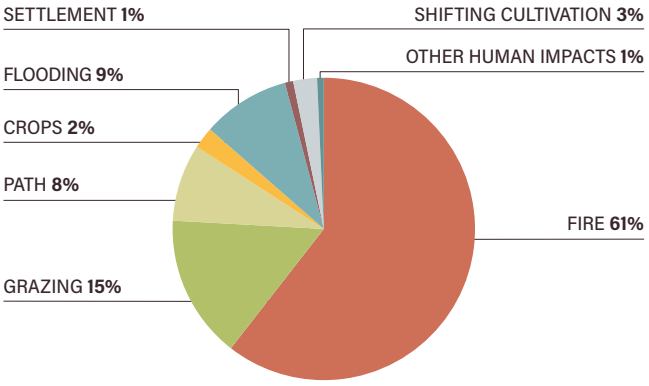
► DISTRIBUTION OF TREES IN NON-FOREST LAND



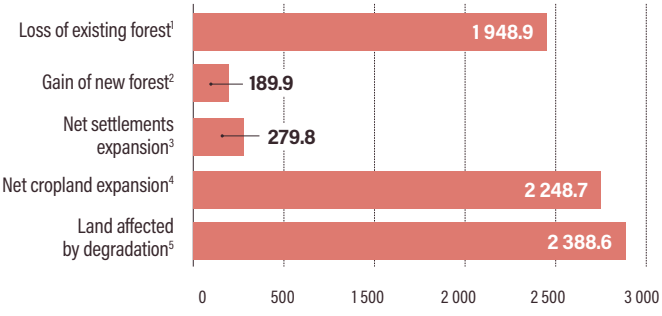
► TREE COVER (PERCENTAGE) IN NON-FOREST LAND, 2019



► PRIMARY OBSERVED DISTURBANCE FACTORS (FOREST/GRASSLAND) 2000-2019



► MAIN LAND USE CHANGES 2000-2019 (000 HA)



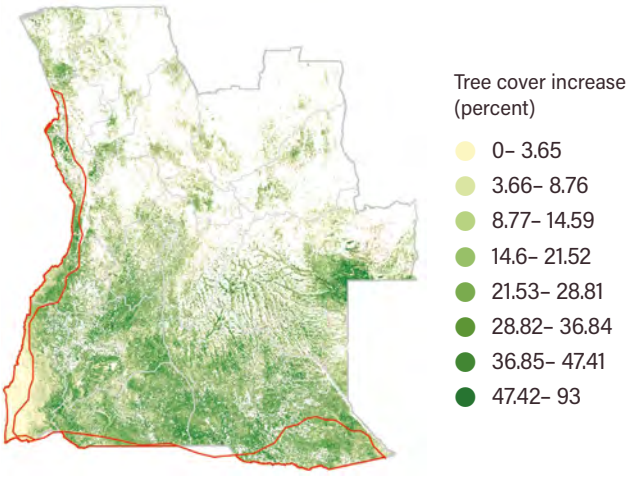
(1) *Any forest land lost to other land uses between 2000 and 2019*
(2) *Any non-forest land that became forest land between 2000 and 2019*
(3) *2019 minus 2000 settlement area*
(4) *2019 minus 2000 cropland area*
(5) *UNCCD-proposed default matrix for the assessment of SDG 15.3.1 land cover change sub-indicator between 2000 and 2019*

Angola counts 236 million trees in non-forest land, 67.7 percent are distributed in grassland, and 27.2 percent in cropland. The average tree density in cropland and settlement is 8 and 7.3 trees/ha, while it is 3.5 trees/ha in grassland.

The average tree cover density is 6.9 percent in cropland, 2.5 percent in grassland, and 8.8 percent in settlement. The average tree cover density in forest land is 64 percent.

The total area affected by primary human disturbances is 41 million ha (33 percent of country area). The first primary disturbance is fire (25 Mha affected).

► RESTORATION POTENTIAL AND OPPORTUNITIES



Source: FAO based on Bastin *et al.*, 2019. Adapted from United Nations World map, 2020.

The total restorable area in Angola is 67.5 million ha (54 percent of total land) with an average potential tree cover increase of 19 percent (13 million ha of cumulated canopy cover). The restorable land in the GGW area is 7.8 million ha, 81 percent of the total GGW area, with an average potential tree cover increase of 20 percent (1.6 million ha of CCC).

In 2010, the carbon stock in living biomass (above and below ground) was estimated at around 4.6 GtC (0.2 in the GGW area). With restoration, the estimated potential carbon net gain ranges between 0.3 (low bound) and 1.15 (high bound) GtC (0.04-0.14 in the GGW area).

Cuando Cubango and Moxico are the provinces with most restorable land, with 15.6 and 11 million ha respectively.

Angola | KEY FACT

BIOPHYSICAL
124.67 MILLION HA

7.8% is GGW area

LAND USE (2019)
8 MILLION HA CROPLAND

46 MILLION HA GRASSLAND

66 MILLION HA FOREST LAND

TREES IN NON-FOREST LAND
236 MILLION

27% in cropland with average 8 trees/ha

POPULATION (2020)*
31 825 295

3.2% annual growth

* Data based on the latest United Nations Population Division estimates 2020.

AGROSILVOPASTORAL SYSTEMS
22 MILLION HA

72% grazed grassland

TREE COVER DENSITY
6.9% IN CROPLAND

2.5% IN GRASSLAND

8.8% IN SETTLEMENT

PRIMARY HUMAN DISTURBANCES
40.8 MILLION HA

61% fires

CHANGE 2000-2019 (MILLION HA)
-1.76 FOREST LAND

+0.28 SETTLEMENT

+2.25 CROPLAND

+2.39 DEGRADED USE

TREE RESTORATION POTENTIAL
67.6 MILLION HA

19.6% average tree cover increase (BASTIN *et al.*, 2019)

RESTORATION IN GGW
7.8 MILLION HA

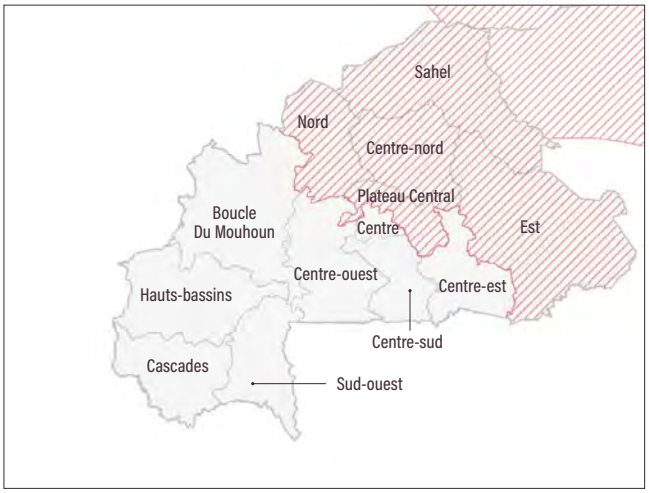
20.1% average tree cover increase

CARBON STOCK (2010)
4.59 GtC FROM LIVING BIOMASS

0.18 GtC in GGW area SOTO-NAVARRO *et al.*, 2020

CARBON GAIN WITH RESTORATION
0.30–1.15 GtC (RANGE)

0.04–0.14 in GGW area



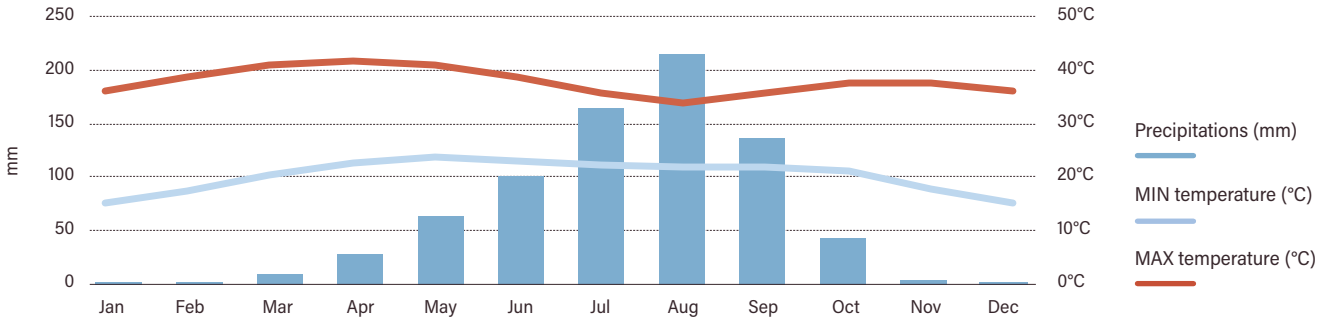
BURKINA FASO

GEOGRAPHICAL CONTEXT (Red hatched zone=GGW area)	
Administrative area (million ha)	**27.42**
Biophysical area (million ha)	**27.33**
Regions (number)	**13**
GGW area (million ha)	**12.73** (47 percent of total land)
Systematic sampling units	**4 246**

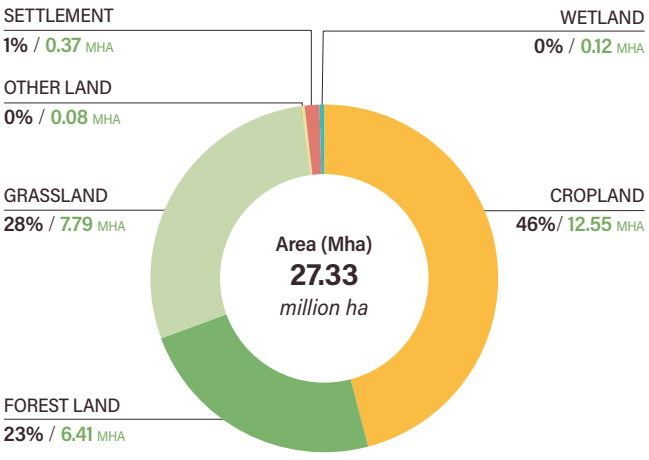
Source: All tables and figures of Burkina Faso are FAO based on Africa Open DEAL database, 2019, unless referenced differently.

► CLIMATE CHART MONTHLY AVERAGES 1991-2019

Source: FAO based on Earth Map platform.



► LAND USE DISTRIBUTION (IPCC categories), 2019 (million ha)

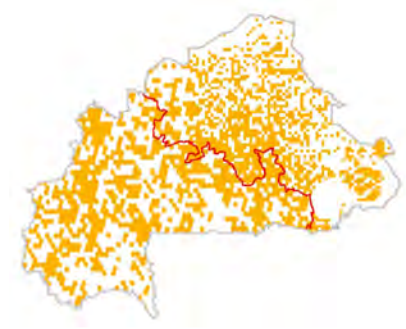


Burkina Faso's climate is primarily Sahelian dry with two very distinct seasons. In the rainy season, the country receives between 600 and 900 mm of rainfall; in the dry season, the harmattan – a hot dry wind from the Sahara – blows. The rainy season is shorter in the north of the country. Three climatic zones can be defined: the Sahel, the Sudan-Sahel, and the Sudan-Guinea.

According to the Global Climate Risk Index (CRI), which focuses on the occurrence of extreme weather events, Burkina Faso scored low (class >100) in the period 2000–2019.

Burkina Faso is covered by 12.6 million ha of cropland, 7.8 million ha of grassland and 6.4 million ha of forest land. In the GGW area, the share of grassland is higher (+11 percent) at the expense of forest land (-7 percent) and cropland (-4 percent).

► LAND USE MAPS

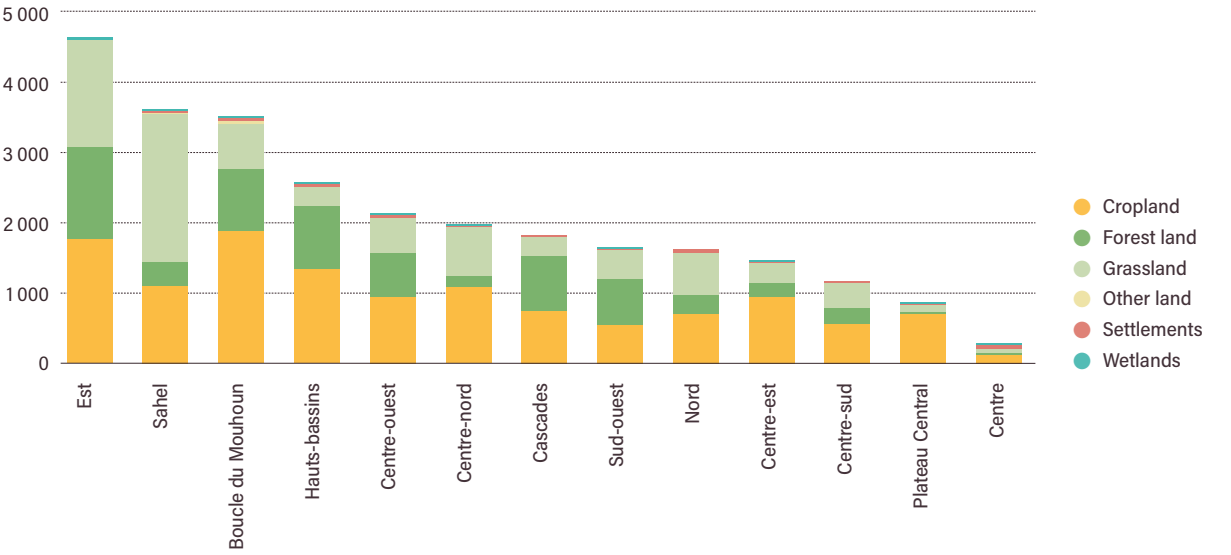


Cropland (46 percent)

Forest land (23 percent)

Grassland (28 percent)

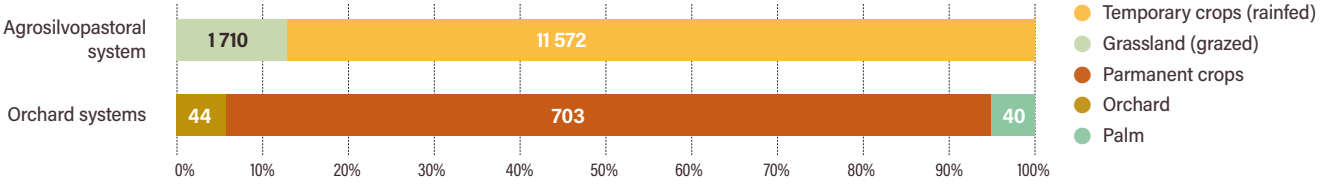
► LAND USE DISTRIBUTION BY REGION, 2019 (MILLION HA)



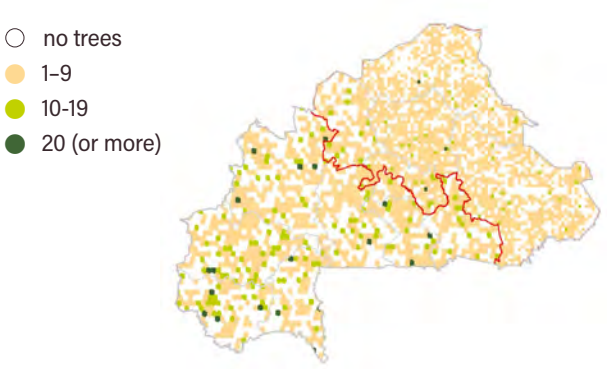
Est (the largest region) is characterized by the largest portion of forest land (1.3 million ha). Boucle du Mouhoun has the largest cropland (1.9) and Sahel the largest grassland (2.1).

The total agrosilvopastoral systems are estimated in 13.3 million ha (49 percent of total land), with a prevalence of annual rainfed crops (87 percent). The orchard systems represent 3 percent of total land (0.3 million ha).

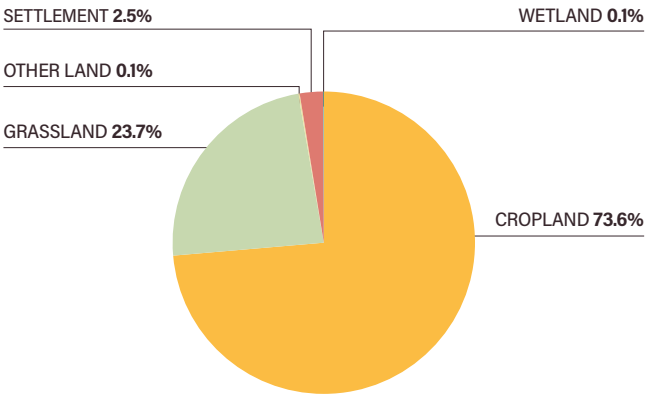
► AGROFORESTRY SYSTEMS, 2019 (000 HA)



► TREE COUNT (/0.5 HA) IN NON-FOREST LAND, 2019

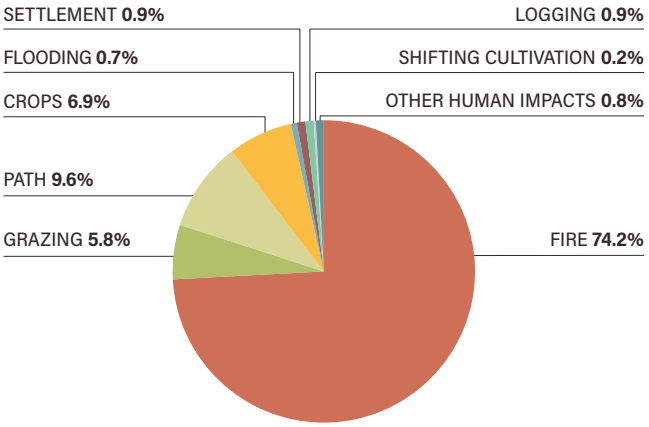


► DISTRIBUTION OF TREES IN NON-FOREST LAND

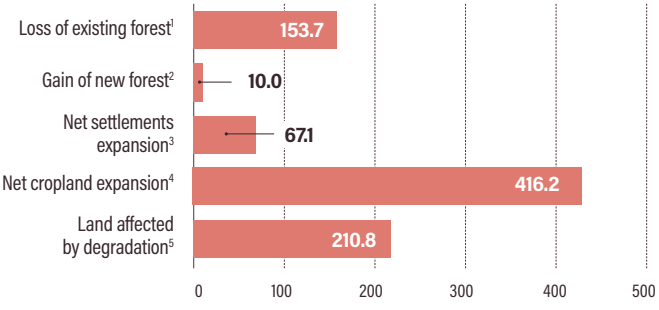


► TREE COVER (PERCENTAGE) IN NON-FOREST LAND, 2019

► PRIMARY OBSERVED DISTURBANCE FACTORS (FOREST/GRASSLAND) 2000-2019



► MAIN LAND USE CHANGES 2000-2019 (000 HA)



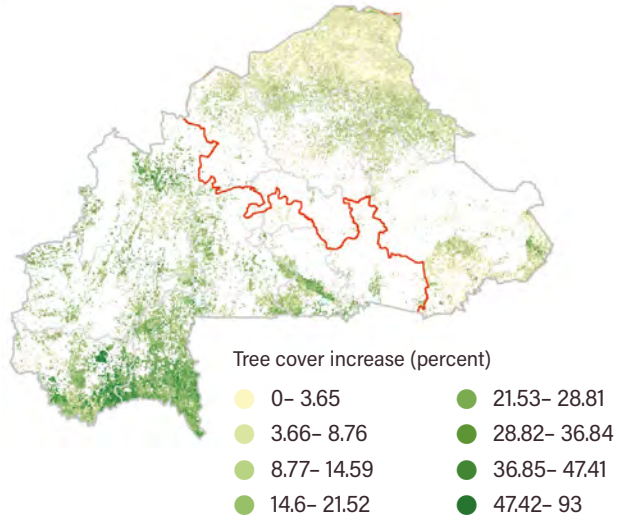
(1) *Any forest land lost to other land uses between 2000 and 2019*
(2) *Any non-forest land that became forest land between 2000 and 2019*
(3) *2019 minus 2000 settlement area*
(4) *2019 minus 2000 cropland area*
(5) *UNCCD-proposed default matrix for the assessment of SDG 15.3.1 land cover change sub-indicator between 2000 and 2019*

Burkina Faso counts 166 million trees in non-forest land, of which 73.6 percent are distributed in cropland and 23.7 percent in grassland. The average tree count density in cropland and settlement is 9.7 and 11.1 trees/ha, while it is 5 in grassland.

