Gola-Foya
Priority Landscape

Land use of the Gola-Foya priority landscape between 2001 and 2020

0.16%	0.23%	0.67%	1.31%
6.96%	5.24%	4.83%	4.80%
0.12%	0.25%	0.34%	0.38%
25.17%	28.82% (+3.65%)	33.11% (+4.29%)	41.59% (+8.48%)
67.59%	65.46%	61.05%	51.92%

Active fires

2001 2007 2014 2020

Bare soil
Urban area
Water
Closed forest
Burnt area
Open forest

VisioTerra

PAPFor
UEMOA
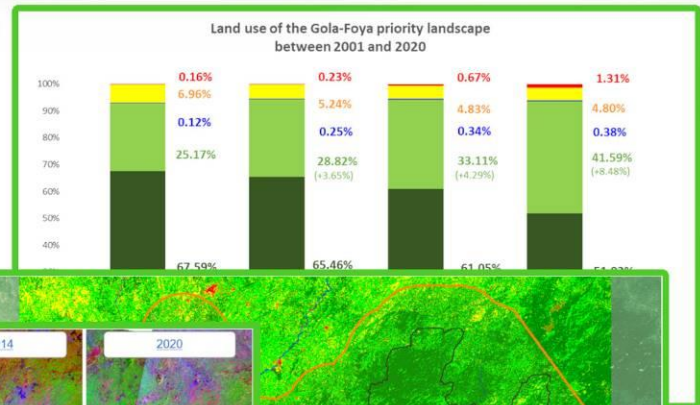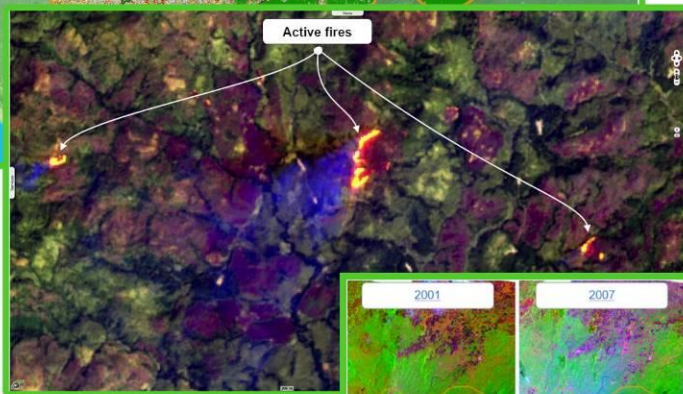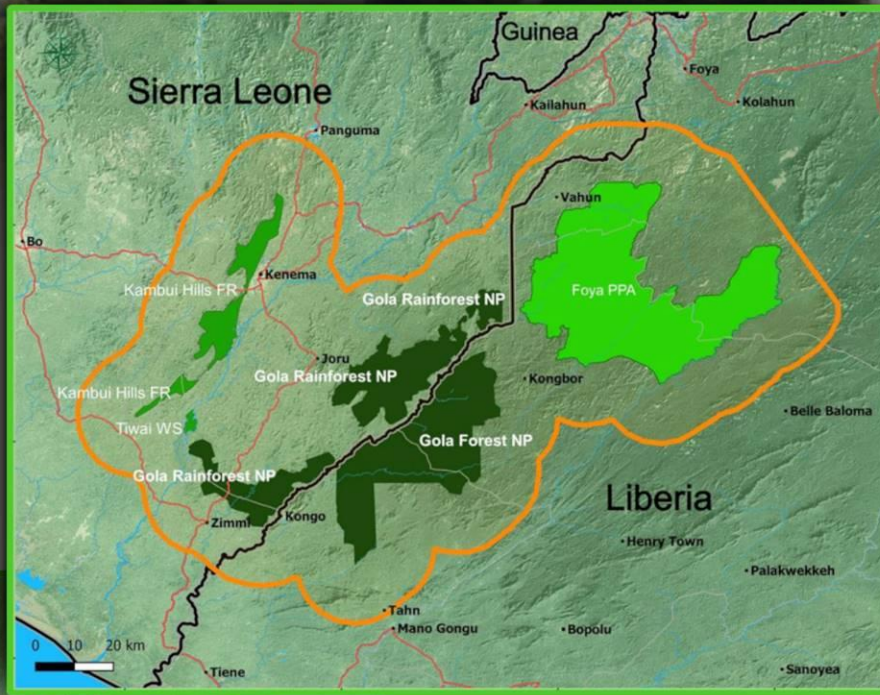
The Gola-Foya landscape, shared between Sierra Leone and Liberia, is home to vast tracts of dense rainforest. It is an important conservation area, protecting over 60 endangered species including the zebra duiker, many primates and the forest elephant. This forest has a key role in mitigating the impact of climate change. BirdLife and its partners work with communities and local government to develop sustainable livelihoods and improve the management of protected areas.

The landscape encompasses Gola Rainforest National Park, Gola Forest National Park, Kambui Hills Forest Reserve, Tiwai Wildlife Sanctuary and the proposed Foya Protected Area (see the PAPFor site).

This document shows the evolution of land cover in the landscape between 2001 and 2020 using Landsat 5/7/8 optical satellite images. The study also gives examples of deforestation, active fires and burned areas detected by the Sentinel satellites of the European Copernicus program.