The average tree cover density is 9 percent in cropland, 4 percent in grassland, 10 percent in settlement, and 42 percent in forest land.

The total area affected by primary human disturbances is 4.38 million ha (16 percent of total land). Fire is the prevalent disturbance.

▶ RESTORATION POTENTIAL AND OPPORTUNITIES



Source: FAO based on Bastin *et al.*, 2019. Adapted from United Nations World map, 2020.

The total restorable area in Burkina Faso is 9.1 million ha (33 percent of total land) with an average potential tree cover increase of 15.4 percent (1.4 million ha of cumulated canopy cover). The restorable land in the GGW area is 4.8 million ha, 38 percent of the total GGW area, with an average potential tree cover increase of 8.5 percent (415 000 ha of cumulated canopy cover).

The carbon stock in living biomass (above and below ground) in Burkina Faso was estimated at around 0.329 GtC (0.092 GtC in the GGW area) by the year 2010. With restoration, the estimated potential carbon net gain ranges between 0.020 (low bound) and 0.111 (high bound) GtC (0.009-0.036 GtC in the GGW area).

Sahel and Sud-ouest are the regions with the most restorable land, with 2.89 and 1.22 million ha respectively. Cascades and Sud-ouest have the highest average potential tree cover increase through restoration with 27 percent and 26 percent respectively.

Burkina Faso | KEY FACT

BIOPHYSICAL
27.33 MILLION HA

47% is GGW area

LAND USE (2019)
12.6 MILLION HA CROPLAND

7.8 MILLION HA GRASSLAND

6.4 MILLION HA FOREST LAND

TREES IN NON-FOREST LAND
166 MILLION

74% in cropland with average 9.7 trees/ha

POPULATION (2020)*
20 321 378

2.8% annual growth

* Data based on the latest United Nations Population Division estimates 2020.

AGROSILVOPASTORAL SYSTEMS
13.3 MILLION HA

87% rainfed crops

TREE COVER DENSITY
9% IN CROPLAND

4% IN GRASSLAND

10% IN SETTLEMENT

PRIMARY HUMAN DISTURBANCES
4.4 MILLION HA

74% fires

CHANGE 2000-2019 (000 HA)
-144 FOREST LAND

+6.7 SETTLEMENT

+416 CROPLAND

+211 DEGRADED USE

TREE RESTORATION POTENTIAL
9.1 MILLION HA

15% average tree cover increase (BASTIN *et al.*, 2019)

RESTORATION IN GGW
4.8 MILLION HA

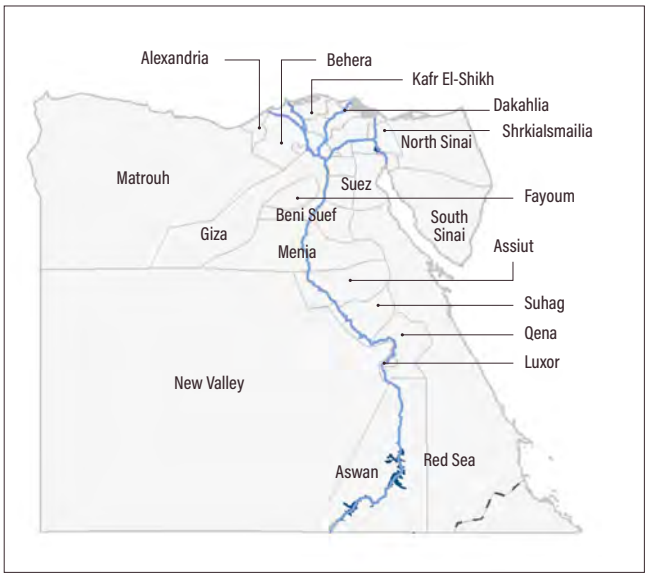
8.5% average tree cover increase

CARBON STOCK (2010)
329 GtC FROM LIVING BIOMASS

92 GtC in GGW area SOTO-NAVARRO *et al.*, 2020

CARBON GAIN WITH RESTORATION
20-111 GtC (RANGE)

(9-36 in GGW area)



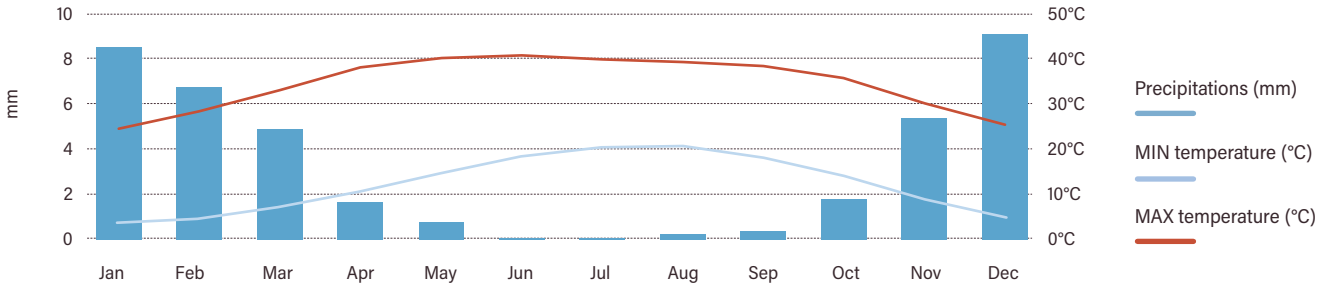
EGYPT

GEOGRAPHICAL CONTEXT (Red hatched zone=GGW area)	
Administrative area (million ha)	**100.15**
Biophysical area (million ha)	**99.95**
Regions (number)	**27**
GGW area (million ha)	**0**
Systematic sampling units	**3 124**

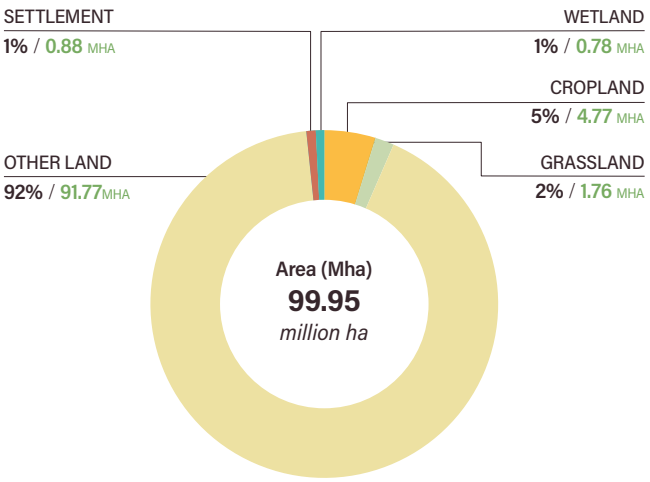
Source: All tables and figures of Egypt are FAO based on Africa Open DEAL database, 2019, unless referenced differently.

► CLIMATE CHART MONTHLY AVERAGES 1991-2019

Source: FAO based on Earth Map platform.



► LAND USE DISTRIBUTION (IPCC categories), 2019 (million ha)



Egypt's climate is dry, hot, and dominated by desert. It has a mild winter season (min 3 °C) with rain falling along coastal areas, and a hot dry summer season (max 41 °C). Average annual precipitations range between 2 mm (southern desert) and 180 mm (northern coasts).

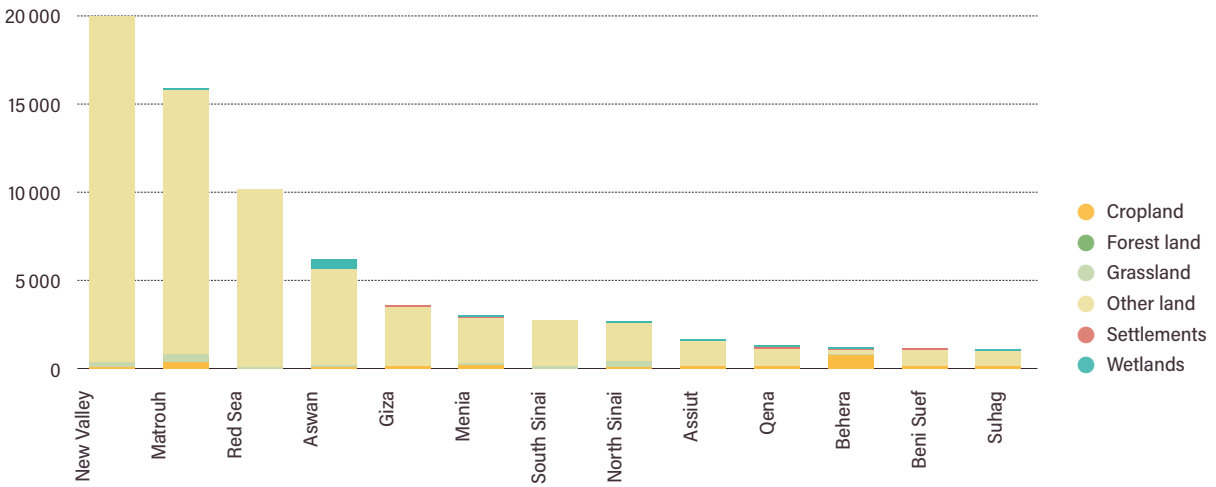
According to the Global Climate Risk Index (CRI), which focuses on the occurrence of extreme weather events, Egypt scored low (class >100) in the period 2000–2019.

Egypt is covered by 4.8 million ha of cropland (5 percent of the total area), and 1.8 million ha of grassland (2 percent). Nearly 92 percent of national land is other land.

► LAND USE MAPS

Cropland (5 percent) | Settlement /Wetland (2 percent) | Grassland (2 percent)

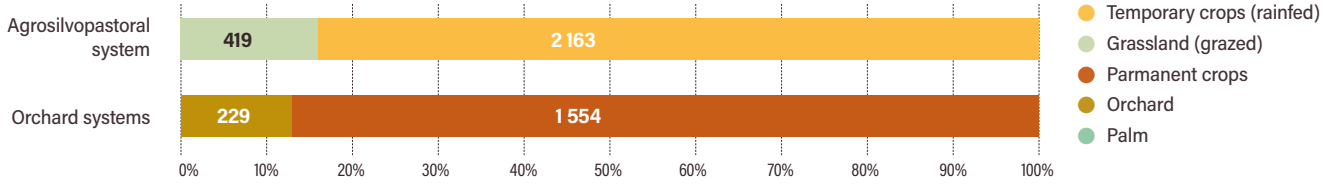
► LAND USE DISTRIBUTION BY REGION, 2019 (MILLION HA)



New Valley (the largest province, 42.8 Mha) is characterized by the largest portion of other land; Behera has the largest cropland (817 000 ha) and Matrouh the largest grassland (448 000 ha).

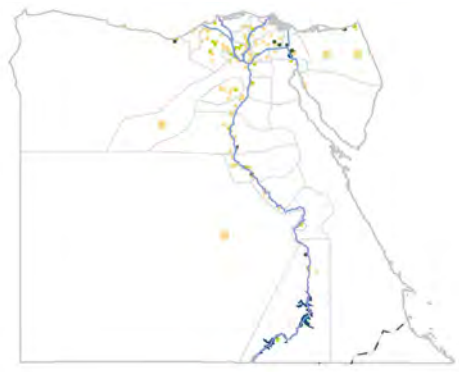
Rainfed annual crops make up 84 percent of all agrosilvopastoral systems (2.6 Mha). 87 percent of orchard systems (1.8 Mha) are based on permanent crops.

► AGROFORESTRY SYSTEMS, 2019 (000 HA)

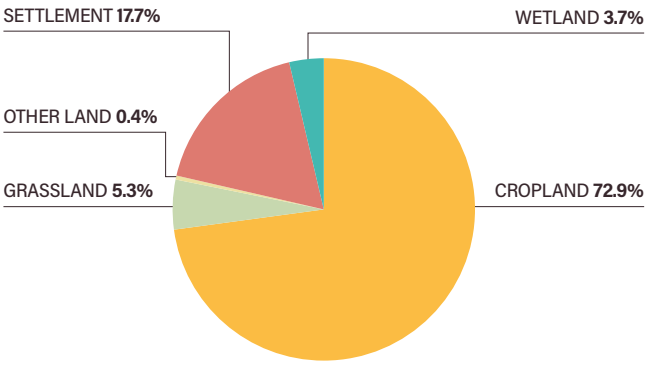


► TREE COUNT (/0.5 HA) IN NON-FOREST LAND, 2019

- no trees
- 1–9
- 10-19
- 20 (or more)



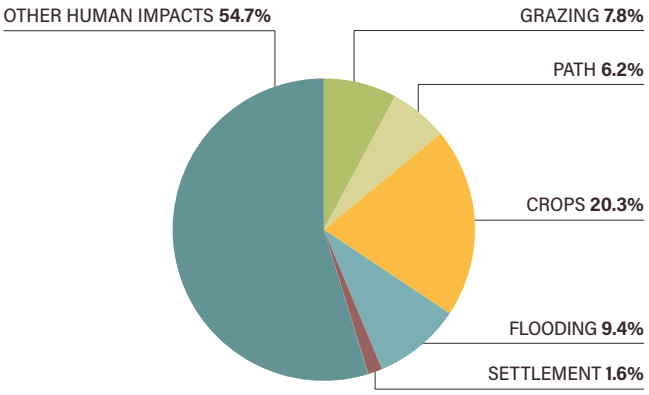
► DISTRIBUTION OF TREES IN NON-FOREST LAND



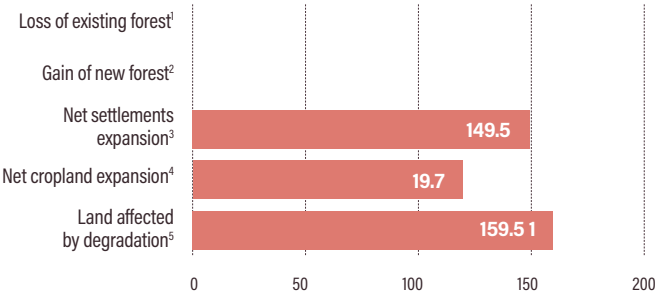
► TREE COVER (PERCENTAGE) IN NON-FOREST LAND, 2019

- 0%
- 1-9%
- 10-29%
- 30-59%
- 60-100%

► PRIMARY OBSERVED DISTURBANCE FACTORS (FOREST/GRASSLAND) 2000–2019



► MAIN LAND USE CHANGES 2000–2019 (000 HA)



(1) *Any forest land lost to other land uses between 2000 and 2019*
(2) *Any non-forest land that became forest land between 2000 and 2019*
(3) *2019 minus 2000 settlement area*
(4) *2019 minus 2000 cropland area*
(5) *UNCCD-proposed default matrix for the assessment of SDG 15.3.1 land cover change sub-indicator between 2000 and 2019*

Egypt counts 23 million trees in non-forest land, of which 72.9 percent are concentrated in cropland. The average tree density in all cropland and settlement is 3.6 (16.7 in cropland with trees only) and 4.7 trees/ha (19.7 in settlement with trees only), as against 0.7 in grassland (6.9).

The total area affected by primary human disturbances is 638 000 ha (less than 1 percent of country area). 'Other human impact' is the prevalent disturbance in other land, while cropping is prevalent in the grassland.

► RESTORATION POTENTIAL AND OPPORTUNITIES

Tree cover increase (percent)

- 0– 3.65
- 3.66– 8.76
- 8.77– 14.59
- 14.6– 21.52
- 21.53– 28.81
- 28.82– 36.84
- 36.85– 47.41
- 47.42– 93

Source: FAO based on Bastin *et al.*, 2019. Adapted from United Nations World map, 2020.

The total restorable area in Egypt is 12.3 million ha (12 percent of total land) with an average potential tree cover increase of 0.9 percent.

In 2010, the carbon stock in living biomass (above and below ground) in Egypt was estimated at around 0.139 GtC. With restoration, the estimated potential carbon net gain ranges between 0.003 (low bound) and 0.010 (high bound) GtC.

Matrouh, Red Sea and North Sinai are the provinces with most restorable land, with 4.15, 1.58 and 1.54 million ha respectively. Menoufia shows the highest potential average tree cover increase from restoration at 10.3 percent.

Egypt | KEY FACT

BIOPHYSICAL

99.95 MILLION HA

0% is GGW area

LAND USE (2019)

4.8 MILLION HA CROPLAND

1.8 MILLION HA GRASSLAND

9.2 MILLION HA OTHER LAND

TREES IN NON-FOREST LAND

23.3 MILLION

73% in cropland with average 3.6 trees/ha

POPULATION (2020)*

100 388 073

2% annual growth

* Data based on the latest United Nations Population Division estimates 2020.

AGROSILVOPASTORAL SYSTEMS

2.6 MILLION HA

84% rainfed crops

TREE COVER DENSITY

3.5% IN CROPLAND

0.6% IN GRASSLAND

4.5% IN SETTLEMENT

PRIMARY HUMAN DISTURBANCES

638 000 HA

55% other

CHANGE 2000-2019 (000 HA)

0 FOREST LAND

+150 SETTLEMENT

+120 CROPLAND

+160 DEGRADED USE

TREE RESTORATION POTENTIAL

12.3 MILLION HA

0.9% average tree cover increase

RESTORATION IN GGW

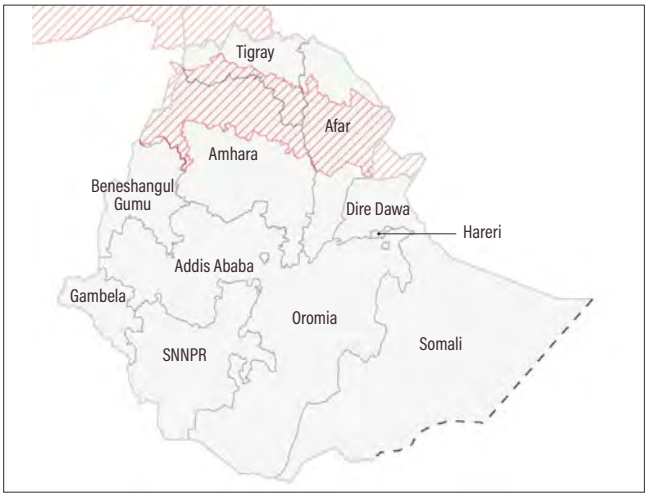
0 MILLION HA

CARBON STOCK (2010)

139 GtC FROM LIVING BIOMASS

CARBON GAIN WITH RESTORATION

3.4-10.4 GtC (RANGE)



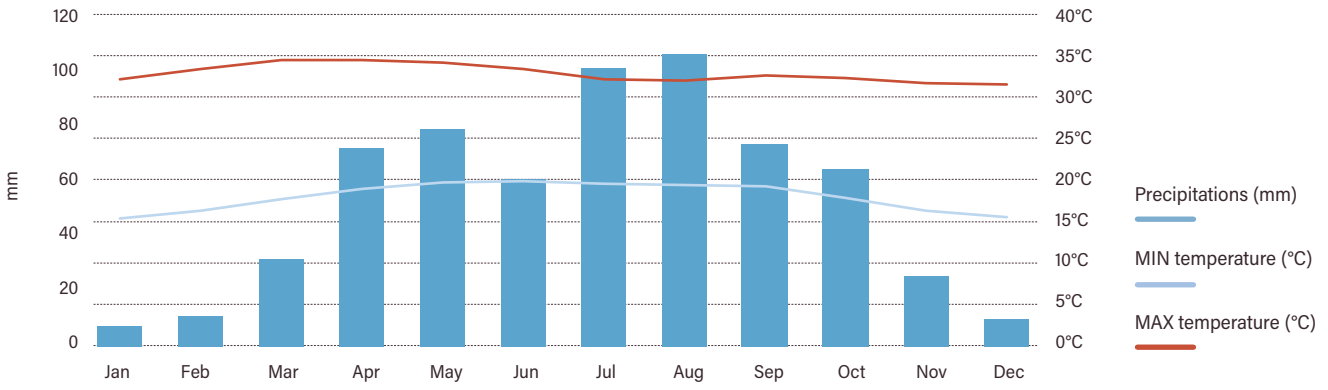
ETHIOPIA

GEOGRAPHICAL CONTEXT (Red hatched zone=GGW area)	
Administrative area (million ha)	**113.62**
Biophysical area (million ha)	**112.93**
Regions (number)	**11**
GGW area (million ha)	**12.82** (11.4 percent of total land)
Systematic sampling units	**13 004**

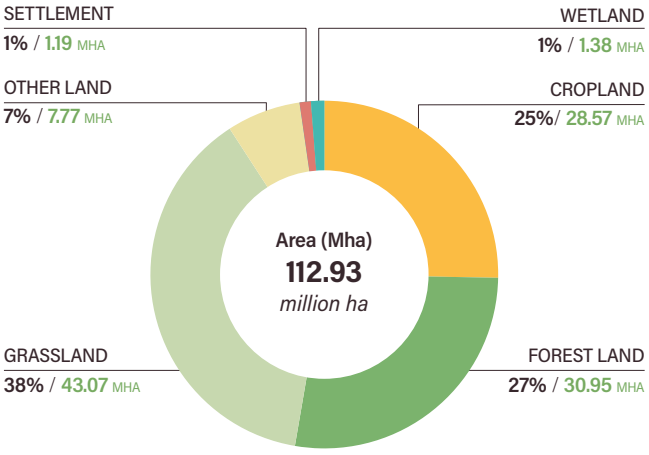
Source: All tables and figures of Ethiopia are FAO based on Africa Open DEAL database, 2019, unless referenced differently.

► CLIMATE CHART MONTHLY AVERAGES 1991–2019

Source: FAO based on Earth Map platform.



► LAND USE DISTRIBUTION (IPCC categories), 2019 (million ha)

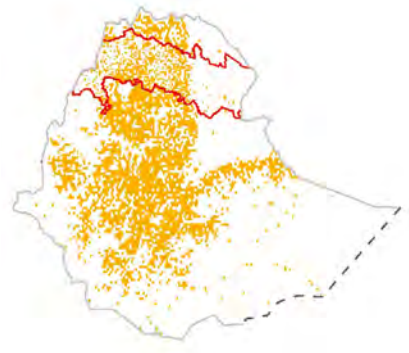


Ethiopia has a diverse climate ranging from equatorial rainforest with high rainfall and humidity in the south and southwest, to Afro-Alpine on the summits of the Simien and Bale Mountains, and desert-like conditions in the north-east, east and south-east lowlands. In areas between 1 500 and 2 500 m asl, temperatures range between 16°C and 30°C; in tropical and arid regions from 27°C to 50°C.

According to the Global Climate Risk Index (CRI), which focuses on the occurrence of extreme weather events, Ethiopia scored medium-low (class 51-100) in the period 2000–2019.

Ethiopia is covered by 28.6 million ha of cropland, 30.9 million ha of forest land and 43.1 million ha of grassland. In the GGW area, the share of cropland is higher (+2 percent) while grassland (–2 percent) and especially forest land (-17 percent) are lower.

► LAND USE MAPS

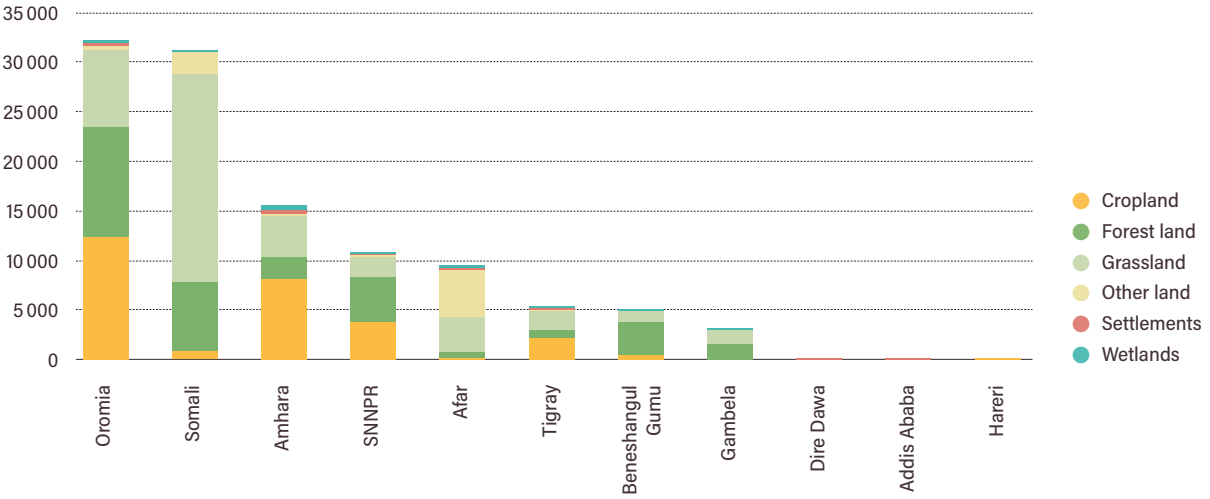


Cropland (25 percent)

Forest land (27 percent)

Grassland (38 percent)

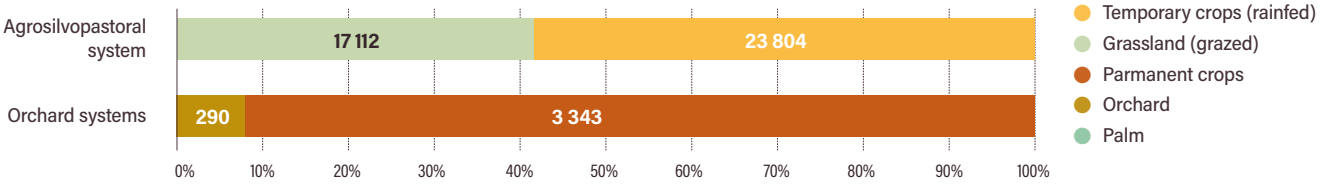
► LAND USE DISTRIBUTION BY REGION, 2019 (MILLION HA)



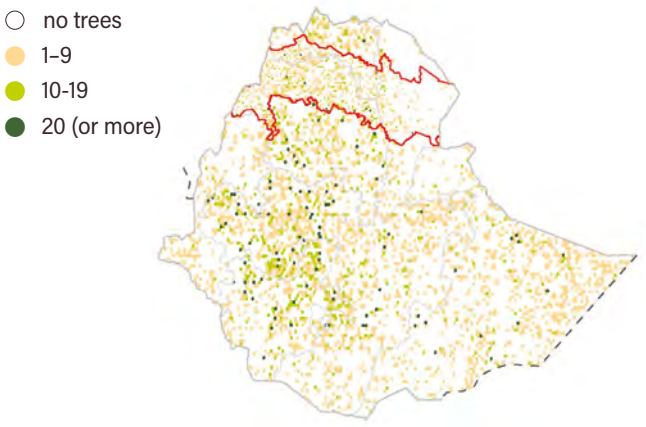
The largest province, Oromia is characterized by the largest portion of cropland (12.5 million ha) and forest land (11.1 million ha). Somali has the largest grassland (21.1 million ha).

36 percent of total land is an agrosilvopastoral system, with a prevalence of rainfed annual crops (58 percent). Almost all orchard systems are permanent crops (91 percent).

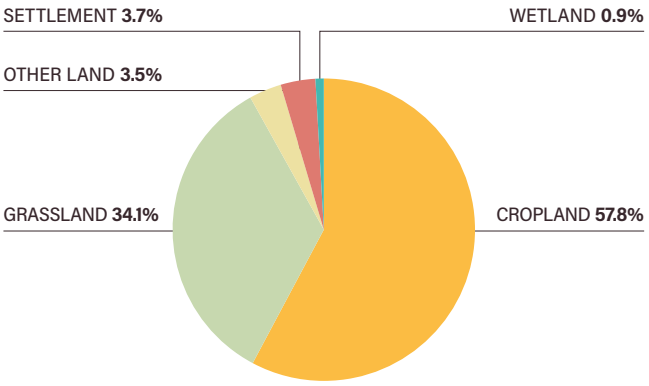
► AGROFORESTRY SYSTEMS, 2019 (000 HA)



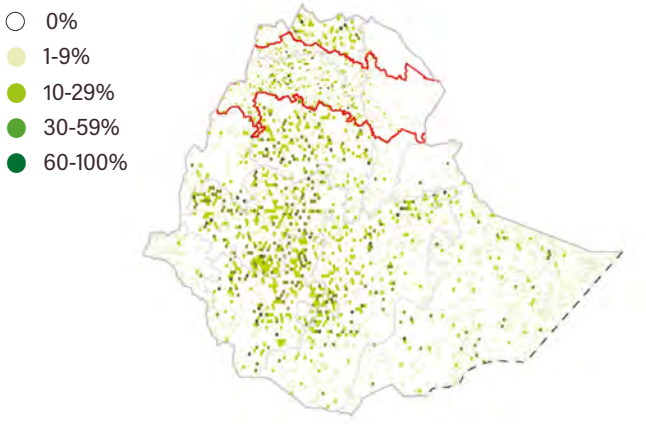
▶ TREE COUNT (/0.5 HA) IN NON-FOREST LAND, 2019



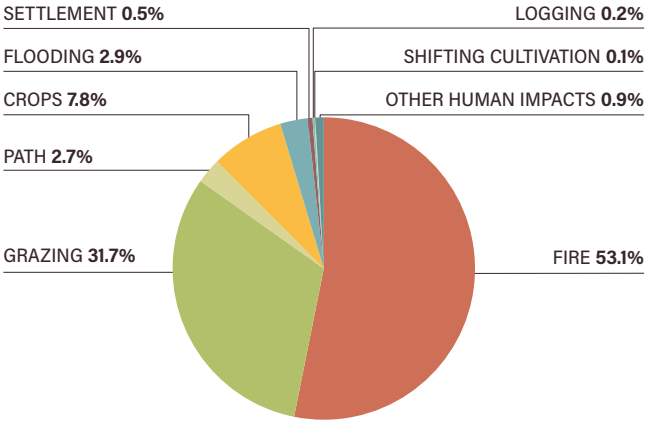
▶ DISTRIBUTION OF TREES IN NON-FOREST LAND



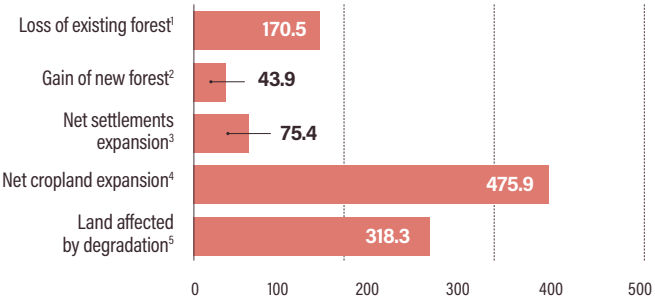
▶ TREE COVER (PERCENTAGE) IN NON-FOREST LAND, 2019



▶ PRIMARY OBSERVED DISTURBANCE FACTORS (FOREST/GRASSLAND) 2000-2019



▶ MAIN LAND USE CHANGES 2000-2019 (000 HA)



(1) *Any forest land lost to other land uses between 2000 and 2019*
(2) *Any non-forest land that became forest land between 2000 and 2019*
(3) *2019 minus 2000 settlement area*
(4) *2019 minus 2000 cropland area*
(5) *UNCCD-proposed default matrix for the assessment of SDG 15.3.1 land cover change sub-indicator between 2000 and 2019*

Ethiopia counts 406 million trees in non-forest land, 57.8 percent distributed in cropland. The average tree density in cropland and settlement is 8.2 and 12.7 trees/ha, as against 3.2 in grassland.

The average tree cover density is 9 percent in cropland, 2 percent in grassland is, 14 percent in settlement, and 60 percent in forest land.

The total area affected by primary human disturbances is 15.8 million ha (14 percent of total land). Fire is the prevalent disturbance (5 million ha in forest land and 3.1 million ha in grassland).

► RESTORATION POTENTIAL AND OPPORTUNITIES

Tree cover increase (percent)

- 0– 3.65
- 3.66– 8.76
- 8.77– 14.59
- 14.6– 21.52
- 21.53– 28.81
- 28.82– 36.84
- 36.85– 47.41
- 47.42– 93

Source: FAO based on Bastin *et al.*, 2019. Adapted from United Nations World map, 2020.

The total restorable area in Ethiopia is 69.6 million ha (62 percent of total land) with an average potential tree cover increase of 13.1 percent (9.1 million ha of cumulated canopy cover). The restorable land in the GGW area is 9.6 million ha, 75 percent of the total GGW area with an average potential tree cover increase of 15.9 percent (1.5 million ha of cumulated canopy cover).

In 2010, the carbon stock in living biomass (above and below ground) in Ethiopia was estimated at around 3.07 GtC. With restoration, the estimated potential carbon net gain ranges between -0.02 (low bound) and 0.57 (high bound) GtC. The negative low bound is due to the presence of habitats which might register higher carbon depletion from soil than the potential gain associated to restoration.

Somali and Oromia are the provinces with most restorable land, with 25.7 and 15 million ha respectively. However, Afar has the highest rate of restorable land compared to the total extent (97 percent). Addis Ababa has the highest potential average tree cover increase with 27.3 percent.

Ethiopia | KEY FACTS

BIOPHYSICAL

112.93 MILLION HA

11% is GGW area

LAND USE (2019)

28.6 MILLION HA CROPLAND

43.1 MILLION HA GRASSLAND

30.9 MILLION HA FOREST LAND

TREES IN NON-FOREST LAND

406 MILLION

58% in cropland with average 8 trees/ha

POPULATION (2020)*

112 078 730

2.6% annual growth

* Data based on the latest United Nations Population Division estimates 2020.

AGROSILVOPASTORAL SYSTEMS

40.9 MILLION HA

58% rainfed crop
42% grazed grassland

TREE COVER DENSITY

9% IN CROPLAND

2% IN GRASSLAND

14% IN SETTLEMENT

PRIMARY HUMAN DISTURBANCES

15.8 MILLION HA

58% fires

CHANGE 2000-2019 (000 HA)

-127 FOREST LAND

+75 SETTLEMENT

+476 CROPLAND

+318 DEGRADED USE

TREE RESTORATION POTENTIAL

69.6 MILLION HA

13.1% average tree cover increase (BASTIN *et al.*, 2019)

RESTORATION IN GGW

9.6 MILLION HA

15.9% average tree cover increase

CARBON STOCK (2010)

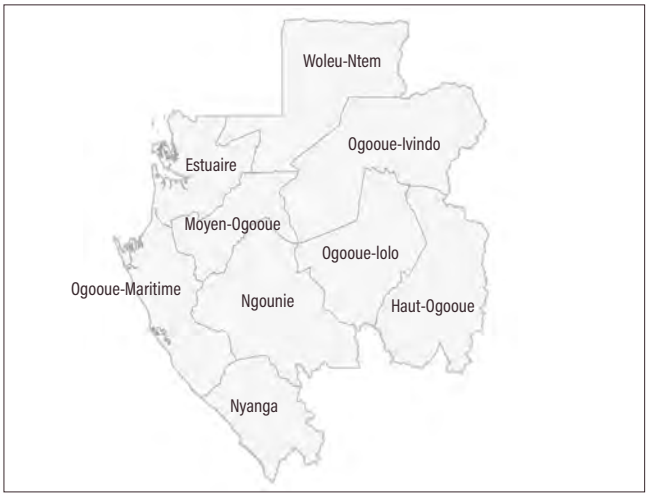
3.07 GtC FROM LIVING BIOMASS

0.27 GtC in GGW area

CARBON GAIN WITH RESTORATION

(-)18-574 GtC (RANGE)

(-)4-95 in GGW



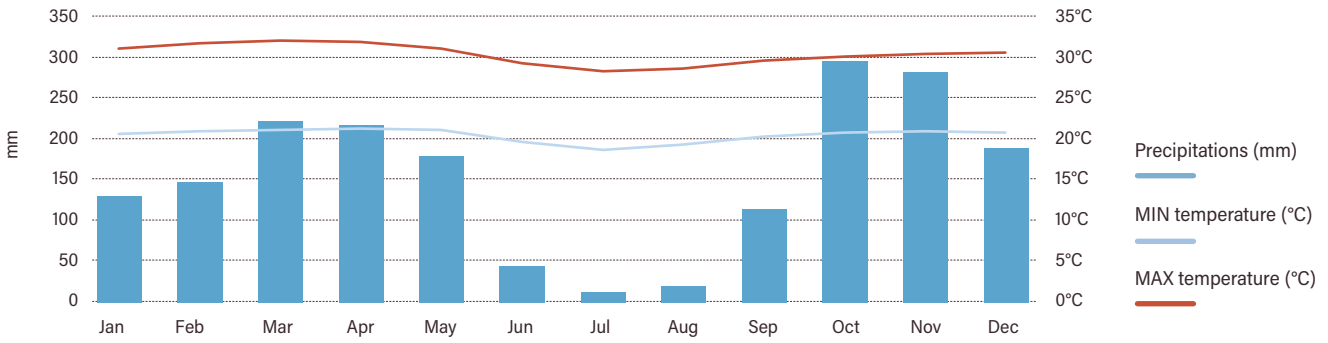
GABON

GEOGRAPHICAL CONTEXT (Red hatched zone=GGW area)	
Administrative area (million ha)	**26.77**
Biophysical area (million ha)	**26.40**
Regions (number)	**9**
GGW area (million ha)	**N/A**
Systematic sampling units	**20 644**

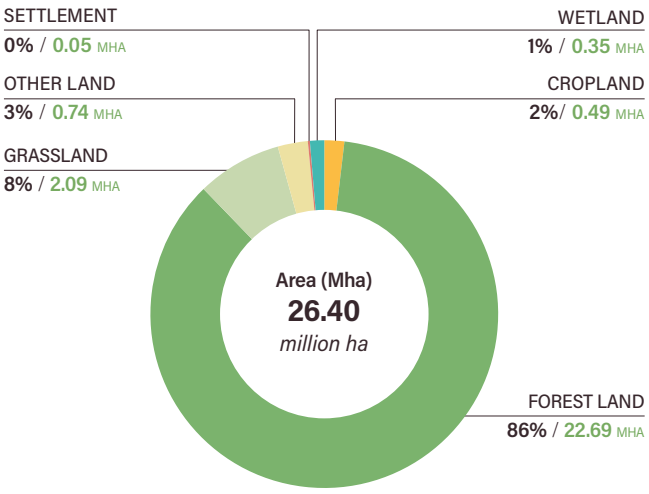
Source: All tables and figures of Gabon are FAO based on Africa Open DEAL database, 2019, unless referenced differently.