Land-use / Land-cover (LU/LC) evolution in Gola-Foya priority landscape

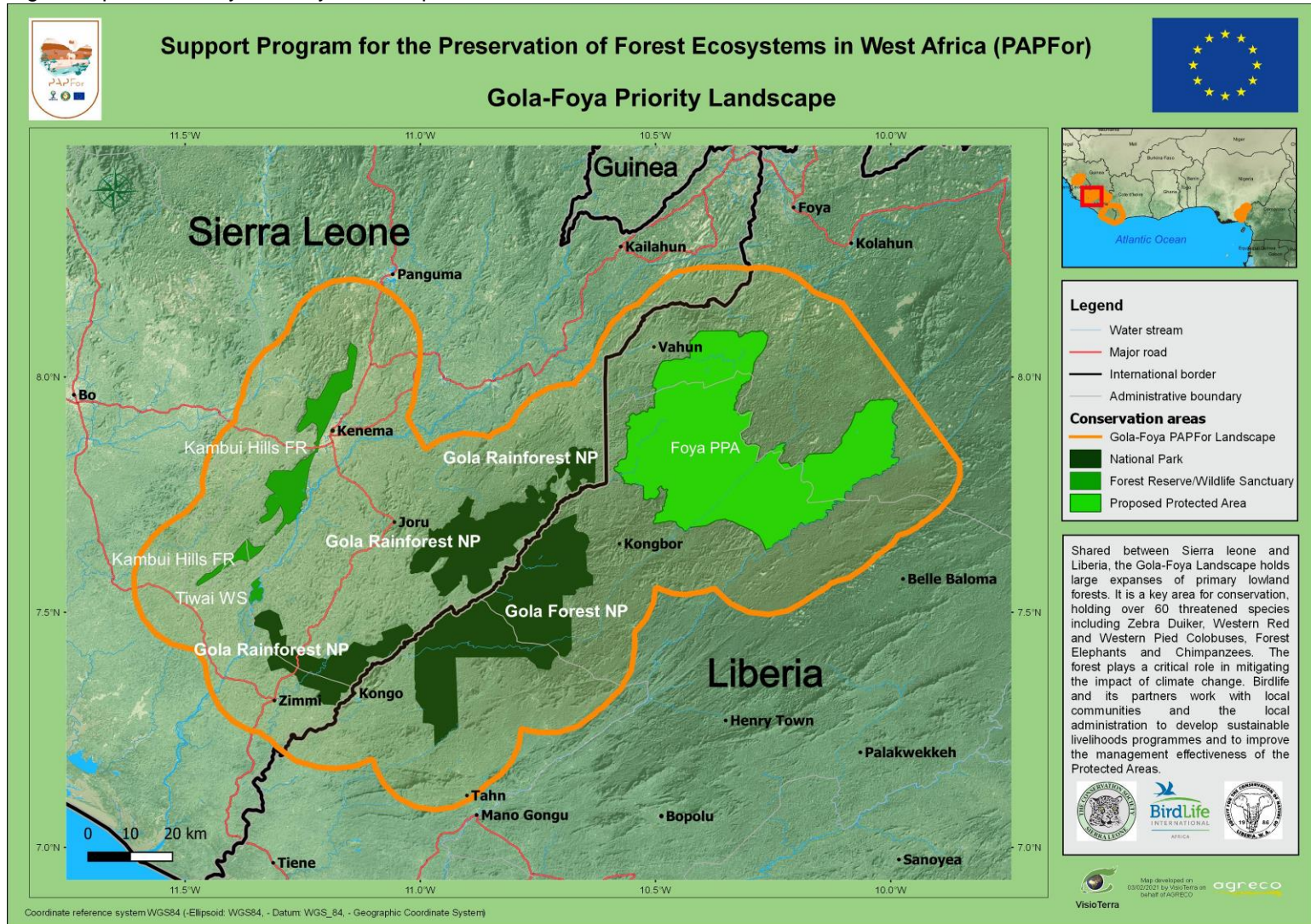2D_layer_stack

Fig.1: Map of Gola-Foya Priority Landscape.

Support Program for the Preservation of Forest Ecosystems in West Africa (PAPFor)

Gola-Foya Priority Landscape

Legend
- Water stream
- Major road
- International border
- Administrative boundary

Conservation areas
- Gola-Foya PAPFor Landscape
- National Park
- Forest Reserve/Wildlife Sanctuary
- Proposed Protected Area

Shared between Sierra leone and Liberia, the Gola-Foya Landscape holds large expanses of primary lowland forests. It is a key area for conservation, holding over 60 threatened species including Zebra Duiker, Western Red and Western Pied Colobuses, Forest Elephants and Chimpanzees. The forest plays a critical role in mitigating the impact of climate change. Birdlife and its partners work with local communities and the local administration to develop sustainable livelihoods programmes and to improve the management effectiveness of the Protected Areas.

Coordinate reference system WGS84 (-Ellipsoid: WGS84, - Datum: WGS_84, - Geographic Coordinate System)

Fig.2: Landsat images of 2001, 2007, 2014 and 2020 of Gola-Foya Priority Landscape.   animation_2D

2001 | 2007 | 2014 | 2020

powered by
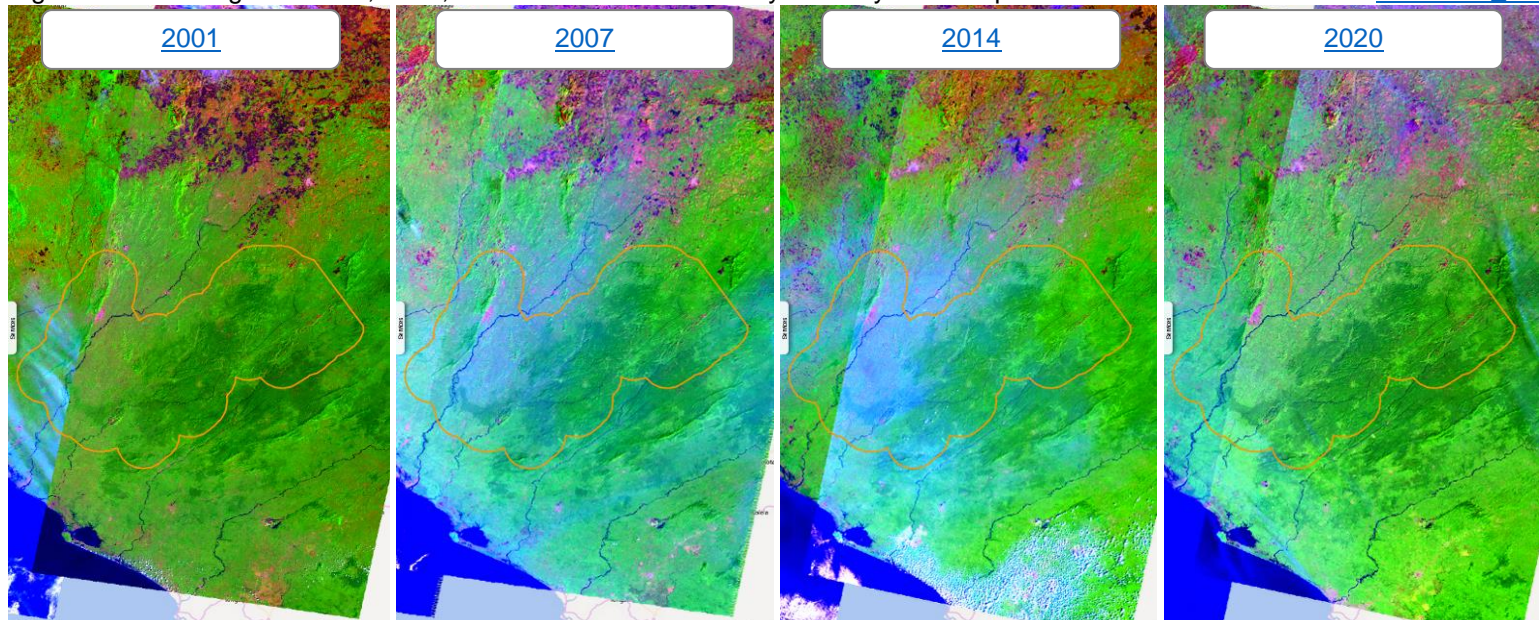
The 2001 classification (Fig.3) was calculated from Landsat-7 images.