► CLIMATE CHART MONTHLY AVERAGES 1991–2019

Source: FAO based on Earth Map platform.



► LAND USE DISTRIBUTION (IPCC categories), 2019 (million ha)



Gabon has an equatorial climate, hot and humid year-round. The country is largely composed of plateaus and hills, covering 3/4 of the country. The average temperatures are between 26-32 °C. The period June-August is generally slightly cooler, while in the months of March-April the temperatures are higher. Gabon has two rainy and two drier periods. From June to September there is little or no rainfall, but humidity remains high. Precipitation is abundant, ranging from 1 500 millimeters (mm) to 3 500 mm per year and spread almost throughout the year.

According to the Global Climate Risk Index (CRI), which focuses on the occurrence of extreme weather events, Gabon scored low (class >100) in the period 2000–2019.

Gabon is covered by 0.5 million ha of cropland, 2.1 million ha of grassland, and 22.7 million ha of forest land (prevalent land use, 86 percent of total area). 3 percent of Gabon land is classified other land.

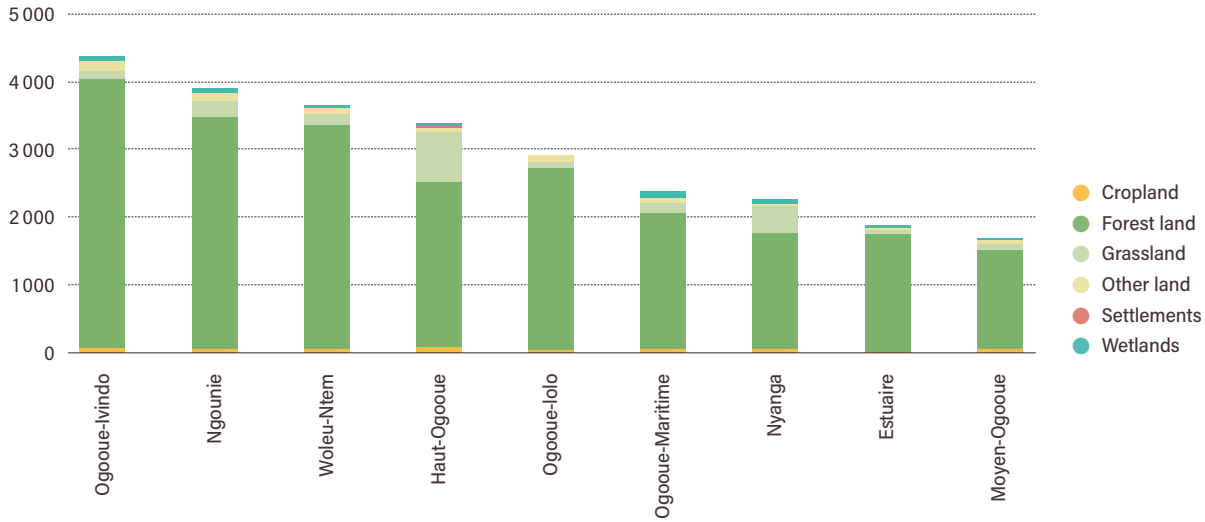
► LAND USE MAPS

Cropland (2 percent)

Forest land (86 percent)

Grassland (8 percent)

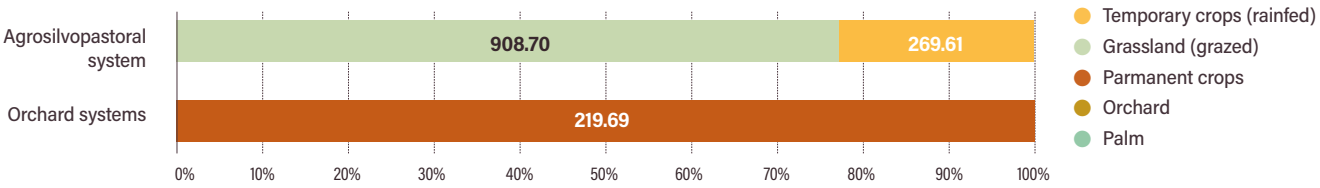
► LAND USE DISTRIBUTION BY REGION, 2019 (MILLION HA)



The largest province, Ogooue-Ivindo, is characterized by the largest portion of forest land (4 million ha). Haut-Ogooue has the largest cropland area (0.1 million ha) and the largest portion of grassland (0.7 million ha).

4 percent of total land is classified as an agrosilvopastoral system, shared between grazed grassland (77 percent) and rainfed annual crops (23 percent). Orchard systems, which cover 1 percent of total land in Gabon are only represented by permanent crops.

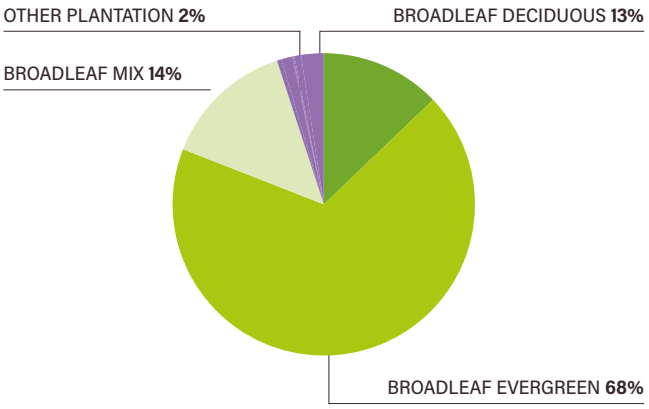
► AGROFORESTRY SYSTEMS, 2019 (000 HA)



FOREST LAND SUBDIVISIONS, 2019

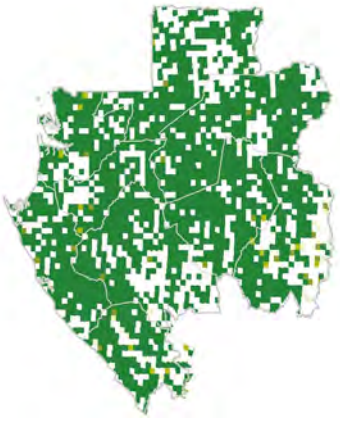
- Broadleaf deciduous
- Broadleaf evergreen
- Broadleaf mixed
- Coniferous deciduous
- Coniferous evergreen
- Coniferous mixed
- Mixed forest (broadleaf-coniferous)
- Acacia plantation
- Coniferous plantation
- Eucalyptus plantation
- Other plantations
- Mangrove forest
- Riparian forest

SHARE OF FOREST LAND SUBDIVISIONS

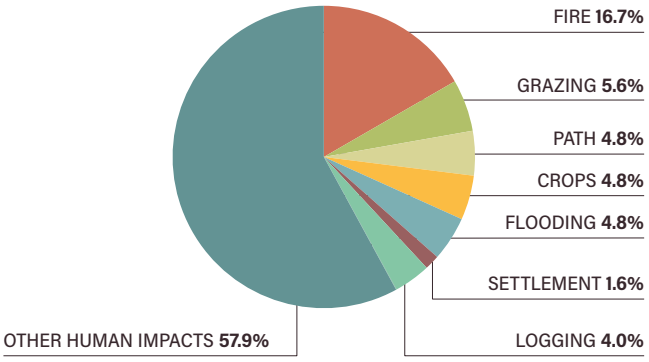


TREE COUNT (NUMBER/0.5 HA), 2019

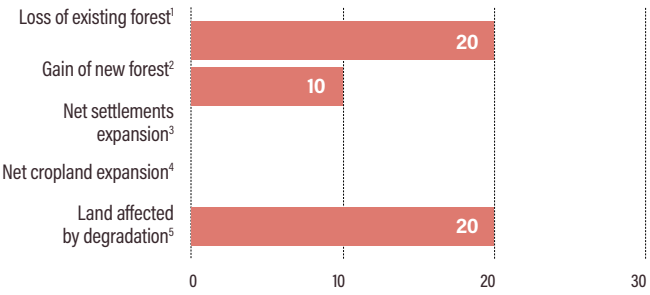
- 0%
- 1-9%
- 10-29%
- 30-59%
- 60-100%



PRIMARY OBSERVED DISTURBANCE FACTORS (FOREST/GRASSLAND) 2000-2019



MAIN LAND USE CHANGES 2000-2019 (000 HA)



(1) *Any forest land lost to other land uses between 2000 and 2019*
(2) *Any non-forest land that became forest land between 2000 and 2019*
(3) *2019 minus 2000 settlement area*
(4) *2019 minus 2000 cropland area*
(5) *UNCCD-proposed default matrix for the assessment of SDG 15.3.1 land cover change sub-indicator between 2000 and 2019*

Gabon is mainly covered by forest land (86 percent of biophysical area). 95 percent of this land is broadleaf type (deciduous and/or evergreen), 2 percent is plantation (0.5 million ha).

The total estimated number of trees is more than 1 billion, of which 99 is percent in forest land. The average tree density in non-forest land is very low (2 or less trees/ha), except in settlement where it shows values of 31 trees/ha.

The total area affected by primary human disturbances is 1.3 million ha (5 percent of total land). "Other" is the prevalent disturbance. 0.2 million ha are affected by fires, nearly equally distributed between forest land and grassland.

► RESTORATION POTENTIAL AND OPPORTUNITIES

Source: FAO based on Bastin *et al.*, 2019. Adapted from United Nations World map, 2020.

The total restorable area in Gabon is 5.1 million ha (19 percent of total land) with an average potential tree cover increase of 10 percent (0.51 million ha of cumulated canopy cover).

In 2010, the carbon stock in living biomass (above and below ground) in Gabon was estimated at around 4.38 GtC (average density 167 tC/ha), while the soil carbon stock is estimated in 5.49 GtC (average density 209 tC/ha). With restoration, the estimated potential carbon net gain ranges between 0.007 (low bound) and 0.040 (high bound) GtC.

Woleu-Ntem and Haut-Ogooue are the provinces with most restorable land, with 1.1 and 0.9 million ha respectively. Haut-Ogooue is also the province with the highest potential average canopy cover increase from restoration, with 20 percent.

Gabon | KEY FACTS

BIOPHYSICAL
26.40 MILLION HA

0% is GGW area

LAND USE (2019)
0.5 MILLION HA CROPLAND

2.1 MILLION HA GRASSLAND

22.7 MILLION HA FOREST LAND

TREES IN NON-FOREST LAND
7.1 MILLION

1% in cropland
52% in grassland

POPULATION (2020)*
2 172 579

2.5% annual growth

* Data based on the latest United Nations Population Division estimates 2020.

AGROSILVOPASTORAL SYSTEMS
1.2 MILLION HA

77% grazed grassland

TREE COVER DENSITY
0.1% IN CROPLAND

0.9% IN GRASSLAND

34% IN SETTLEMENT

PRIMARY HUMAN DISTURBANCES
1.26 MILLION HA

58% other

CHANGE 2000-2019 (000 HA)
-10 FOREST LAND

0 SETTLEMENT

0 CROPLAND

+20 DEGRADED USE

TREE RESTORATION POTENTIAL
5.1 MILLION HA

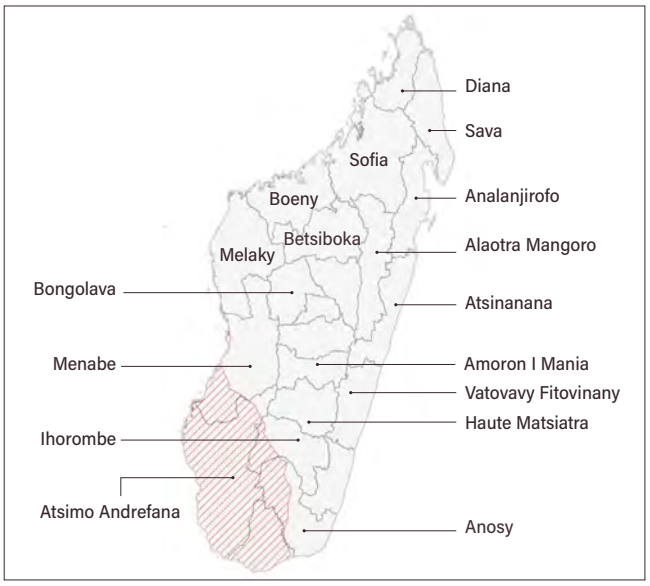
10% average tree cover increase

RESTORATION IN GGW
0 MILLION HA

CARBON STOCK (2010)
4 378 GtC FROM LIVING BIOMASS

CARBON GAIN WITH RESTORATION
7-40 GtC (RANGE)

(-)4-95 in GGW



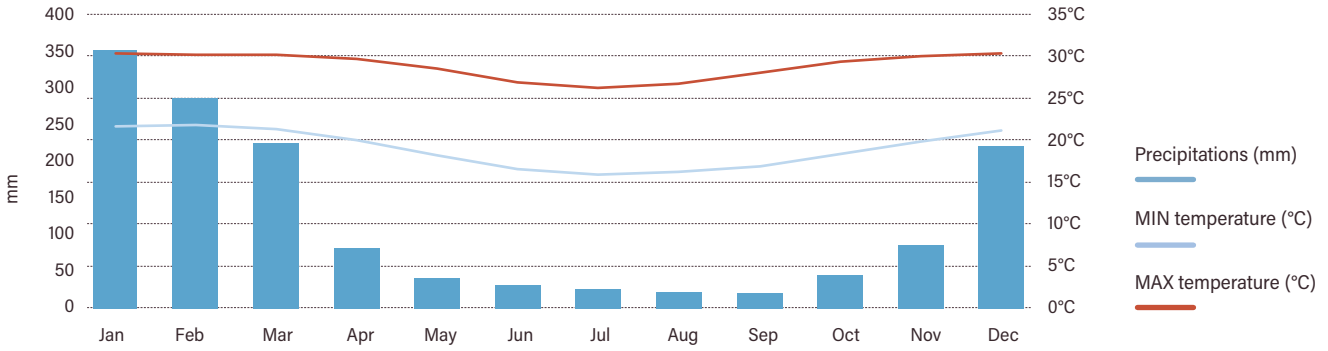
MADAGASCAR

GEOGRAPHICAL CONTEXT (Red hatched zone=GGW area)	
Administrative area (million ha)	**58.73**
Biophysical area (million ha)	**57.94**
Regions (number)	**22**
GGW area (million ha)	**11.05** (19.1 percent of total land)
Systematic sampling units	**23 724**

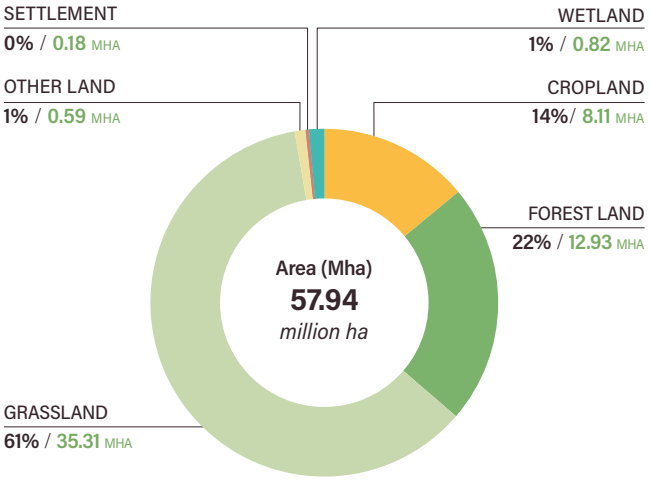
Source: All tables and figures of Madagascar are FAO based on Africa Open DEAL database, 2019, unless referenced differently.

▶ CLIMATE CHART MONTHLY AVERAGES 1991-2019

Source: FAO based on Earth Map platform.



▶ LAND USE DISTRIBUTION (IPCC categories), 2019 (million ha)

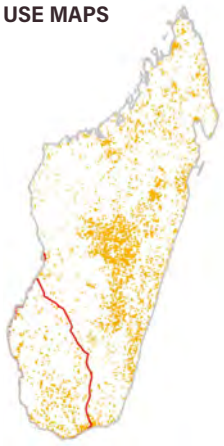


The climate of Madagascar is subtropical, with a hot and rainy season between November and March and a cooler dry season from May to October. The west coast is drier than the east coast, while the far south and southwest is a semi-desert region that experiences very little rainfall. Temperatures are cooler in the highlands.

According to the Global Climate Risk Index (CRI), which focuses on the occurrence of extreme weather events, Madagascar scored high (class 11–20) in the period 2000–2019.

Madagascar is covered by 8.1 million ha of cropland, 12.9 million ha of forest land and 35.3 million ha of grassland. In the GGW area, the share of forest land is higher (+5 percent) while grassland (–2 percent) and cropland (-3 percent) are lower.

► LAND USE MAPS

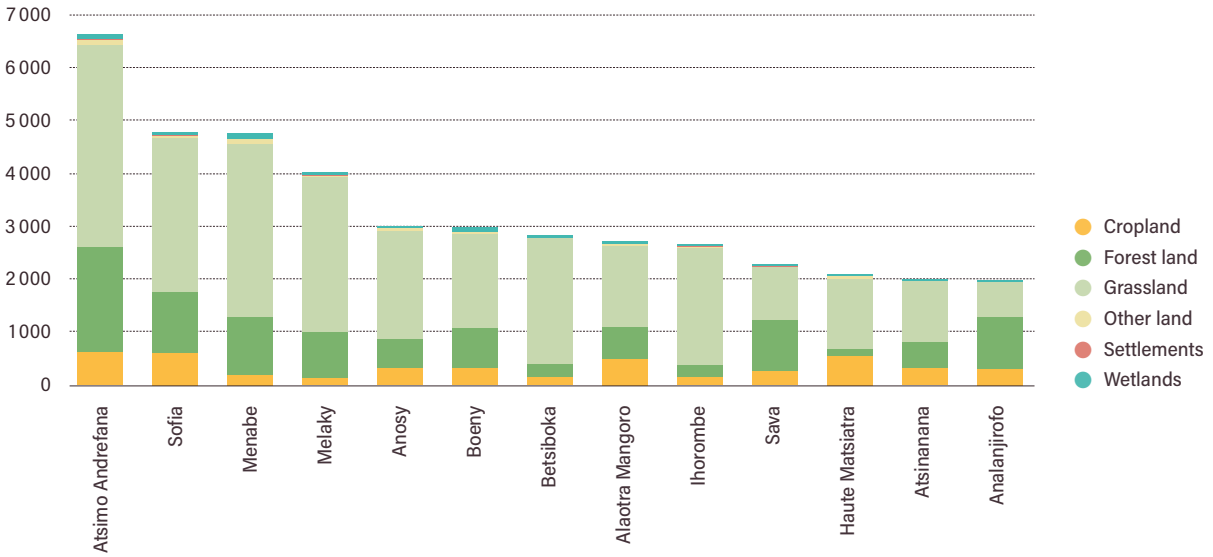


Cropland (14 percent)

Forest land (22 percent)

Grassland (61 percent)

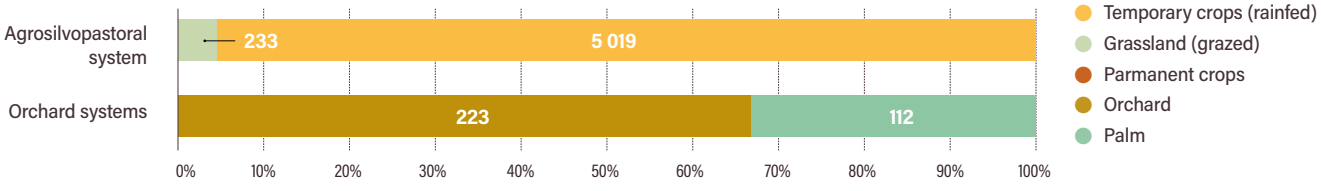
► LAND USE DISTRIBUTION BY REGION, 2019 (MILLION HA)



Atsimo Andrefana (the largest province) is characterized by the largest portion of grassland and forest land (3.8 and 2 Mha). Vakinankaratra has the largest cropland (0.7 Mha).

Annual rainfed crops represent 96 percent of all agrosilvopastoral systems (9 percent of total land). Orchard systems make up only 1 percent of total land.

► AGROFORESTRY SYSTEMS, 2019 (000 HA)



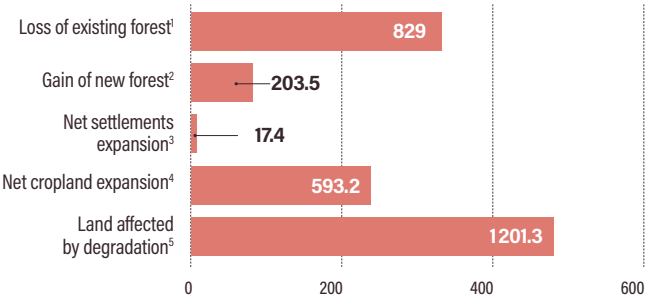
TREE COUNT (/0.5 HA) IN NON-FOREST LAND, 2019

- no trees
- 1–9
- 10-19
- 20 (or more)

TREE COVER (PERCENTAGE) IN NON-FOREST LAND, 2019

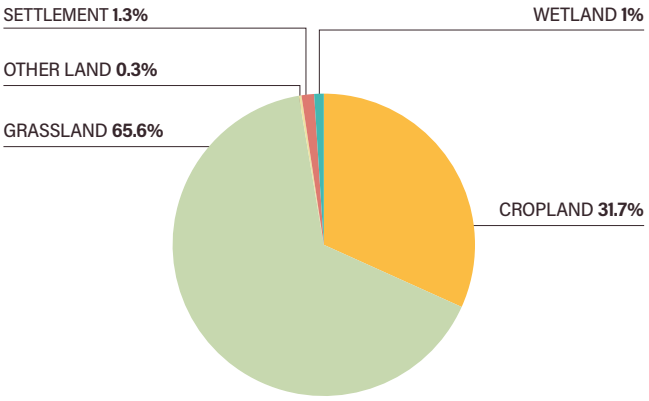
- 0%
- 1-9%
- 10-29%
- 30-59%
- 60-100%

MAIN LAND USE CHANGES 2000-2019 (000 HA)

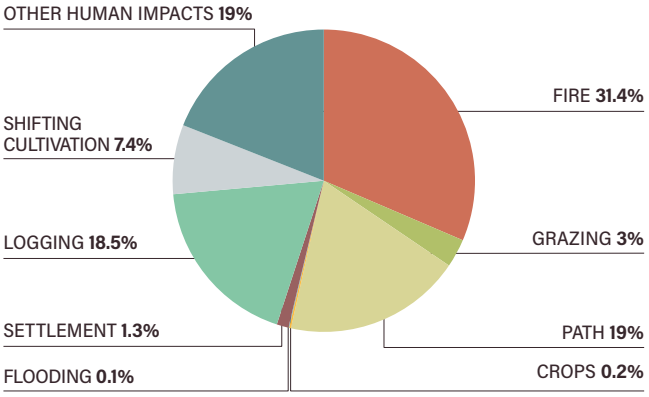


(1) *Any forest land lost to other land uses between 2000 and 2019*
(2) *Any non-forest land that became forest land between 2000 and 2019*
(3) *2019 minus 2000 settlement area*
(4) *2019 minus 2000 cropland area*
(5) *UNCCD-proposed default matrix for the assessment of SDG 15.3.1 land cover change sub-indicator between 2000 and 2019*

DISTRIBUTION OF TREES IN NON-FOREST LAND



PRIMARY OBSERVED DISTURBANCE FACTORS (FOREST/GRASSLAND) 2000-2019

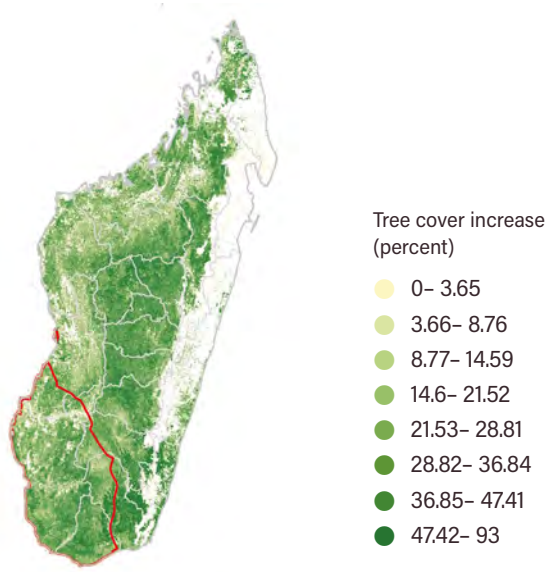


Madagascar counts 142 million trees in non-forest land, 66 percent in grassland and 32 percent in cropland. The average tree density in cropland and settlement is 5.6 and 10.8 trees/ha, while it is 2.6 in grassland.

The average tree cover density is 5 percent in cropland, 2 percent in grassland, 8 percent, in settlement, and 69 percent in forest land.

The total area affected by primary human disturbances is 6.3 million ha (11 percent of total land). Fire is the prevalent disturbance (1.82 million ha of grassland and 0.15 million ha of forest land).

► RESTORATION POTENTIAL AND OPPORTUNITIES



Source: FAO based on Bastin *et al.*, 2019. Adapted from United Nations World map, 2020.

The total restorable area in Madagascar is 45.9 million ha (79 percent of total land) with an average potential tree cover (TC) increase of 29.6 percent (13.6 million ha of cumulated canopy cover). The restorable land in the GGW area is 10.5 million ha, 95 percent of the total GGW area, with an average potential tree cover increase of 29.5 percent (3.1 million ha of cumulated canopy cover).

In 2010, the carbon stock in living biomass (above and below ground) in Madagascar was estimated at around 2.2 GtC (0.28 GtC in GGW area). With restoration, the estimated potential carbon net gain ranges between 0.124 (low bound) and 1.004 (high bound) GtC (0.061-0.263 GtC in GGW area).

Atsimo Andrefana, Menabe and Sofia are the provinces with most restorable land, with 6.3, 4.4 and 4 million ha respectively. Atsimo Atsinanana has the highest potential average tree cover increase from restoration with 41.6 percent.

Madagascar | KEY FACT

BIOPHYSICAL
57.94 MILLION HA

19.1% is GGW area

LAND USE (2019)
8 MILLION HA CROPLAND

35 MILLION HA GRASSLAND

13 MILLION HA FOREST LAND

TREES IN NON-FOREST LAND
142 MILLION

32% in cropland with average 6 trees/ha

POPULATION (2020)*
26 969 307

2.7% annual growth

* Data based on the latest United Nations Population Division estimates 2020.

AGROSILVOPASTORAL SYSTEMS
5.3 MILLION HA

96% annual rainfed crops

TREE COVER DENSITY
5.4% IN CROPLAND

1.6% IN GRASSLAND

8.1% IN SETTLEMENT

PRIMARY HUMAN DISTURBANCES
6.3 MILLION HA

31% fires

CHANGE 2000-2019 (MILLION HA)
-0.63 FOREST LAND

+0.02 SETTLEMENT

+0.59 CROPLAND

+1.2 DEGRADED USE

TREE RESTORATION POTENTIAL
46 MILLION HA

29.6% average tree cover increase

RESTORATION IN GGW
10.5 MILLION HA

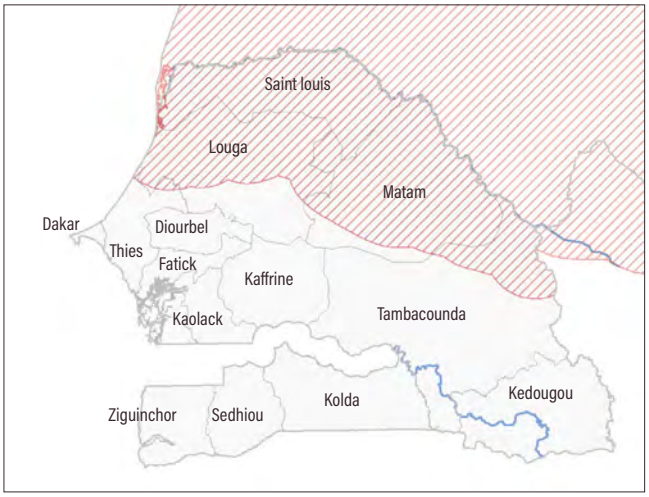
29.5% average tree cover increase

CARBON STOCK (2010)
2.21 GtC FROM LIVING BIOMASS

0.28 in GGW area

CARBON GAIN WITH RESTORATION
0.12-1.00 GtC (RANGE)

0.06-0.26 in GGW area



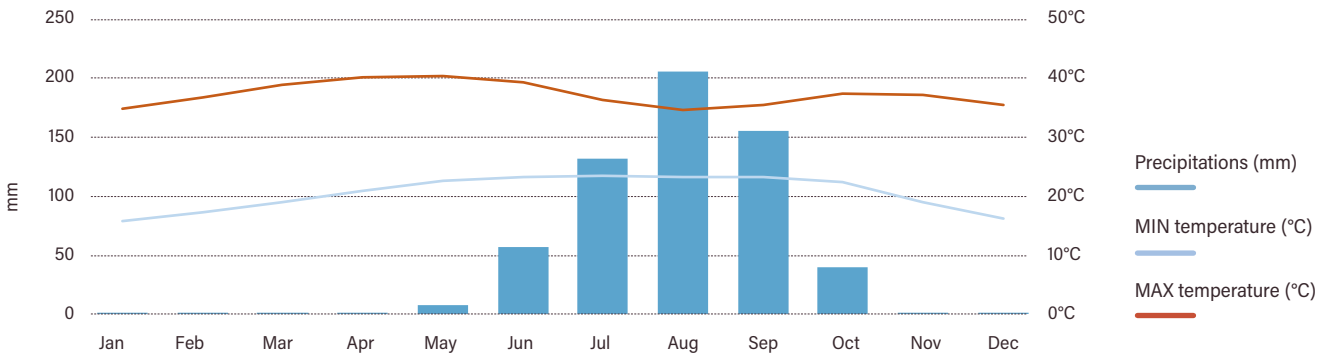
SENEGAL

GEOGRAPHICAL CONTEXT (Red hatched zone=GGW area)	
Administrative area (million ha)	**19.67**
Biophysical area (million ha)	**19.62**
Regions (number)	**14**
GGW area (million ha)	**7.03** (35.8 percent of total land)
Systematic sampling units	**3 550**

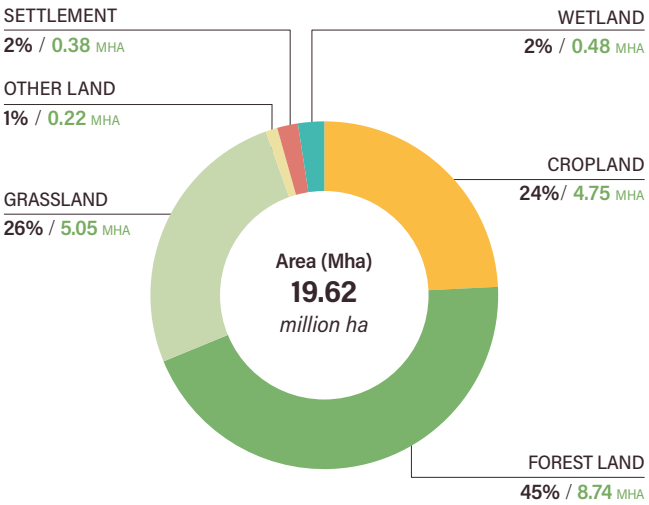
Source: All tables and figures of Senegal are FAO based on Africa Open DEAL database, 2019, unless referenced differently.

▶ CLIMATE CHART MONTHLY AVERAGES 1991–2019

Source: FAO based on Earth Map platform.



▶ LAND USE DISTRIBUTION (IPCC categories), 2019 (million ha)



While the majority of Senegal has a tropical climate, the country's northern regions (located in the Sahel) are arid. The country experiences one long rainy season, which varies along a latitudinal gradient (north-south). While the arid zones receive rainfall of under 300 mm/year, the forested south receives an average of 1 200 mm/year. The average annual temperature for Senegal is 28.9°C in the period 1991–2019, with monthly averages in the hottest seasons of up to 40°C.

According to the Global Climate Risk Index (CRI), which focuses on the occurrence of extreme weather events, Senegal scored low (class >100) in the period 2000–2019.

Senegal is covered by 4.7 million ha of cropland, 8.7 million ha of forest land and 5.1 million ha of grassland. In the GGW area, the share of grassland is higher (+16 percent) at the expense of forest land (-7 percent) and cropland (-9 percent).

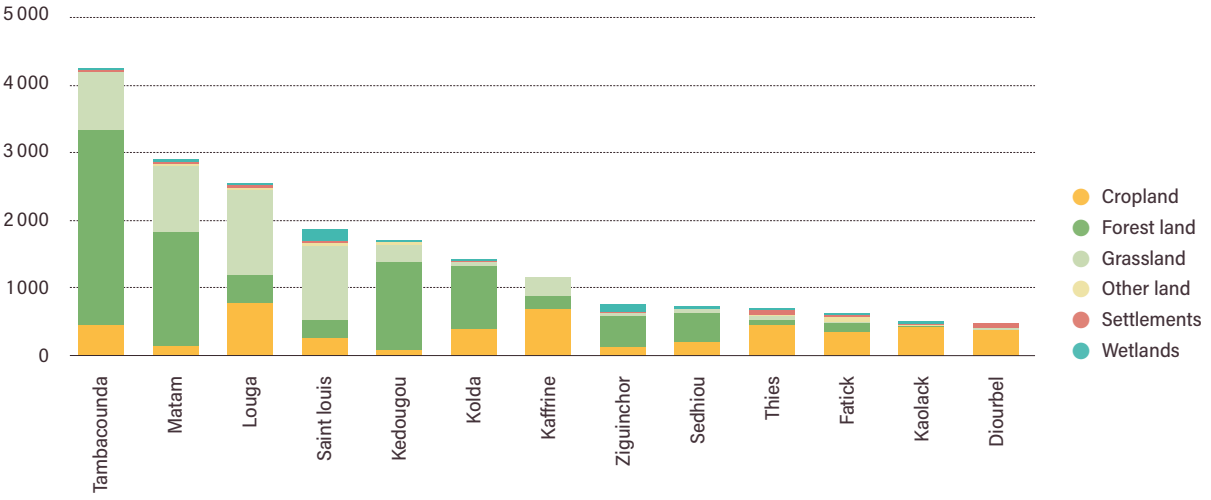
► LAND USE MAPS

Cropland (24 percent)

Forest land (45 percent)

Grassland (26 percent)

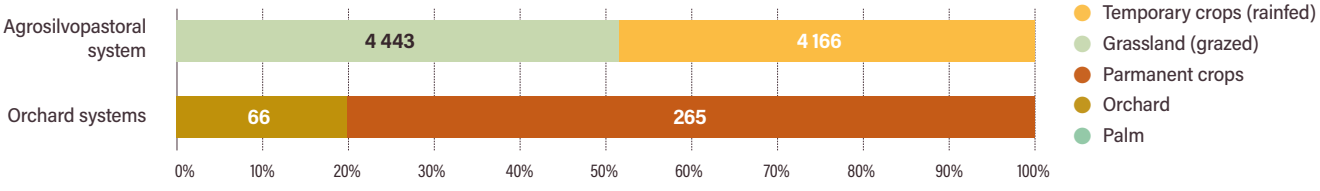
► LAND USE DISTRIBUTION BY REGION, 2019 (MILLION HA)



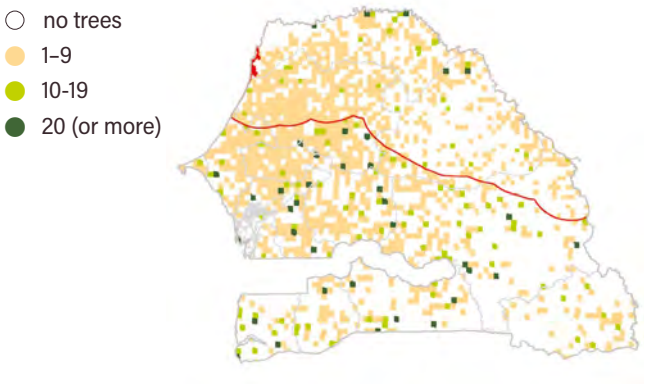
Tambacounda (largest province, 4.25 Mha) is characterized by the largest share of forest land (2.9 Mha). Louga has the largest cropland (0.78 Mha) and the largest grassland (1.27 Mha).

Agrosilvopastoral systems cover 8.6 million ha (44 percent of total land). The orchard systems represent 2 percent of total land (0.33 million ha).