The land cover classes used are:

- ⬛ Bare soil
- ⬛ Water
- ⬛ Burnt area
- ⬛ Built
- ⬛ Forest
- ⬛ Degraded forest

The 2007 classification (Fig.4) was calculated from Landsat 5 images.

Between 2001 and 2007, we can see a degradation of the forest to the west of the landscape with an urban extension of the town of Kenema.

However, the forest cover of all the protected areas of the landscape seems preserved.

Land-use / Land-cover of the Gola-Foya Landscape between 2001 and 2007

Fig.3: LU/LC map of Gola-Foya in 2001.

Legend:
- ⬛ Bare soil
- ⬛ Built
- ⬛ Water
- ⬛ Forest
- ⬛ Burnt area
- ⬛ Degraded forest
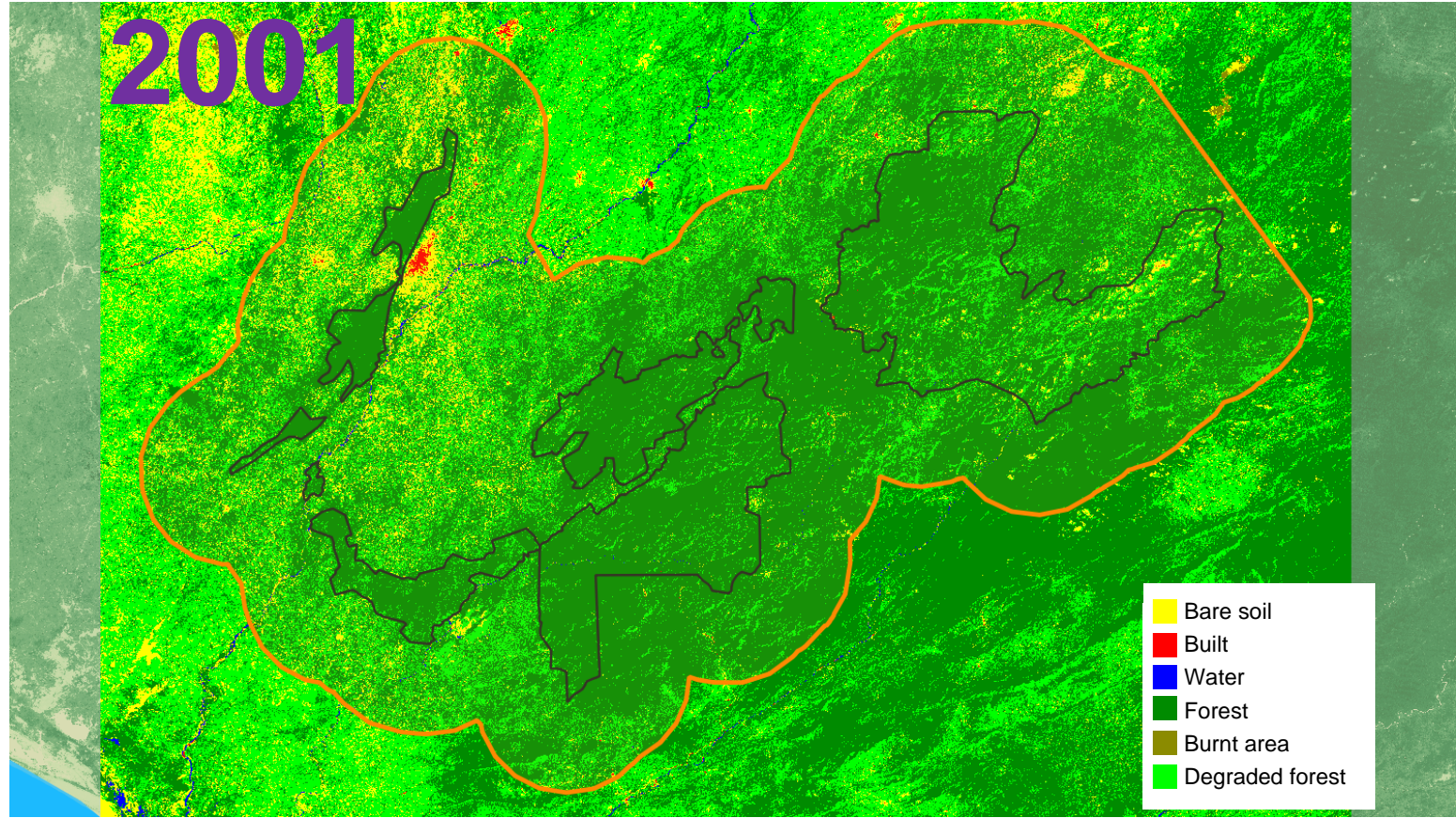
Fig.4: LU/LC map of Gola-Foya in 2007.

powered by VisioTerra
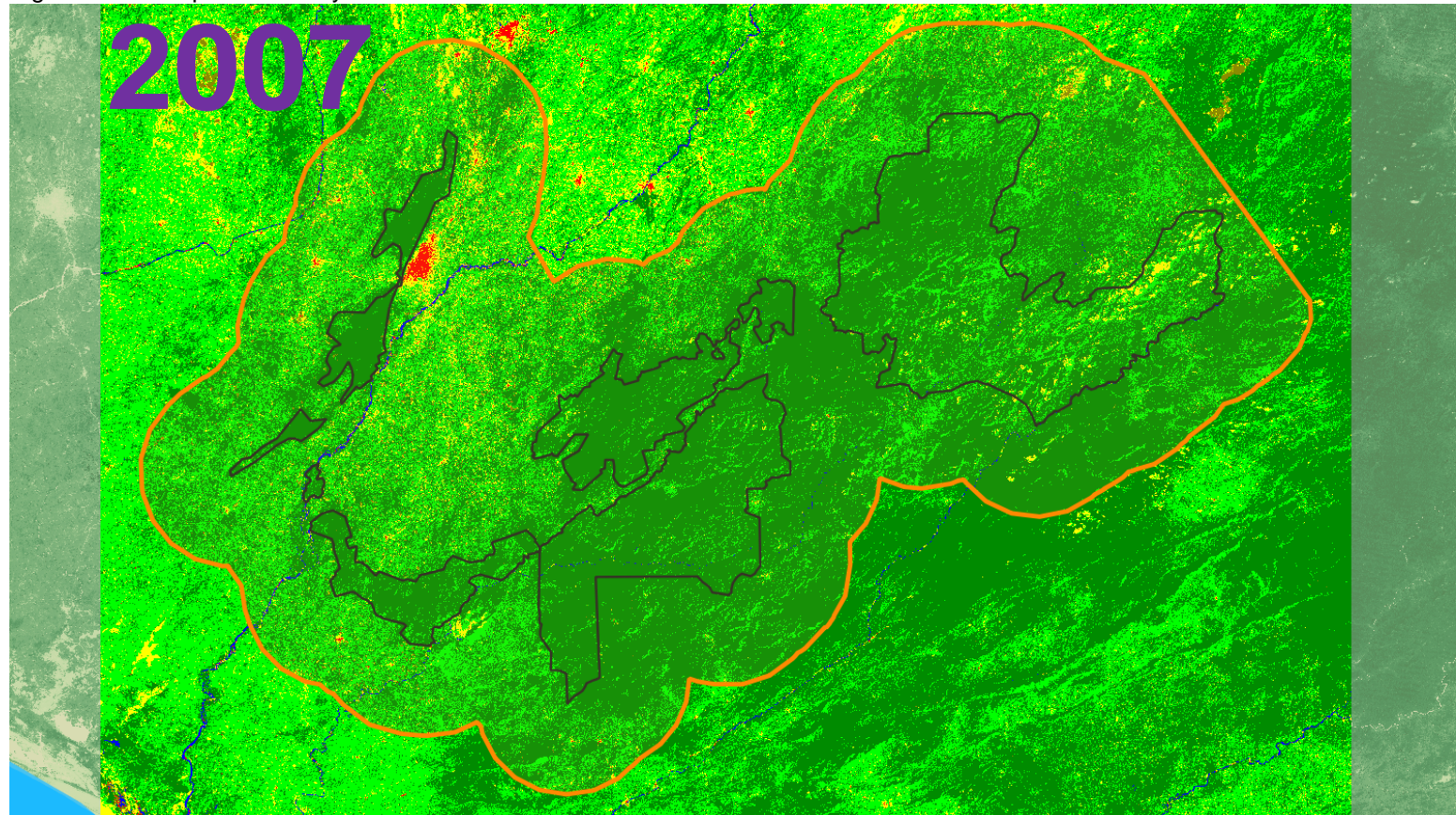
The 2014 classification (Fig.5) was calculated from Landsat-8 images. The 2020 classification (Fig.6) was also calculated from Landsat-8 images.

The comparison of the two classifications highlights a clear deforestation between 2014 and 2020 in the landscape outside the protected areas for which the forest cover remains preserved. However, there is a slight decrease in forest in the proposed protected area (PPA) of Foya.

There is also a pronounced urban expansion of the town of Kenema.

Land-use / Land-cover of the Gola-Foya Landscape between 2014 and 2020

Fig.5: LU/LC map of Gola-Foya in 2014.
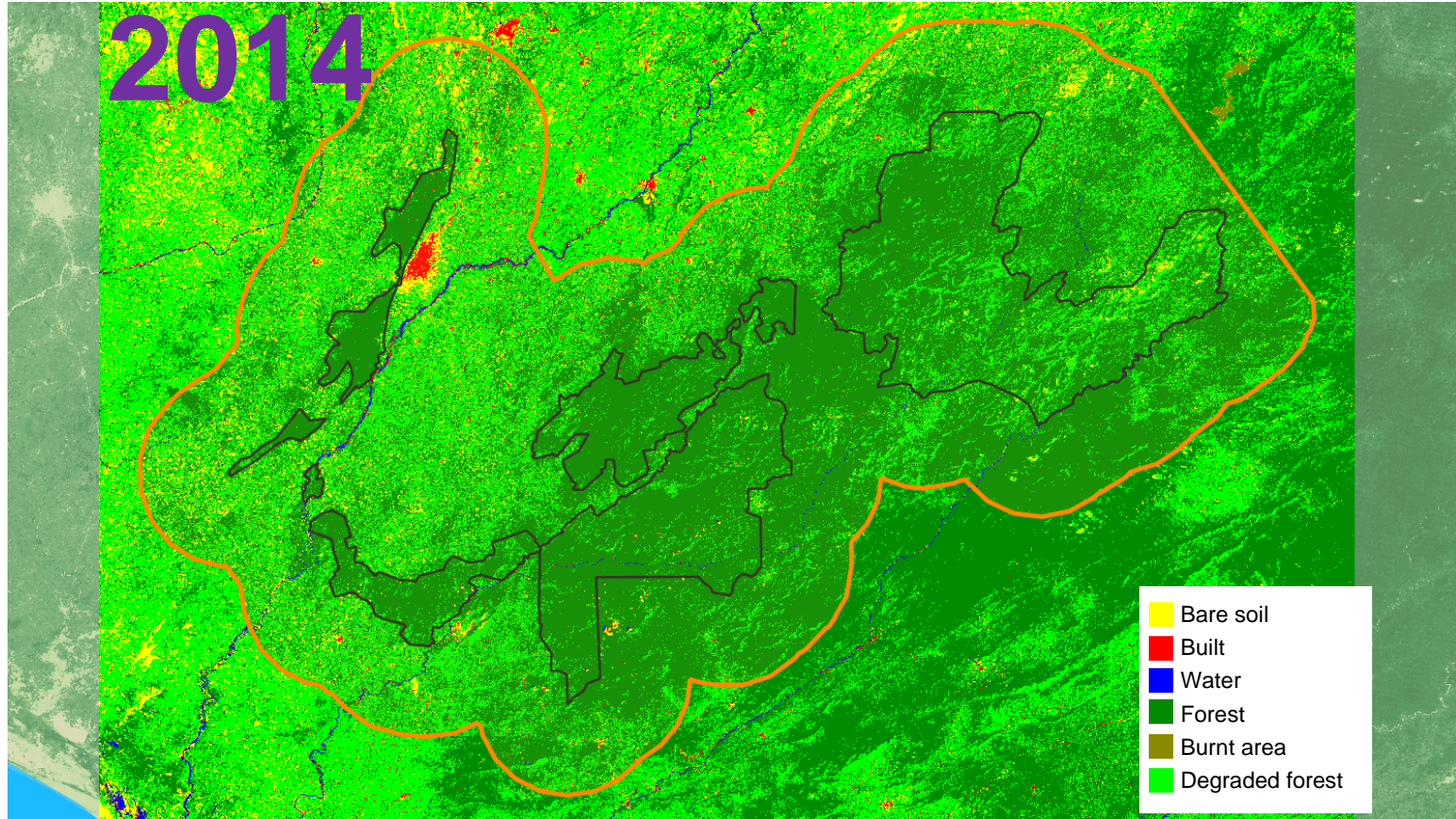
Fig.6: LU/LC map of Gola-Foya in 2020.