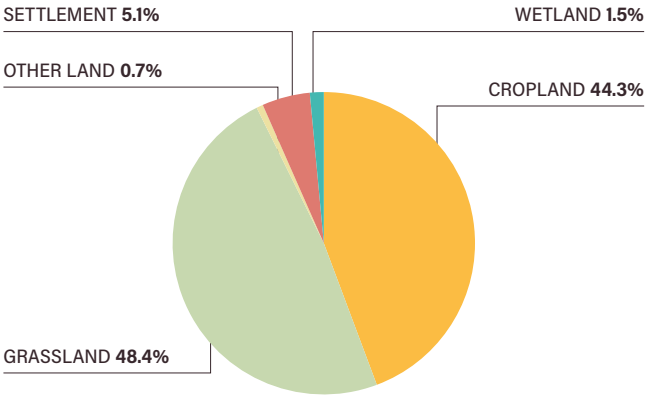
► AGROFORESTRY SYSTEMS, 2019 (000 HA)



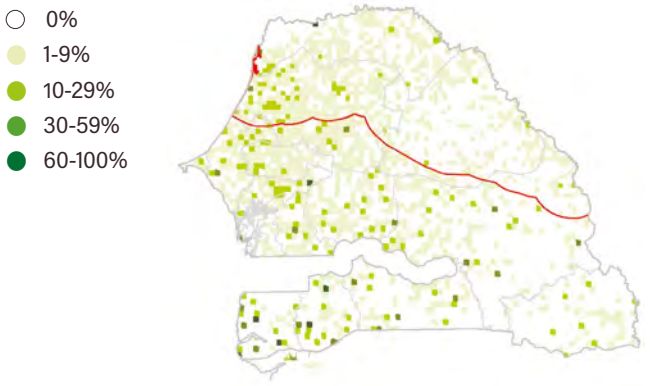
▶ TREE COUNT (/0.5 HA) IN NON-FOREST LAND, 2019



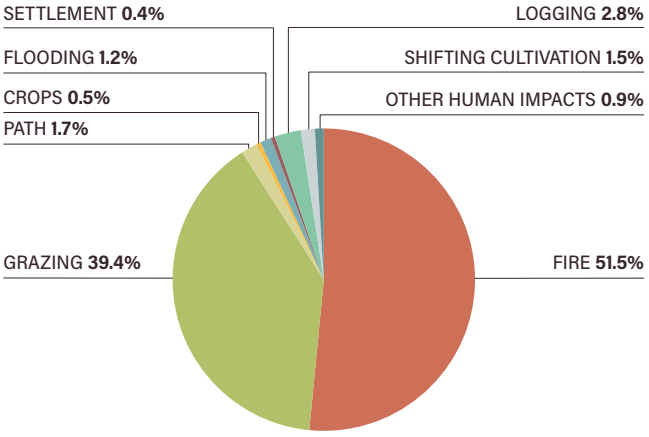
▶ DISTRIBUTION OF TREES IN NON-FOREST LAND



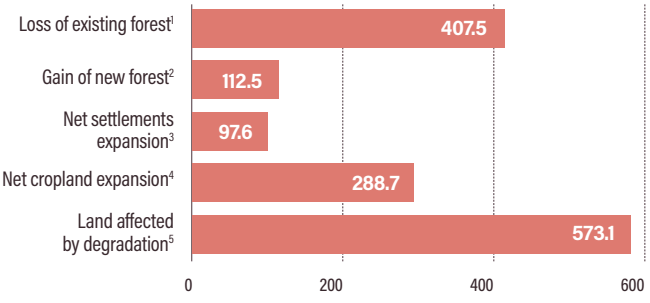
▶ TREE COVER (PERCENTAGE) IN NON-FOREST LAND, 2019



▶ PRIMARY OBSERVED DISTURBANCE FACTORS (FOREST/GRASSLAND) 2000-2019



▶ MAIN LAND USE CHANGES 2000-2019 (000 HA)



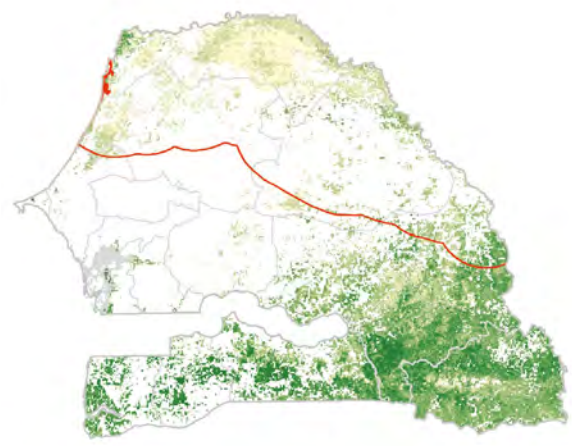
(1) *Any forest land lost to other land uses between 2000 and 2019*
(2) *Any non-forest land that became forest land between 2000 and 2019*
(3) *2019 minus 2000 settlement area*
(4) *2019 minus 2000 cropland area*
(5) *UNCCD-proposed default matrix for the assessment of SDG 15.3.1 land cover change sub-indicator between 2000 and 2019*

Senegal counts 83 million trees in non-forest land (17.6 percent of total number of trees), of which 44.3 percent are concentrated in cropland and 48.4 percent in grassland. The average tree density in cropland and settlement is 7.7 and 11.2 trees/ha, while it is 7.9 in grassland.

The average tree cover density is 6 percent in cropland, 4 percent in grassland, 10 percent in settlement and 44.3 percent in forest land.

The total area affected by primary human disturbances is 10.9 million ha (56 percent of total land). Fire is the prevalent disturbance (5.6 million ha).

► RESTORATION POTENTIAL AND OPPORTUNITIES



Tree cover increase (percent)

- 0– 3.65
- 3.66– 8.76
- 8.77– 14.59
- 14.6– 21.52
- 21.53– 28.81
- 28.82– 36.84
- 36.85– 47.41
- 47.42– 93

Source: FAO based on Bastin *et al.*, 2019. Adapted from United Nations World map, 2020.

The total restorable area in Senegal is 7.3 million ha (37 percent of total land) with an average potential tree cover (TC) increase of 23.7 percent (1.75 million ha of cumulated canopy cover). The restorable land in the GGW area is 2.1 million ha, 30 percent of the total GGW area with an average potential tree cover increase of 9.7 percent (208 000 ha of CCC).

In 2010, the carbon stock in living biomass (above and below ground) was estimated at around 0.219 GtC (0.034 GtC in the GGW area). With restoration, the estimated potential carbon net gain ranges between 0.017 (low bound) and 0.130 (high bound) GtC (0.005-0.018 GtC in the GGW area).

Tambacounda and Kedougou are the provinces with most restorable land, with 2.51 and 1.46 million ha respectively, and also the highest rate compared to the other provinces. Sedhiou and Ziguinchor have the highest potential increase of tree cover through restoration with 46 percent and 38 percent.

Senegal | KEY FACT

BIOPHYSICAL

19.62 MILLION HA

39% is GGW area

LAND USE (2019)

4.7 MILLION HA CROPLAND

5 MILLION HA GRASSLAND

8.7 MILLION HA FOREST LAND

TREES IN NON-FOREST LAND

82.5 MILLION

44% in cropland
with average 8 trees/ha

POPULATION (2020)*

16 296 364

2.7% annual growth

* Data based on the latest United Nations Population Division estimates 2020.

AGROSILVOPASTORAL SYSTEMS

8.6 MILLION HA

48% rainfed crops
52% grazed grassland

TREE COVER DENSITY

6% IN CROPLAND

4% IN GRASSLAND

10% IN SETTLEMENT

PRIMARY HUMAN DISTURBANCES

11 MILLION HA

51% fires

CHANGE 2000-2019 (000 HA)

-295 FOREST LAND

+98 SETTLEMENT

+289 CROPLAND

+573 DEGRADED USE

TREE RESTORATION POTENTIAL

7.3 MILLION HA

23.7% average tree cover increase

RESTORATION IN GGW

2.1 MILLION HA

9.7% average tree cover increase

CARBON STOCK (2010)

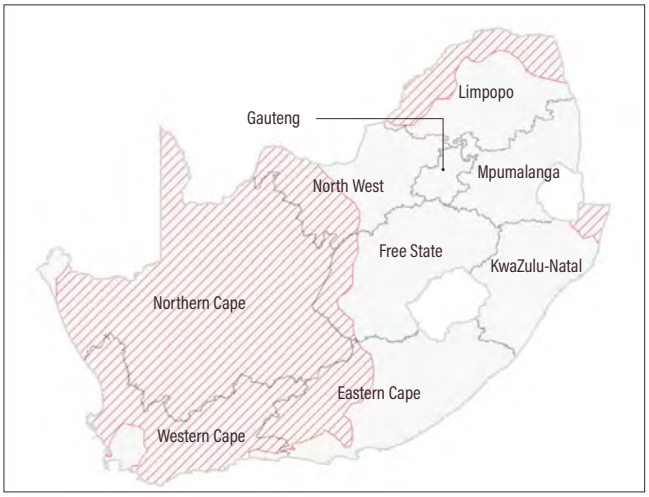
219 GtC FROM LIVING BIOMASS

34.1 in GGW area

CARBON GAIN WITH RESTORATION

17.1-130.4 GtC (RANGE)

4.6-18.1 in GGW



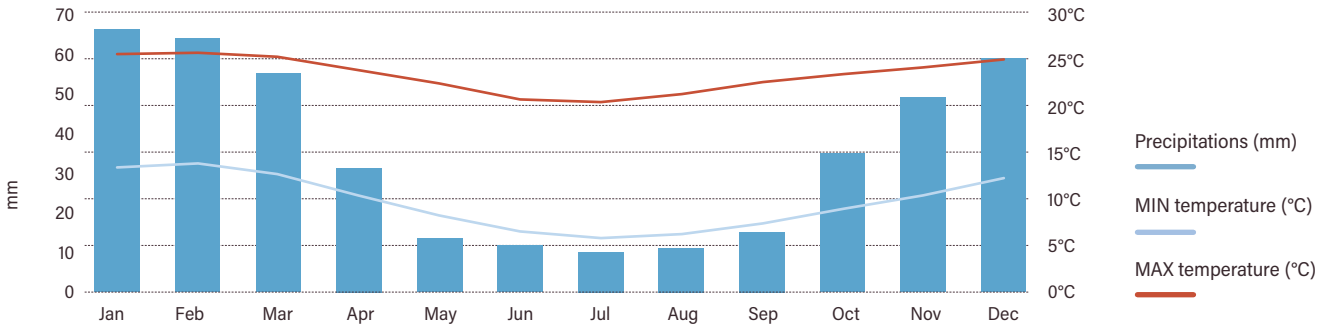
SOUTH AFRICA

GEOGRAPHICAL CONTEXT (Red hatched zone=GGW area)	
Administrative area (million ha)	**122.10**
Biophysical area (million ha)	**121.17**
Regions (number)	**9**
GGW area (million ha)	**64.92** (53.6 percent of total land)
Systematic sampling units	**9 087**

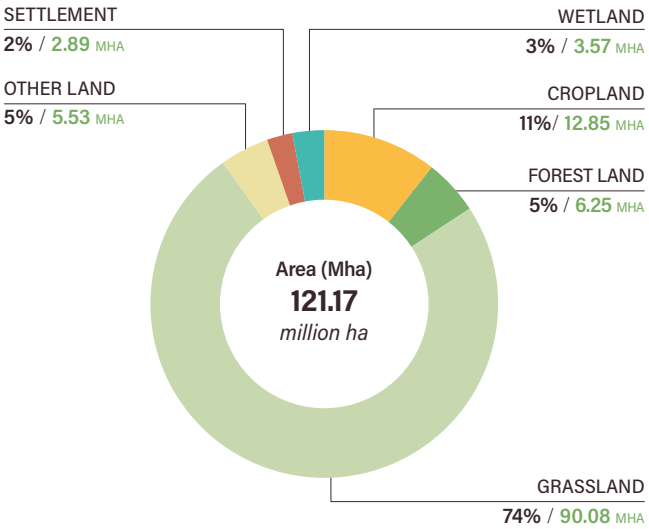
Source: All tables and figures of South Africa are FAO based on Africa Open DEAL database, 2019, unless referenced differently.

▶ CLIMATE CHART MONTHLY AVERAGES 1991-2019

Source: FAO based on Earth Map platform.



▶ LAND USE DISTRIBUTION (IPCC categories), 2019 (million ha)



South Africa's climatic conditions generally range from Mediterranean in the south-western corner of the country to temperate in the interior plateau, and subtropical in the north-east. South Africa is a relatively dry country, with an average annual rainfall of about 464 mm. Temperatures tend to be lower than surrounding countries: the average high is 28°C while the average low is **°8C in the summer months**. Winter temperatures range from 1°C at night to around 18°C in the day. Coastal regions are relatively warmer in winter.

According to the Global Climate Risk Index (CRI), which focuses on the occurrence of extreme weather events, South Africa scored medium-low (class 51-100) in the period 2000–2019.

South Africa is covered by 12.8 million ha of cropland, 6.2 million ha of forest land and 90.1 million ha of grassland. In the GGW area, the share of cropland and forest land is lower (-6 percent and -3 percent respectively) while grassland is higher (+9 percent).

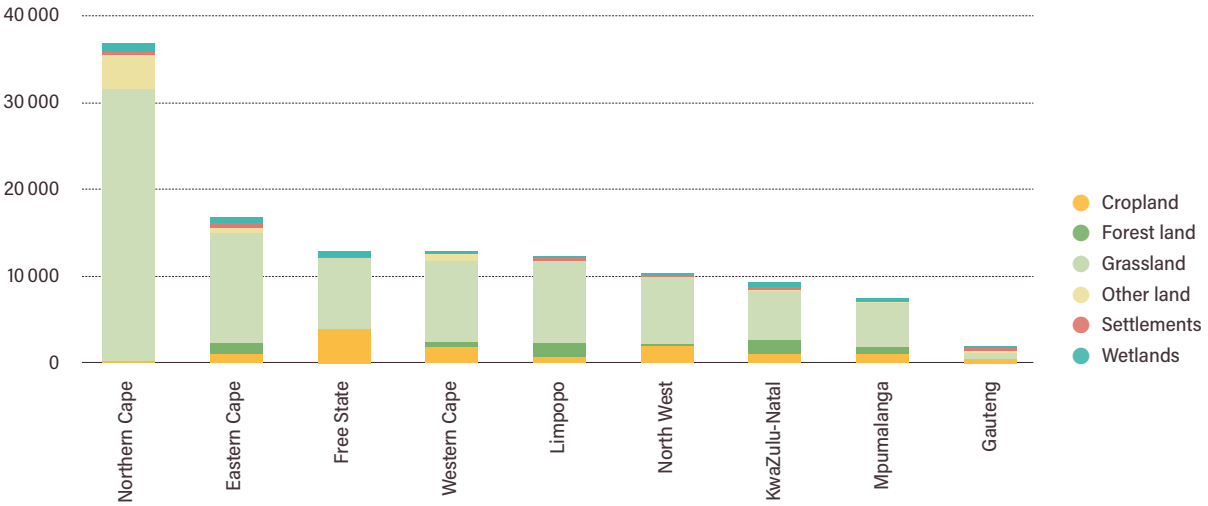
► LAND USE MAPS

Cropland (11 percent)

Forest land (5 percent)

Grassland (74 percent)

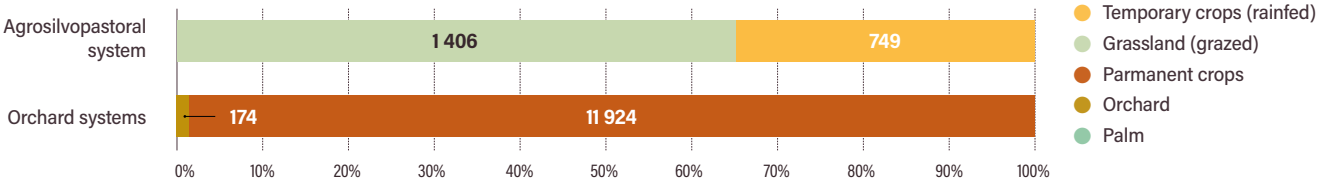
► LAND USE DISTRIBUTION BY REGION, 2019 (MILLION HA)



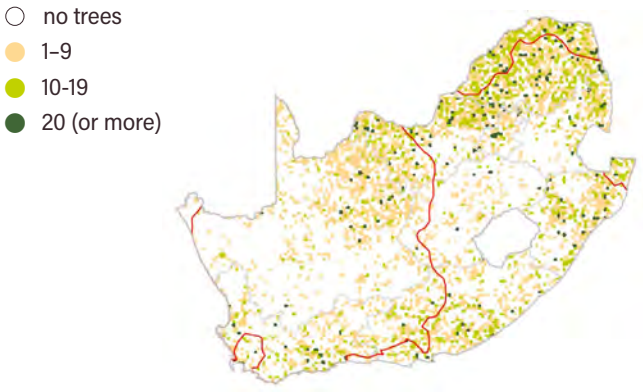
The largest province, Northern Cape, is characterized by the largest portion of grassland (31.4 million ha). Free State has the largest cropland (4 million ha) and KwaZulu-Natal the largest portion of forest land (1.6 million ha).

Only 2 percent of total land is agrosilvopastoral system, with a prevalence of grazed grassland (65 percent). Most orchard systems (10 percent of total land) are permanent crops (99 percent).

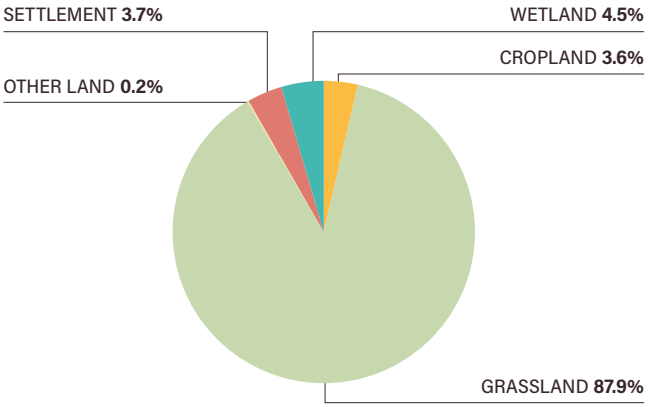
► AGROFORESTRY SYSTEMS, 2019 (000 HA)



► TREE COUNT (/0.5 HA) IN NON-FOREST LAND, 2019

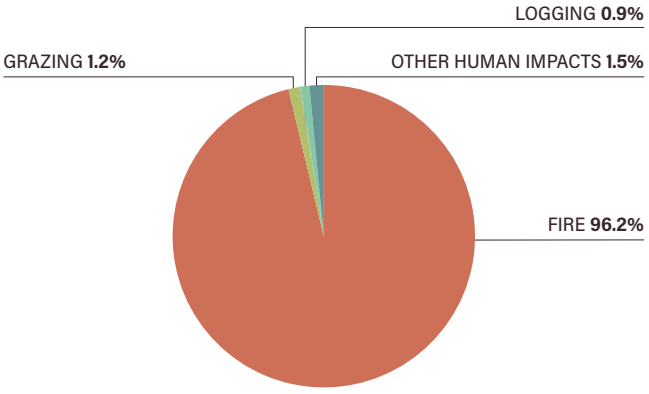


► DISTRIBUTION OF TREES IN NON-FOREST LAND

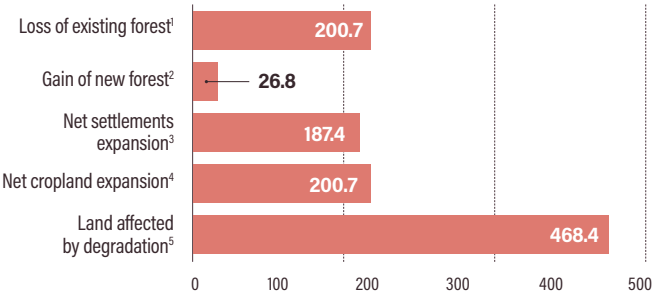


► TREE COVER (PERCENTAGE) IN NON-FOREST LAND, 2019

► PRIMARY OBSERVED DISTURBANCE FACTORS (FOREST/GRASSLAND) 2000-2019



► MAIN LAND USE CHANGES 2000-2019 (000 HA)



(1) *Any forest land lost to other land uses between 2000 and 2019*
(2) *Any non-forest land that became forest land between 2000 and 2019*
(3) *2019 minus 2000 settlement area*
(4) *2019 minus 2000 cropland area*
(5) *UNCCD-proposed default matrix for the assessment of SDG 15.3.1 land cover change sub-indicator between 2000 and 2019*

The average tree cover density is 1.4 percent in cropland, 2.1 percent in grassland is 2.1 percent and 5.4 percent in settlement. The tree cover density in forest land is 63.8 percent.

South Africa counts 713 million trees in non-forest land, 88 percent distributed in grassland only. The average tree density in cropland and settlement is 2 and 9.3 trees/ha, while it is 7 trees/ha in grassland.

The total area affected by primary human disturbances is 22.8 million ha (19 percent of total land). Fire is the prevalent disturbance (20.8 million ha of grassland affected, and 1.1 million ha of forest land affected).

► RESTORATION POTENTIAL AND OPPORTUNITIES

Tree cover increase (percent)

- 0– 3.65
- 3.66– 8.76
- 8.77– 14.59
- 14.6– 21.52
- 21.53– 28.81
- 28.82– 36.84
- 36.85– 47.41
- 47.42– 93

Source: FAO based on Bastin *et al.*, 2019. Adapted from United Nations World map, 2020.

The total restorable area in South Africa is 86.7 million ha (72 percent of total land) with an average potential tree cover (TC) increase of 9.1 percent (7.9 million ha of cumulated canopy cover). The restorable land in the GGW area is 57.3 million ha, 88 percent of the total GGW area, with an average potential tree cover increase of 6.5 percent (3.8 million ha of CCC).