powered by VisioTerra
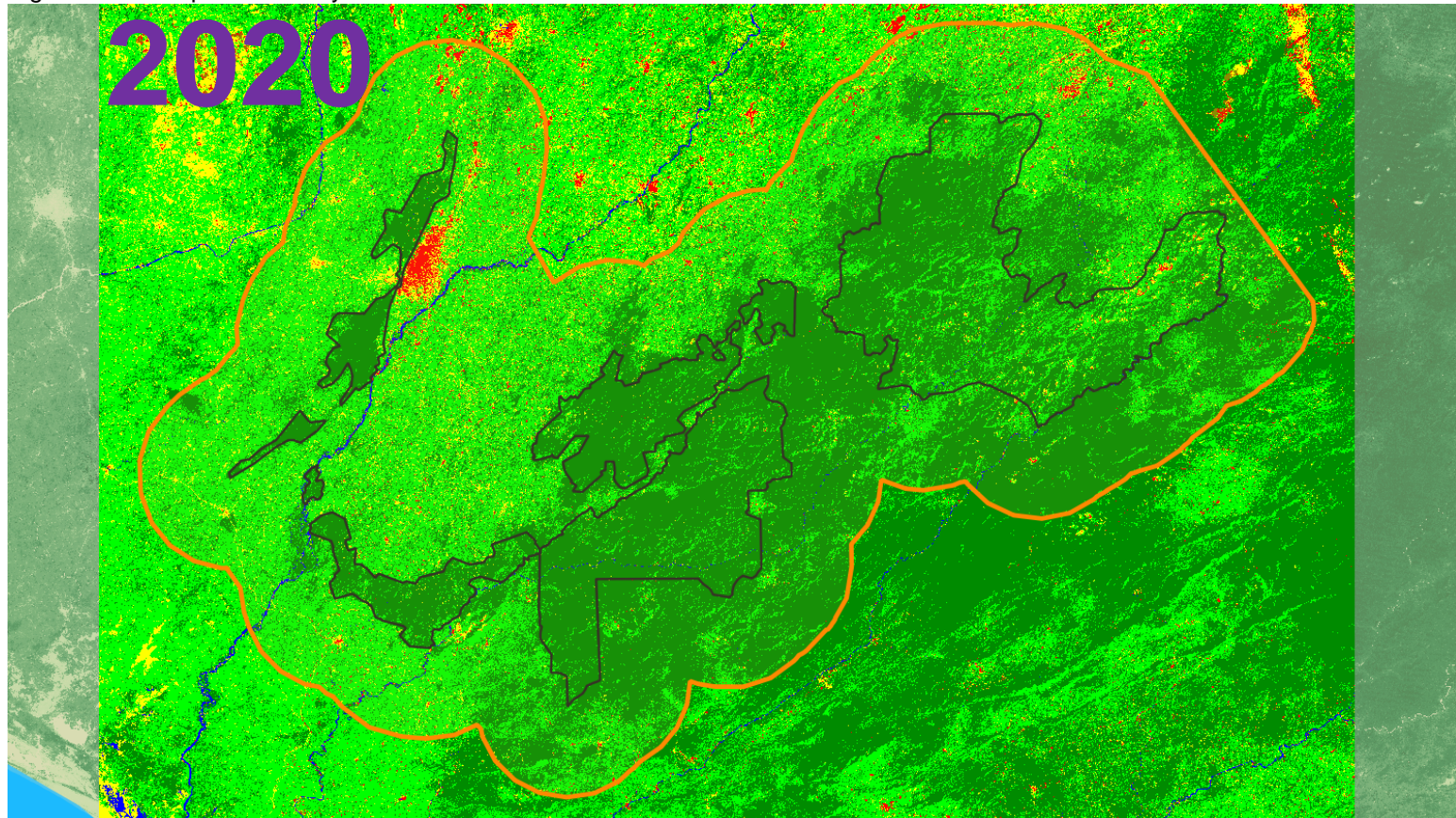
In the following (pages 4 to 8), the statistics are calculated for the different spatial extents of the -whole landscape, -national parks, -forest reserves and -proposed protected area.

Fig.8 shows the evolution of the different land cover classes in the **entire priority landscape of Gola-Foya** (Fig.7) from 2001 to 2020.

It can be seen that the forest cover has suffered a progressive degradation between 2001 and 2020. This growth follows an exponential law of a factor of 2. A loss of **2.13%** during the period 2001-2007, a loss of **4.41%** during the period 2007 2014 and a loss of **9.13%** during the period 2014-2020.

Urban expansion also follows an exponential growth with statistics of **0.16%** (2001), **0.23%** (2007), **0.67%** (2014) and **1.31%** (2020).

Evolution of Land-Use / Land-cover in the entire Gola-Foya priority landscape

Fig.7: Full view of the Gola-Foya priority landscape showing the extent over which the statistics have been computed.
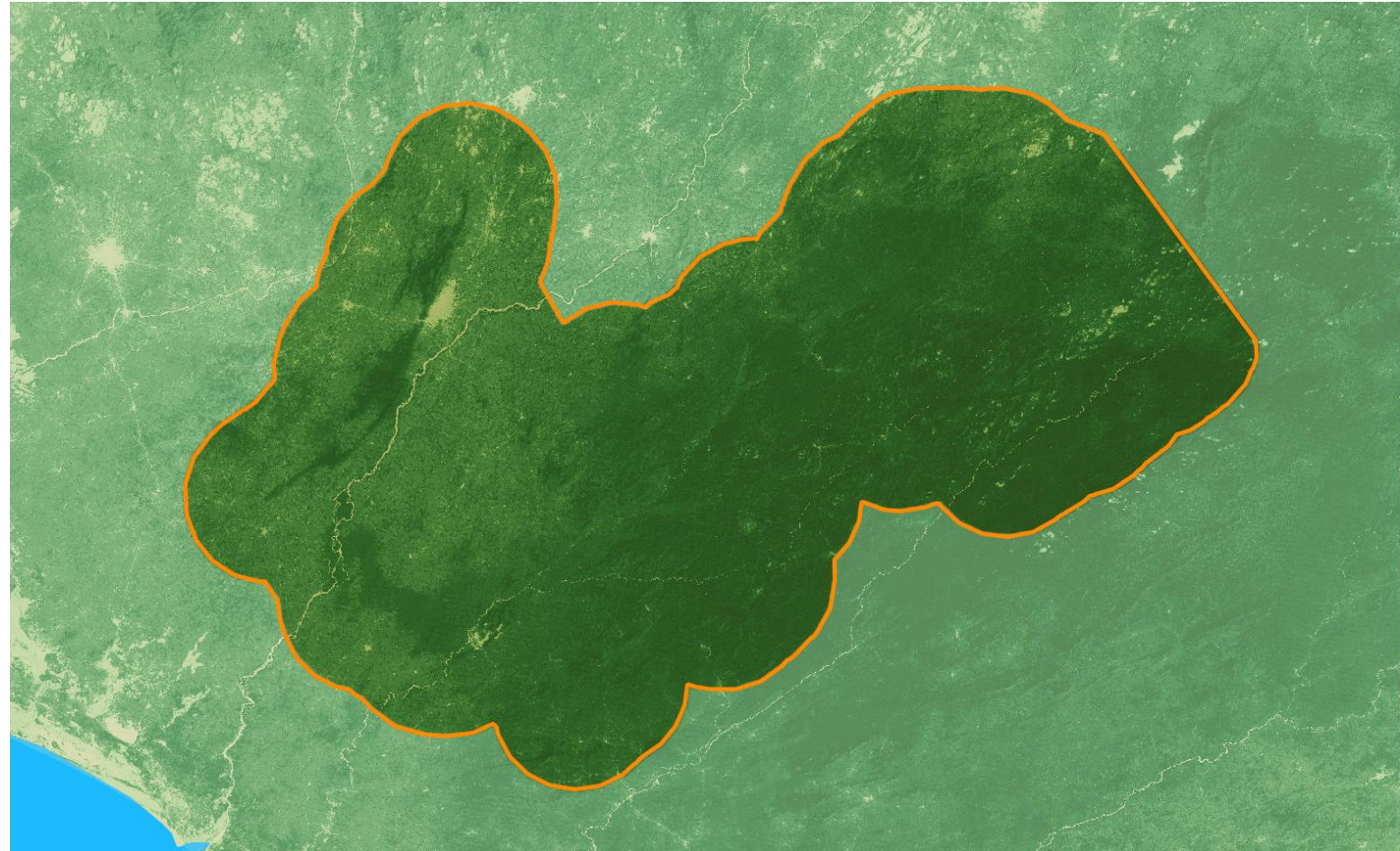

Fig.8: Assessment of the Land-use / Land-cover of the Priority Conservation Landscape (PCL) of Gola-Foya in 2001, 2007, 2014 and 2020 (statistics calculated on the entire landscape).

Land-Use / Land-cover of the full Gola-Foya priority landscape between 2001 and 2020

■ Forest   ■ Degraded forest   ■ Bare soil   ■ Built   ■ Water

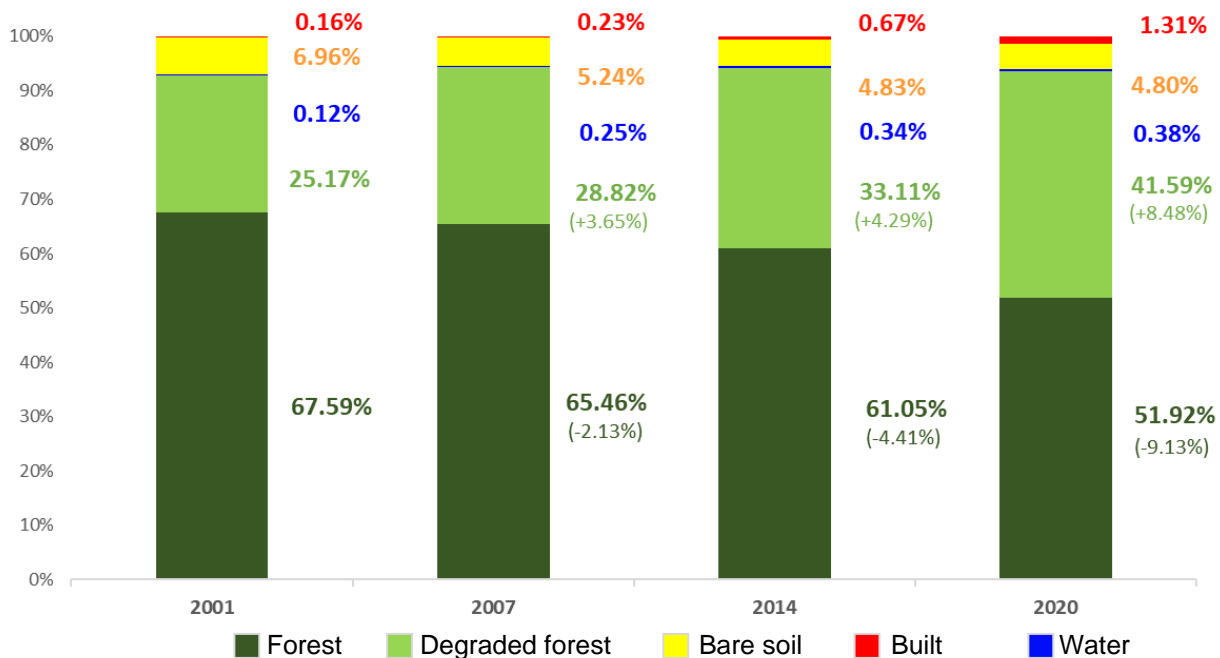Copernicus · esa · HYP-119-Sentinels-F (p.5) · powered by VisioTerra

Fig.10 shows the evolution of the different land cover classes in the two **national parks** (Gola Rainforest National Park and Gola Forest National Park) of the Gola-Foya priority landscape (Fig.9) between 2001 and 2020.

These national parks are mainly occupied by forest (about 90%).

It can be seen that this forest cover was preserved between 2001 and 2020 with low losses of: **0.19%** during the period 2001-2007, **0.64%** during the period 2007-2014 and **0.65%** during the period 2014-2020.

However, there are some recent human settlements in the Gola Forest National Park.