In 2010, the carbon stock in living biomass (above and below ground) in South Africa was estimated at around 1.21 GtC (0.4 in the GGW area). With restoration, the estimated potential carbon net gain ranges between 0.133 (low bound) and 0.647 (high bound) GtC (0.10-0.34 in the GGW area).

Northern Cape and Eastern Cape are the provinces with most restorable land, with 35.3 and 11.7 million ha respectively. Limpopo has the highest potential average canopy cover increase from restoration, with 20.3 percent.

South Africa | KEY FACT

BIOPHYSICAL

121.17 MILLION HA

53.6% is GGW area

LAND USE (2019)

13 MILLION HA CROPLAND

90 MILLION HA GRASSLAND

6 MILLION HA FOREST LAND

TREES IN NON-FOREST LAND

713 MILLION

88% in grassland
with average 7 trees/ha

POPULATION (2020)*

58 558 267

1.3% annual growth

* Data based on the latest United Nations Population Division estimates 2020.

AGROSILVOPASTORAL SYSTEMS

2.2 MILLION HA

65% grazed grassland

TREE COVER DENSITY

1.4% IN CROPLAND

2.1% IN GRASSLAND

5.4% IN SETTLEMENT

PRIMARY HUMAN DISTURBANCES

22.8 MILLION HA

96% fires

CHANGE 2000-2019 (000 HA)

-0.17 FOREST LAND

+0.19 SETTLEMENT

+0.20 CROPLAND

+0.47 DEGRADED USE

TREE RESTORATION POTENTIAL

86.7 MILLION HA

9.1% average tree cover increase

RESTORATION IN GGW

57.3 MILLION HA

6.5% average tree cover increase

CARBON STOCK (2010)

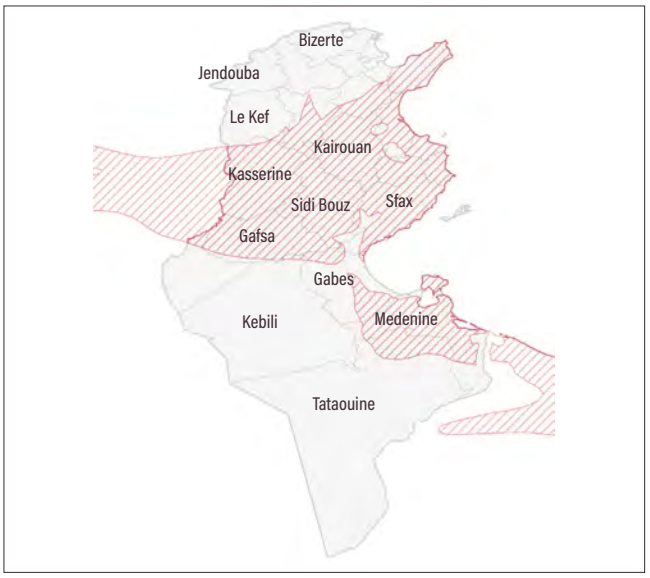
1.21 GtC FROM LIVING BIOMASS

0.40 in GGW area

CARBON GAIN WITH RESTORATION

0.13-0.65 GtC (RANGE)

0.10-0.34 in GGW area



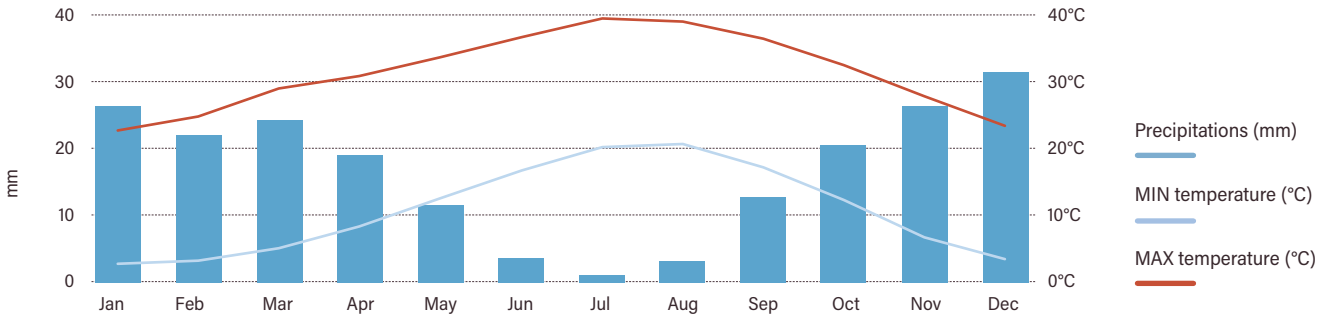
TUNISIA

GEOGRAPHICAL CONTEXT (Red hatched zone=GGW area)	
Administrative area (million ha)	**16.36**
Biophysical area (million ha)	**15.52**
Regions (number)	**24**
GGW area (million ha)	**5.99** (38.6 percent of total land)
Systematic sampling units	**9 696**

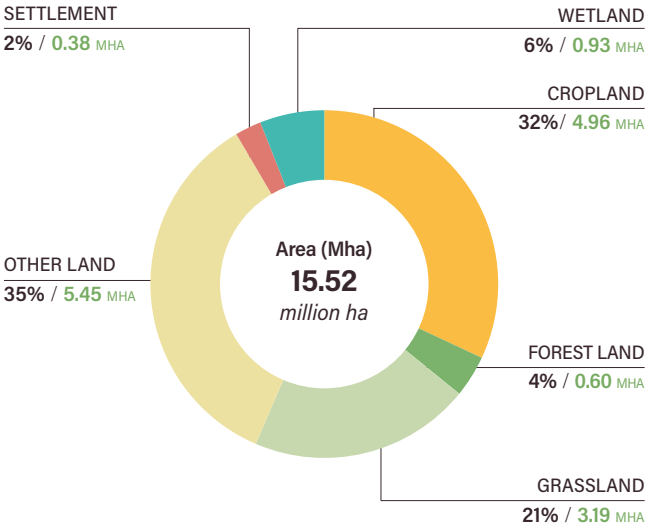
Source: All tables and figures of Tunisia are FAO based on Africa Open DEAL database, 2019, unless referenced differently.

▶ CLIMATE CHART MONTHLY AVERAGES 1991-2019

Source: FAO based on Earth Map platform.



▶ LAND USE DISTRIBUTION (IPCC categories), 2019 (million ha)



Tunisia's climate is Mediterranean in the North, where winters are mild (rarely exceeding 20°C and moderate rainfall), and summers are hot and dry (July and August can exceed 40 °C). The south of the country is desert. Annual average rainfall amount is lower than 500 mm nearly everywhere in Tunisia; areas with a pre-Saharan climate receive below 250 mm, while areas with a typical Saharan climate receive below 100 mm.

According to the Global Climate Risk Index (CRI), which focuses on the occurrence of extreme weather events, Tunisia scored low (class >100) in the period 2000–2019.

Tunisia is covered by 5 Mha of cropland (32 percent of total), and 3.2 Mha of grassland (21 percent). More than 1/3 are other land. The forest land is minimal (4 percent of total). In the GGW area, the share of cropland and grassland are much higher (+24 percent and +9 percent) while other land is lower (-32 percent).

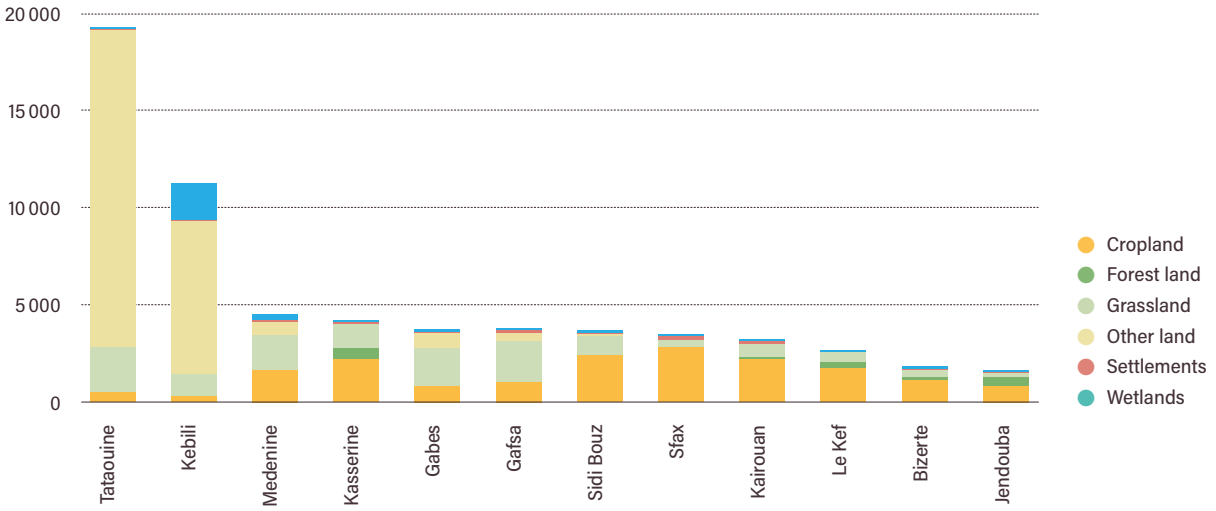
► LAND USE MAPS

Cropland (32 percent)

Forest land (2 percent)

Grassland (21 percent)

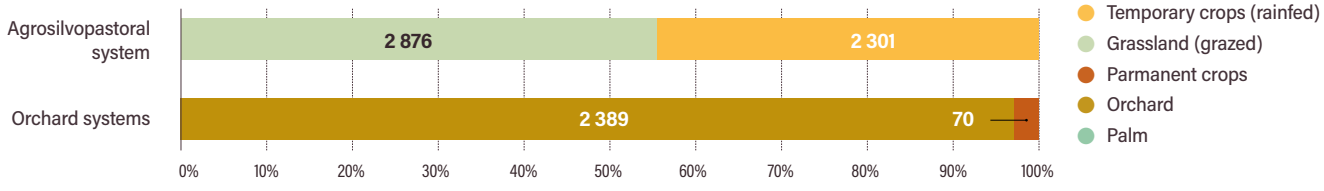
► LAND USE DISTRIBUTION BY REGION, 2019 (MILLION HA)



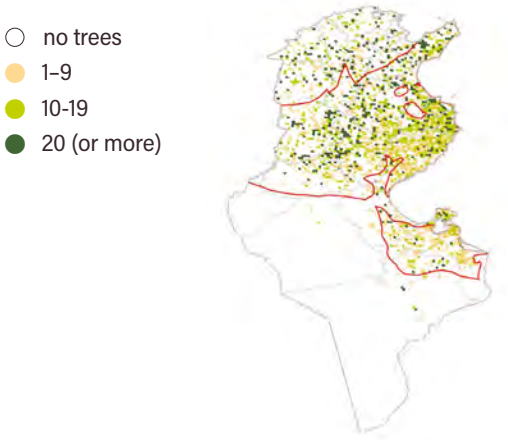
Tataouine (the largest province at 3.86 Mha) is characterized by the largest portion of grassland (480 000 ha). Sfax has the largest cropland (557) and Kasserine the largest forest land (126).

33 percent of total land is agrosilvopastoral, with a prevalence of grazed grassland (56 percent). 97 percent of orchard systems (16 percent of total land) is orchards.

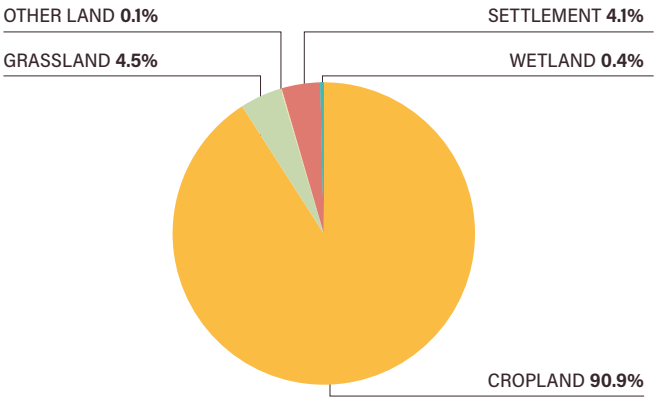
► AGROFORESTRY SYSTEMS, 2019 (000 HA)



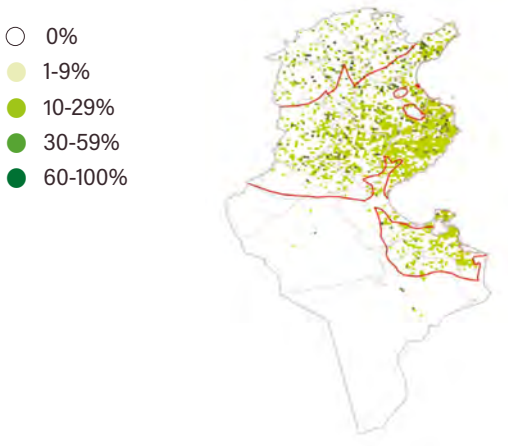
TREE COUNT (/0.5 HA) IN NON-FOREST LAND, 2019



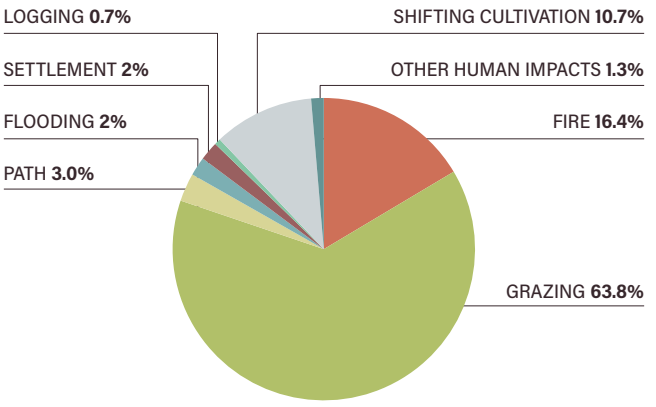
DISTRIBUTION OF TREES IN NON-FOREST LAND



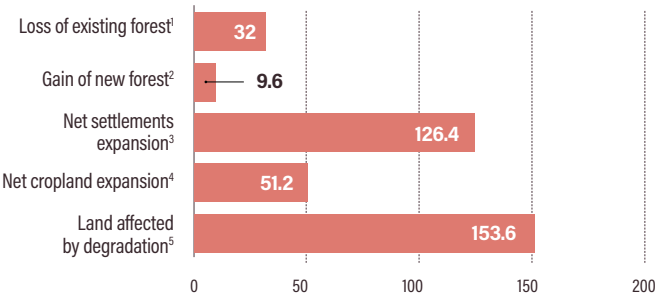
TREE COVER (PERCENTAGE) IN NON-FOREST LAND, 2019



PRIMARY OBSERVED DISTURBANCE FACTORS (FOREST/GRASSLAND) 2000–2019



MAIN LAND USE CHANGES 2000–2019 (000 HA)

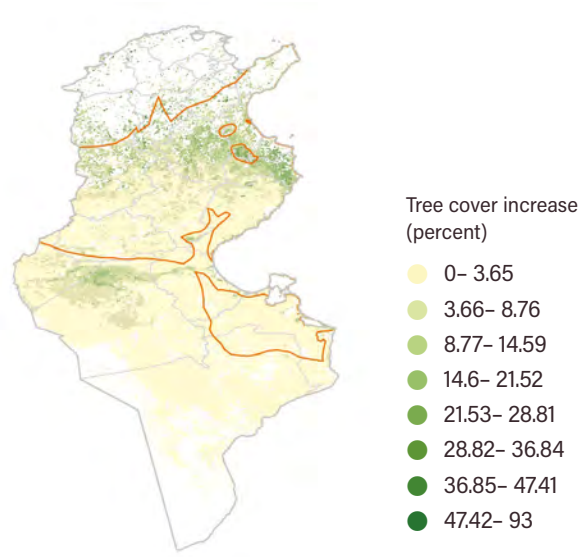


(1) *Any forest land lost to other land uses between 2000 and 2019*
(2) *Any non-forest land that became forest land between 2000 and 2019*
(3) *2019 minus 2000 settlement area*
(4) *2019 minus 2000 cropland area*
(5) *UNCCD-proposed default matrix for the assessment of SDG 15.3.1 land cover change sub-indicator between 2000 and 2019*

Tunisia counts 89 million trees in non-forest land, of which 90.9 percent are concentrated in cropland. The average tree density in cropland and settlement is 16 and 9.7 trees/ha, while it is 1.2 in grassland. The average tree cover density is 12 percent in cropland, 1 percent in grassland, 8 percent in settlement, and 71 percent in forest land.

The total area affected by primary human disturbances is 477 000 ha (3.1 percent of country area). Grazing is the prevalent disturbance (64 percent).

► RESTORATION POTENTIAL AND OPPORTUNITIES



Source: FAO based on Bastin *et al.*, 2019. Adapted from United Nations World map, 2020.

The total restorable area in Tunisia is 10 million ha (64 percent of total land) with an average potential tree cover (TC) increase of 3.3 percent (332 000 ha of cumulated canopy cover). The restorable land in the GGW area is 4.7 million ha, 78 percent of the total GGW area, with an average potential tree cover increase of 4.6 percent (217 000 ha of cumulated canopy cover).

In 2010, the carbon stock in living biomass (above and below ground) in Tunisia was estimated at around 0.092 GtC (0.05 GtC in the GGW area). With restoration, the estimated potential carbon net gain ranges between 0.007 (low bound) and 0.028 (high bound) GtC (0.005-0.019 GtC in the GGW area).

Tataouine and Kebili are the provinces with most restorable land, with 1.97 and 1.86 million ha respectively. Jendouba shows the highest potential average tree cover increase from restoration with 20.4 percent.

Tunisia | KEY FACT

BIOPHYSICAL
15.52 MILLION HA

39% is GGW area

LAND USE (2019)
5 MILLION HA CROPLAND

3.2 MILLION HA GRASSLAND

0.6 MILLION HA FOREST LAND

TREES IN NON-FOREST LAND
89 MILLION

91% in cropland
with average 16 trees/ha

POPULATION (2020)*
11 694 719

1.1% annual growth

* Data based on the latest United Nations Population Division estimates 2020.