Evolution of Land-Use / Land-cover in the Gola-Foya national parks

Fig.9: View of the Gola-Foya national parks showing the extent over which the statistics have been computed.
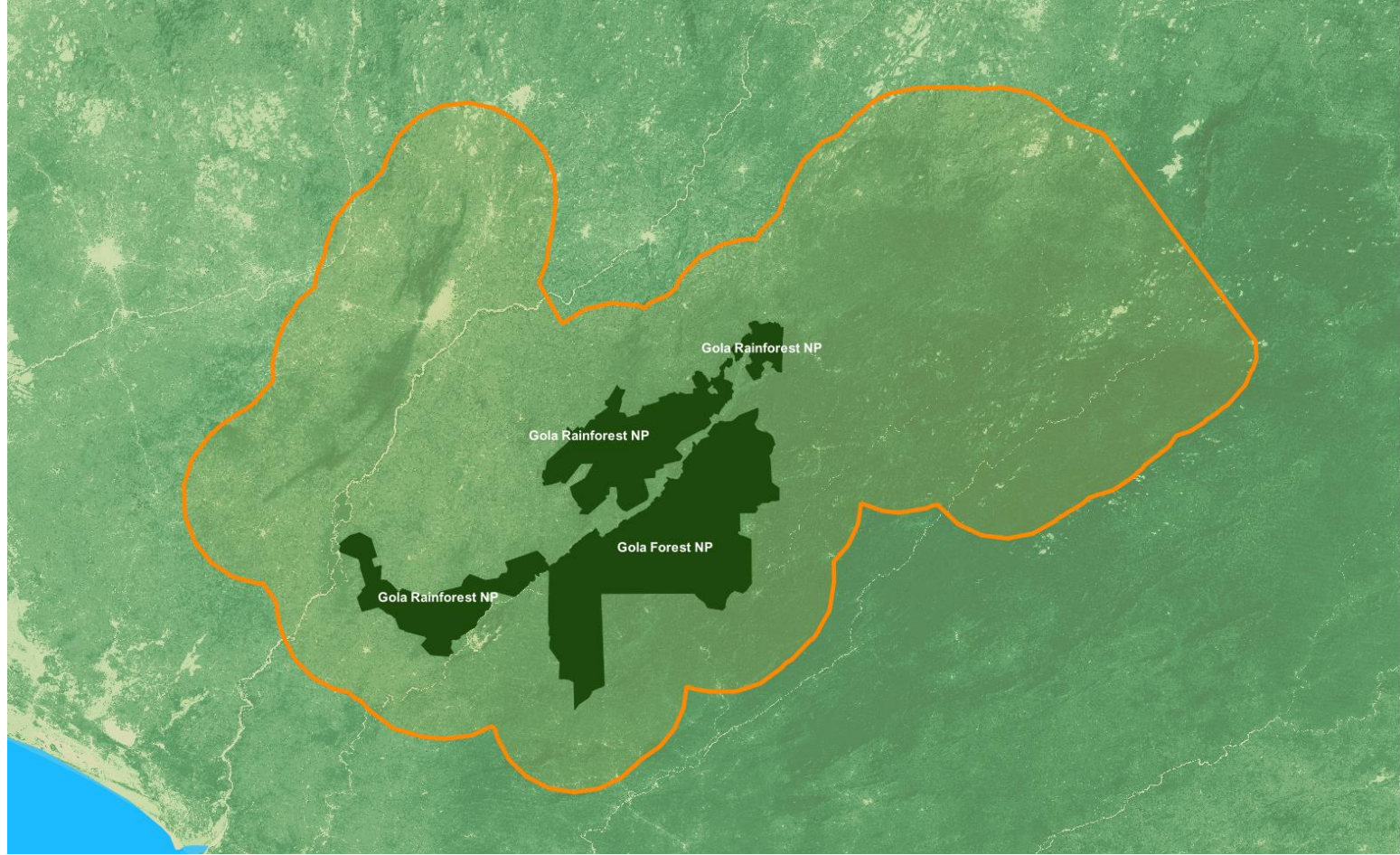
Fig.10: Assessment of the Land-use / Land-cover of the Gola-Foya national parks in 2001, 2007, 2014 and 2020 (statistics calculated on the extents shown in Fig.9 only).

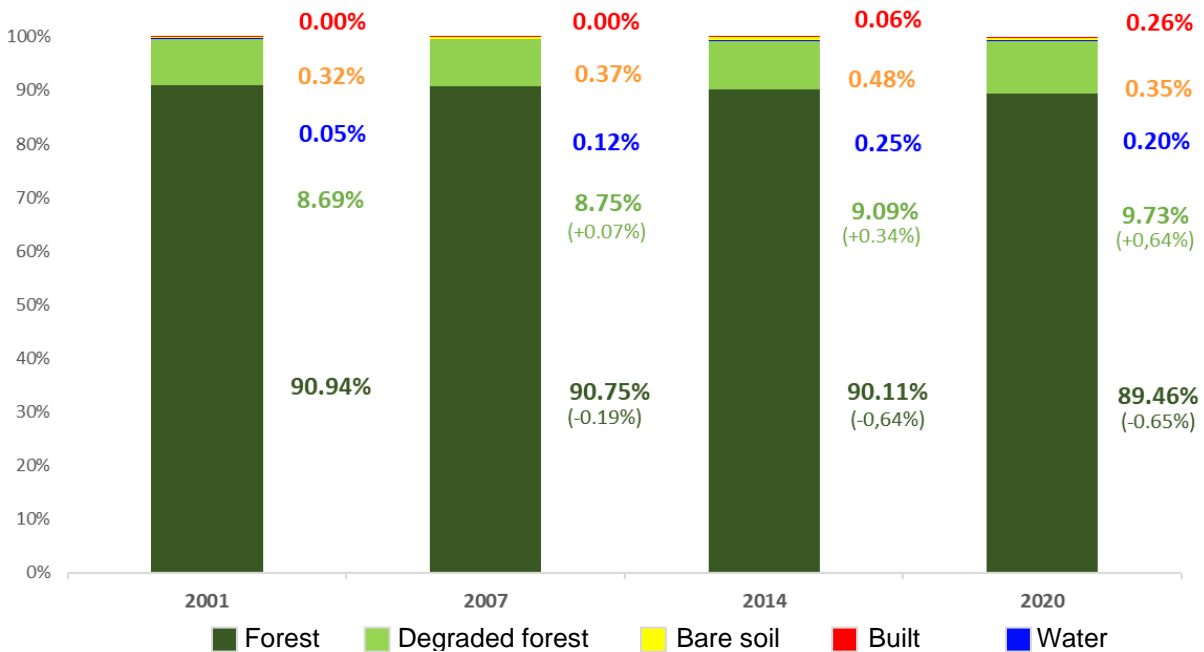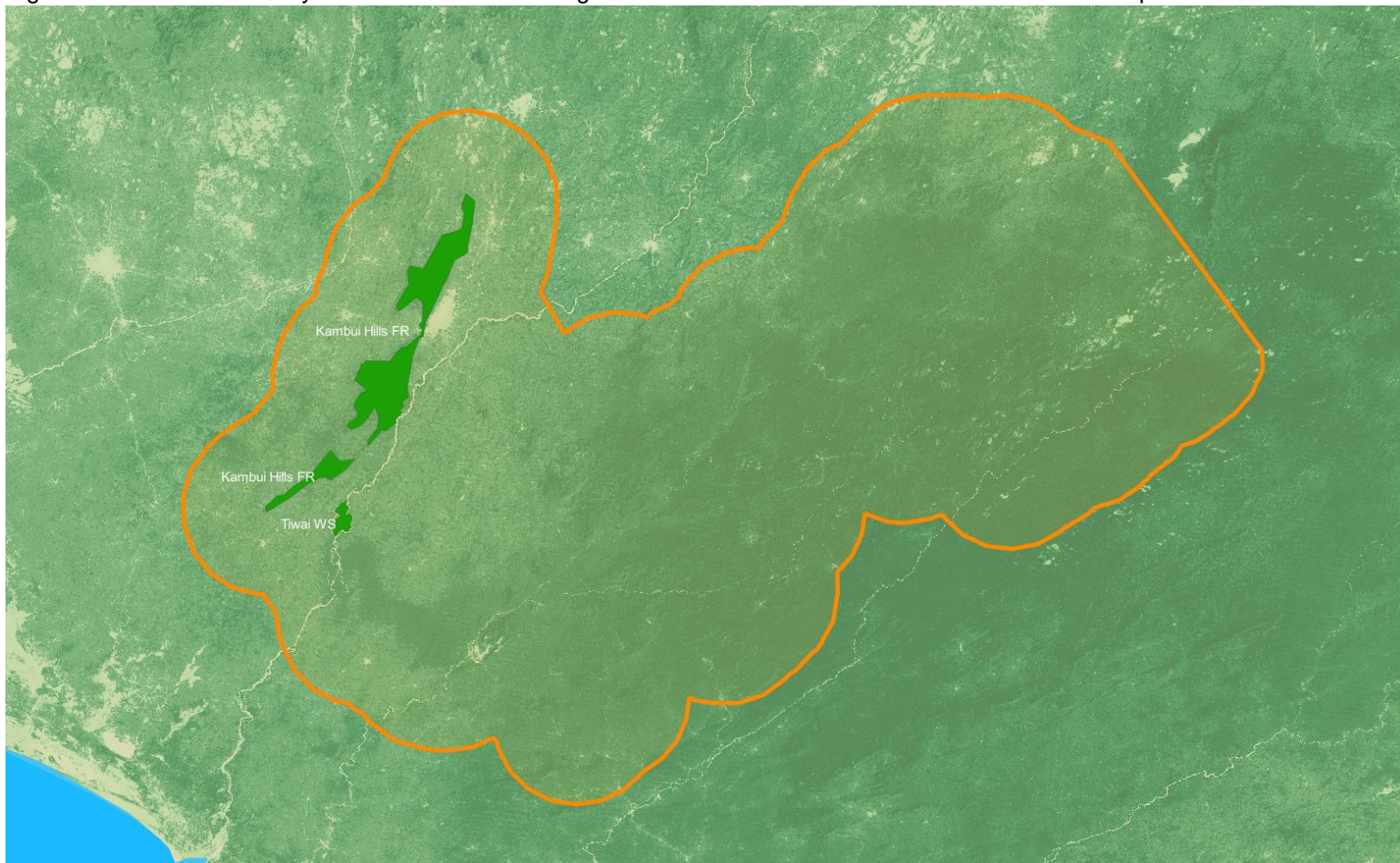**Land-Use / Land-cover of the Gola-Foya national parks between 2001 and 2020**