AGROSILVOPASTORAL SYSTEMS
5.2 MILLION HA

44% rainfed crops
56% grazed grassland

TREE COVER DENSITY
12% IN CROPLAND

1% IN GRASSLAND

8% IN SETTLEMENT

PRIMARY HUMAN DISTURBANCES
0.48 MILLION HA

64% grazing

CHANGE 2000-2019 (MILLION HA)
-22 FOREST LAND

+126 SETTLEMENT

+51 CROPLAND

+154 DEGRADED USE

TREE RESTORATION POTENTIAL
10 MILLION HA

3.3% average tree cover increase

RESTORATION IN GGW
4.7 MILLION HA

4.6% average tree cover increase

CARBON STOCK (2010)
91.9 GtC FROM LIVING BIOMASS

49.6 in GGW area

CARBON GAIN WITH RESTORATION
6.55–28.09 GtC (RANGE)

4.5-18.6 in GGW

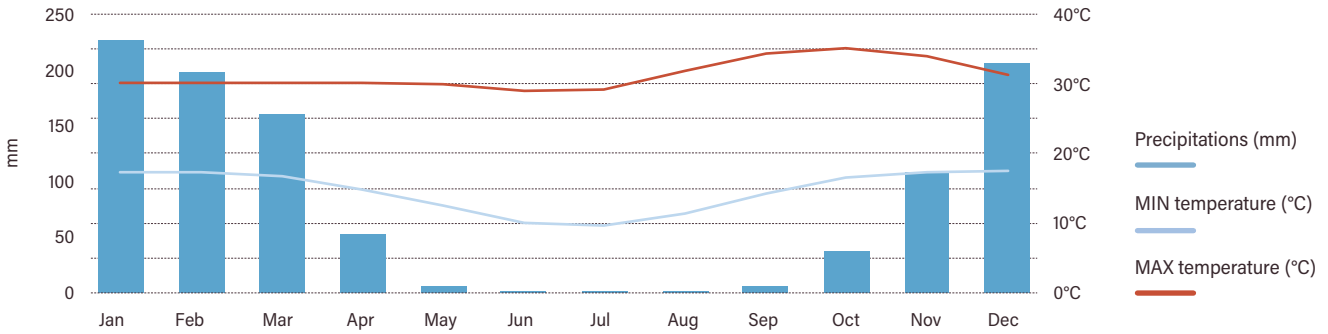
ZAMBIA

GEOGRAPHICAL CONTEXT (Red hatched zone=GGW area)	
Administrative area (million ha)	**75.26**
Biophysical area (million ha)	**75.11**
Regions (number)	**10**
GGW area (million ha)	**0.52** (0.7 percent of total land)
Systematic sampling units	**11 734**

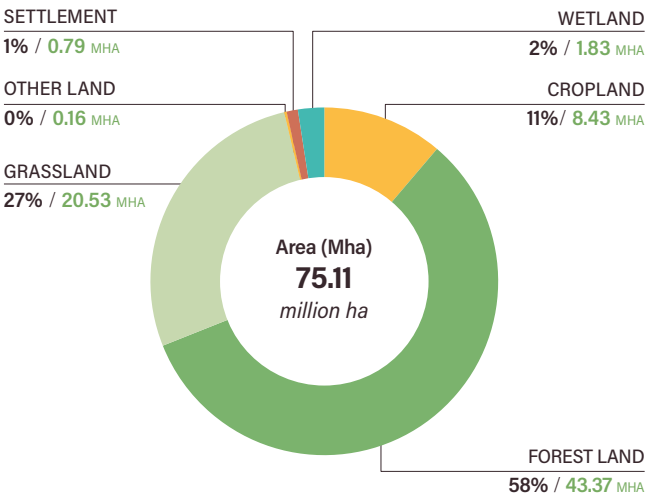
Source: All tables and figures of Zambia are FAO based on Africa Open DEAL database, 2019, unless referenced differently.

▶ CLIMATE CHART MONTHLY AVERAGES 1991-2019

Source: FAO based on Earth Map platform.



▶ LAND USE DISTRIBUTION (IPCC categories), 2019 (million ha)



Although Zambia lies within the tropics, its climate is modified by the altitude of the country. There are wide seasonal variations in temperature and rainfall. October is the hottest month. The main rainy season starts in mid-November, with heavy tropical storms lasting well into April. The northern and north-western provinces have an annual rainfall of about 1 250 mm, while areas in the far south have as little as 750 mm. May to mid-August is the cool season. Daytime temperatures may range from 23° to 31° C; at night drops as low as 5° C in June and July.

According to the Global Climate Risk Index (CRI), which focuses on the occurrence of extreme weather events, Zambia scored low (class >100) in the period 2000–2019.

Zambia is covered by 8.4 million ha of cropland, 43.4 million ha of forest land and 20.5 million ha of grassland. In the GGW area (less than 1 percent of total national area), the share of cropland and grassland is lower in favour of forest land.

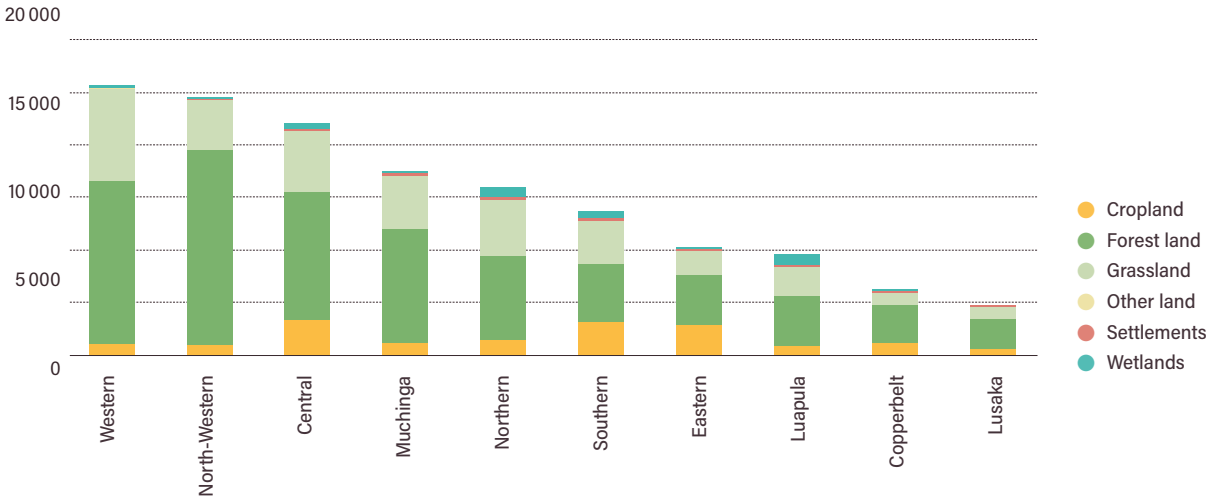
► LAND USE MAPS

Cropland (11 percent)

Forest land (58 percent)

Grassland (27 percent)

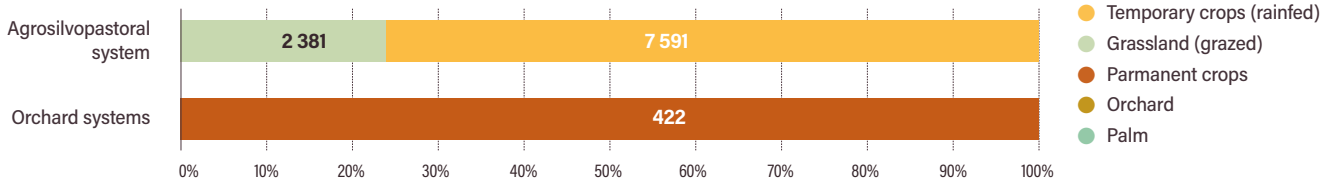
► LAND USE DISTRIBUTION BY REGION, 2019 (MILLION HA)



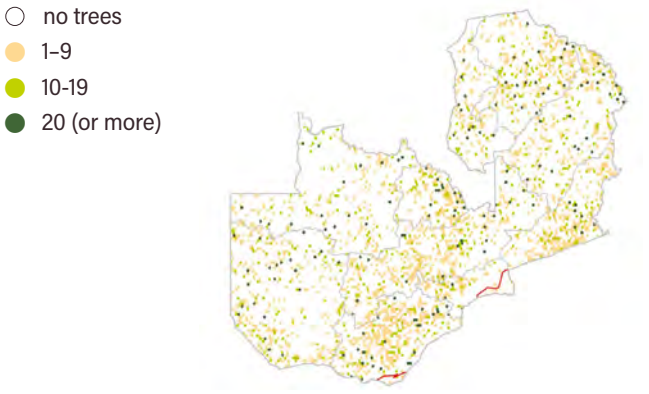
Western is characterized by the largest portion of grassland (4.4 million ha). North-Western has the largest forest land (9.2 million ha). Central has the largest cropland (1.7 million ha).

13 percent of total land is agrosilvopastoral, with a prevalence of annual rainfed crops (76 percent). 100 percent of orchard systems (1 percent of total land) is permanent crop.

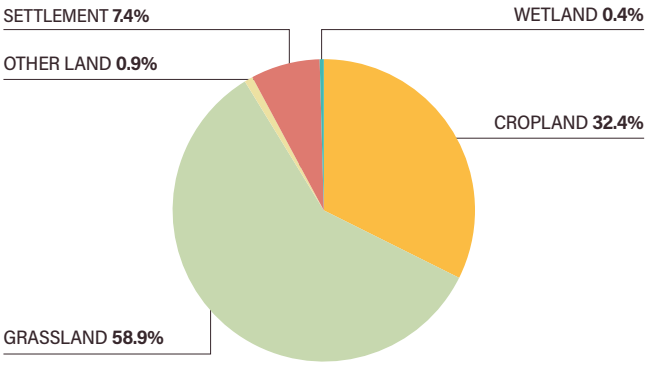
► AGROFORESTRY SYSTEMS, 2019 (000 HA)



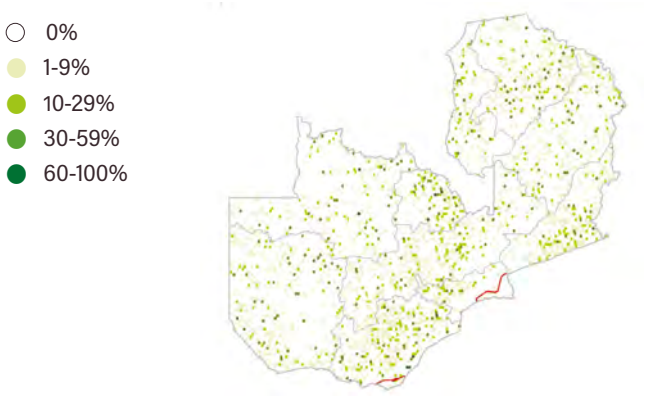
TREE COUNT (/0.5 HA) IN NON-FOREST LAND, 2019



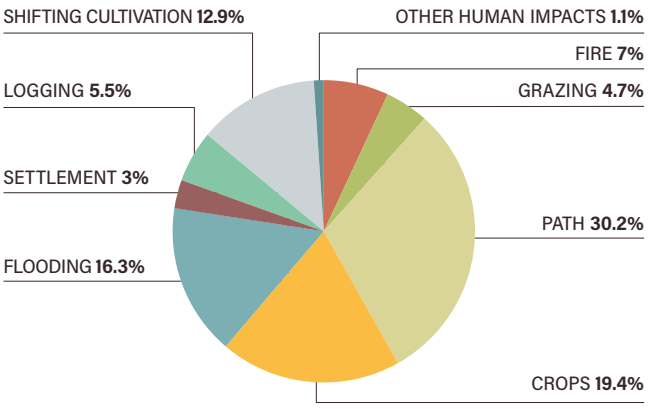
DISTRIBUTION OF TREES IN NON-FOREST LAND



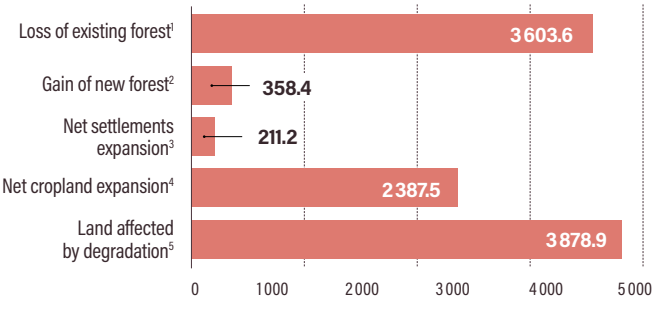
TREE COVER (PERCENTAGE) IN NON-FOREST LAND, 2019



PRIMARY OBSERVED DISTURBANCE FACTORS (FOREST/GRASSLAND) 2000-2019



MAIN LAND USE CHANGES 2000-2019 (000 HA)



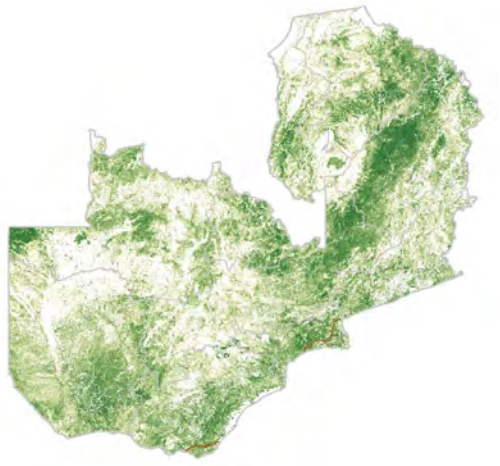
(1) *Any forest land lost to other land uses between 2000 and 2019*
(2) *Any non-forest land that became forest land between 2000 and 2019*
(3) *2019 minus 2000 settlement area*
(4) *2019 minus 2000 cropland area*
(5) *UNCCD-proposed default matrix for the assessment of SDG 15.3.1 land cover change sub-indicator between 2000 and 2019*

Zambia counts 259 million trees in non-forest land, more than 91 percent distributed in grassland and cropland. The average tree density in cropland and settlement is 9.9 and 24.3 trees/ha, while it is 7.4 in grassland.

The average tree cover density is 7 percent in cropland, 5 percent in grassland, 23 percent in settlement, and 66 percent in forest land.

The total area affected by primary human disturbances is 13.9 million ha (19 percent of total land). "Path" is the prevalent disturbance (3.3 million ha in forest land and 1.9 million ha in grassland affected).

► RESTORATION POTENTIAL AND OPPORTUNITIES



Tree cover increase (percent)

- 0– 3.65
- 3.66– 8.76
- 8.77– 14.59
- 14.6– 21.52
- 21.53– 28.81
- 28.82– 36.84
- 36.85– 47.41
- 47.42– 93

Source: FAO based on Bastin *et al.*, 2019. Adapted from United Nations World map, 2020.

The total restorable area in Zambia is 53 million ha (71 percent of total land) with an average potential tree cover (TC) increase of 19.8 percent (10.5 million ha of cumulated canopy cover). The restorable land in the GGW area is 0.4 million ha, 79 percent of the total GGW area with an average potential tree cover increase of 26.9 percent (0.16 million ha of CCC).

In 2010, the carbon stock in living biomass (above and below ground) was estimated at around 2.38 GtC. With restoration, the estimated potential carbon net gain ranges between 0.21 GtC (low bound) and 0.89 GtC (high bound).

Western and Central are the provinces with most restorable land, with 9.5 and 8.2 million ha respectively. However, Lusaka has the highest rate of restorable land compared to the province (82 percent). Muchinga has the highest potential mean rate of canopy cover increase from restoration, with 26.8 percent, followed by Lusaka and Southern.

Zambia | KEY FACT

BIOPHYSICAL

75.11 MILLION HA

0.7% is GGW area

LAND USE (2019)

8.1 MILLION HA CROPLAND

20.5 MILLION HA GRASSLAND

43.4 MILLION HA FOREST LAND

TREES IN NON-FOREST LAND

259 MILLION

32% in cropland
with average 10 trees/ha

POPULATION (2020)*

17 861 030

2.9% annual growth

* Data based on the latest United Nations Population Division estimates 2020.

AGROSILVOPASTORAL SYSTEMS

10 MILLION HA

76% rainfed crops
24% grazed grassland

TREE COVER DENSITY

7% IN CROPLAND

5% IN GRASSLAND

23% IN SETTLEMENT

PRIMARY HUMAN DISTURBANCES

13.9 MILLION HA

30% paths

CHANGE 2000-2019 (MILLION HA)

-3.2 FOREST LAND

+0.2 SETTLEMENT

+2.4 CROPLAND

+3.9 DEGRADED USE

TREE RESTORATION POTENTIAL

53 MILLION HA

19.8% average tree cover increase

RESTORATION IN GGW

0.4 MILLION HA

26.9% average tree cover increase

CARBON STOCK (2010)

2.38 GtC FROM LIVING BIOMASS

0.02 in GGW area

CARBON GAIN WITH RESTORATION

0.21-0.8 GtC (RANGE)

4-15 MtCO2 in GGW

ANNEX 04
TRAININGS AND MAPATHONS

Countries, institutions and participants involved in Africa Open DEAL & GGW data collections and analyses (2018–2021)

COUNTRY	INSTITUTION / ORGANIZATION	NUMBER OF PARTICIPANTS	NATIONAL COORDINATORS
Algeria	Direction Générale des Forets	32	Wahid Tefiani, Assia Azzi
Botswana	University of Botswana hosted the regional AAD/ GGW workshop for 12 SADC countries	18	Sibongile Mavimbela (SADC secretariat), Moctar Sacande, Antonio Martucci (AAD), Danilo Mollicone
Burkina Faso	Centre National de Semences Forestières (CNSF), Coordination Nationale de l'Initiative de la Grande Muraille Verte pour le Sahara et le Sahel (CN IGMVSS /BF)	10	Regis Oubida, Jean Jacques Bahire
Burundi	Ministère de l'Environnement, de l'Agriculture et de l'Elevage (MINEAGRI), FAO-Burundi	17	Salvator Ndabirorere
Cape Verde	Ministério de Agricultura e Ambiente/ Direção Geral da Agricultura, Silvicultura E Pecuária	22	Miguel Moura
Democratic Republic of the Congo	Ecole Régionale post-universitaire d'Aménagement et de gestion Intégrés des Forêts et Territoires tropicaux (ERAIFT)	35	Hervé Mishidi
Ethiopia	FAO-SFE hosted the regional training workshop for 5 AAD/GGW countries	16	Moctar Sacande, Patrick Bahal (AAD), Danilo Mollicone
Ghana	Ghana Environmental Protection Agency and the Ghana Forestry Commission	12	Emmanuel Donkor
Italy	FAO headquarters hosted the very first regional training workshop on Collect Earth tools organised by AAD for all the 11 GGW Sahel countries, the PA-GGW and several other partners	30	Moctar Sacande, Antonio Martucci (AAD), Abakar Zougoulou (PA-GGW secretariat)
Italy	University La Sapienza	5	Fabio Attorre
Kenya	Kenya Meteorological Department (KMD)/ Climate Change Directorate (CCD)	40	David Buluku Adegu
Madagascar	University of Antananarivo's Land, Landscape and Development (LLandDev) Research Laboratory of the Water and Forest Department (School of Agronomy ESSA-Forêts)	14	Harifidy Rakoto Ratsimba, Olitina Ratovo

COUNTRY	INSTITUTION / ORGANIZATION	NUMBER OF PARTICIPANTS	NATIONAL COORDINATORS
Mali	Agence Nationale de la Grande Muraille Verte du Mali	5	Maiga N'Danna
Mauritania	Agence Nationale de la Grande Muraille Verte en Mauritanie (ANGMV), FAO-Mauritanie,	2	Papa Mohamed Niang
Morocco	Département des Eaux et Forets	52	Abdelmoula Lefhaili, Mohamed Amhajar
Niger	Agrhymet (CILSS centre) hosted the regional training workshop for AAD/GGW countries	12	Francois Tapsoba (AAD), Mamane Bako (Agrhymet)
Niger	Secrétariat Exécutif du Conseil National de l'Environnement pour un Développement Durable (SE/CNEDD), Agence Nationale de la Grande Muraille Verte du Niger	33	Abdoulaye Issa, Abdou Chitou
Rwanda	Forest Management Bureau of the Department of Natural Resources (FMU-DENR)	22	Alphonse Mutabazi
Senegal	Direction de l'Environnement et des Etablissements Classés (DEEC), Direction des Eaux et Forêts, Chasses et Conservation des Sols (DEFCCS)	52	Madeleine Diouff Sarr, Lamine Diatta, Maodo Ba, Modou Moustapha Sarr
South Africa	Ministry of Forestry, Fisheries and the Environment	10	Christo Marais
Tunisia	Direction Générale des Forets	32	Aloui Kamel
Türkiye	International Agriculture Training Center in Ankara, hosted the training workshop for completing data collection gaps by OMO and AAD/BRIDGES	22	Ibrahim Belen (OMO); Dr Ayhan ATEŞOĞLU; Ibrahim Yamac (AAD/ BRIDGES)
Zambia	Ministry of Lands and Natural Resources (Department of Forestry and Department of Climate Change)	20	Joy Sinyangwe

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