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Fig.12 shows the evolution of the different classes of land cover in the Kambui Hills **Forest Reserve** and the Tiwai Wildlife Sanctuary of the Gola-Foya Priority Landscape (Fig.11) between 2001 and 2020.

These forest reserves are also essentially occupied by forest (about 90%).

It can be seen that the forest cover suffered a gradual degradation between 2001 and 2014 with an acceleration between 2014 and 2020. Indeed, forest cover losses stand at **1.13%** during the 2001-2007 period, **2.74%** during the 2007-2014 period and **6.61%** during the 2014-2020 period.

These losses are more pronounced than those observed in national parks (see Fig.9 and Fig.10).

Evolution of Land-Use / Land-cover in the Gola-Foya forest reserves

Fig.11: View of the Gola-Foya forest reserves showing the extent over which the statistics have been computed.

Fig.12: Assessment of the Land-use / Land-cover of the Gola-Foya forest reserves in 2001, 2007, 2014 and 2020 (statistics calculated on the extents shown in Fig.11 only).

Land-Use / Land-cover of the Gola-Foya forest reserves between 2001 and 2020
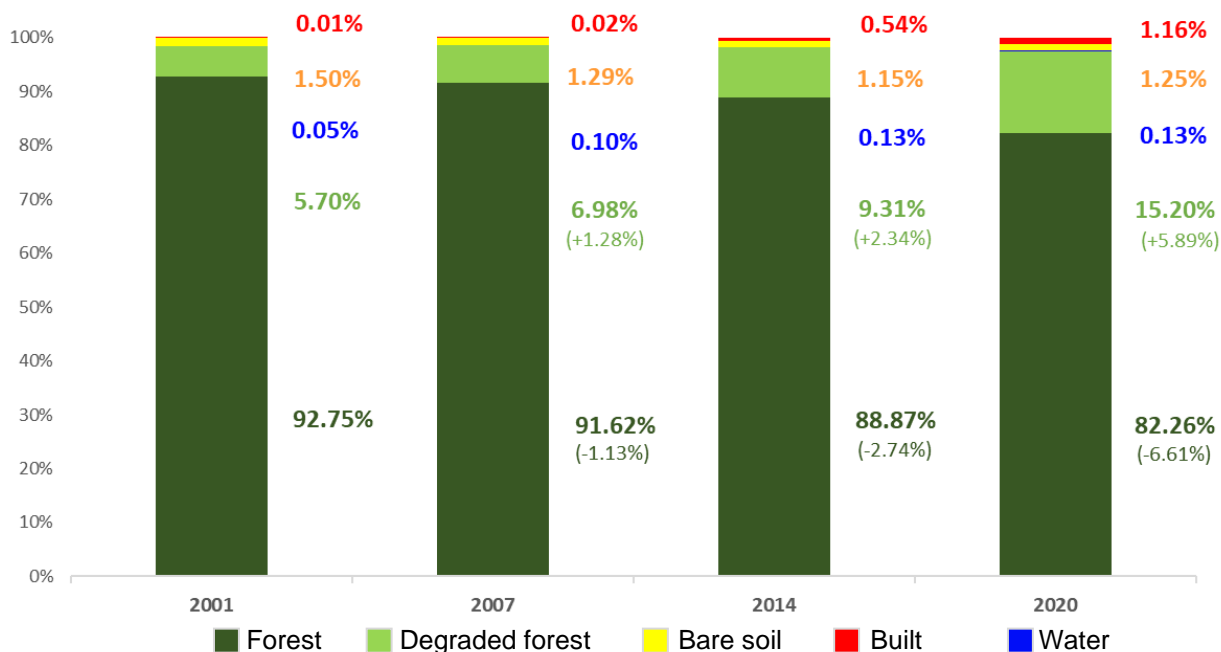
powered by VisioTerra

Fig.14 shows the evolution of the different classes of land cover in the proposed protected area (PPA) of Foya in the priority landscape of Gola-Foya (Fig.13) between 2001 and 2020.

Compared to national parks (Fig.9 and Fig.10) and forest reserves (Fig.11 and Fig.12) for which forest represented about 90% of their total surface area, the proposed protected area of Foya offers less forest cover at 75%.

It can be seen that this forest cover was preserved between 2001 and 2020 with fairly low losses of: **0.34%** during the period 2001-2007, **0.84%** during the period 2007-2014 and **1.99%** during the period 2014-2020.

There is also growing human activity, as evidenced by the "Built" class in 2020.

Evolution of Land-Use / Land-cover in the proposed protected area of Foya

Fig.13: View of the proposed protected area of Foya showing the extent over which the statistics have been computed.
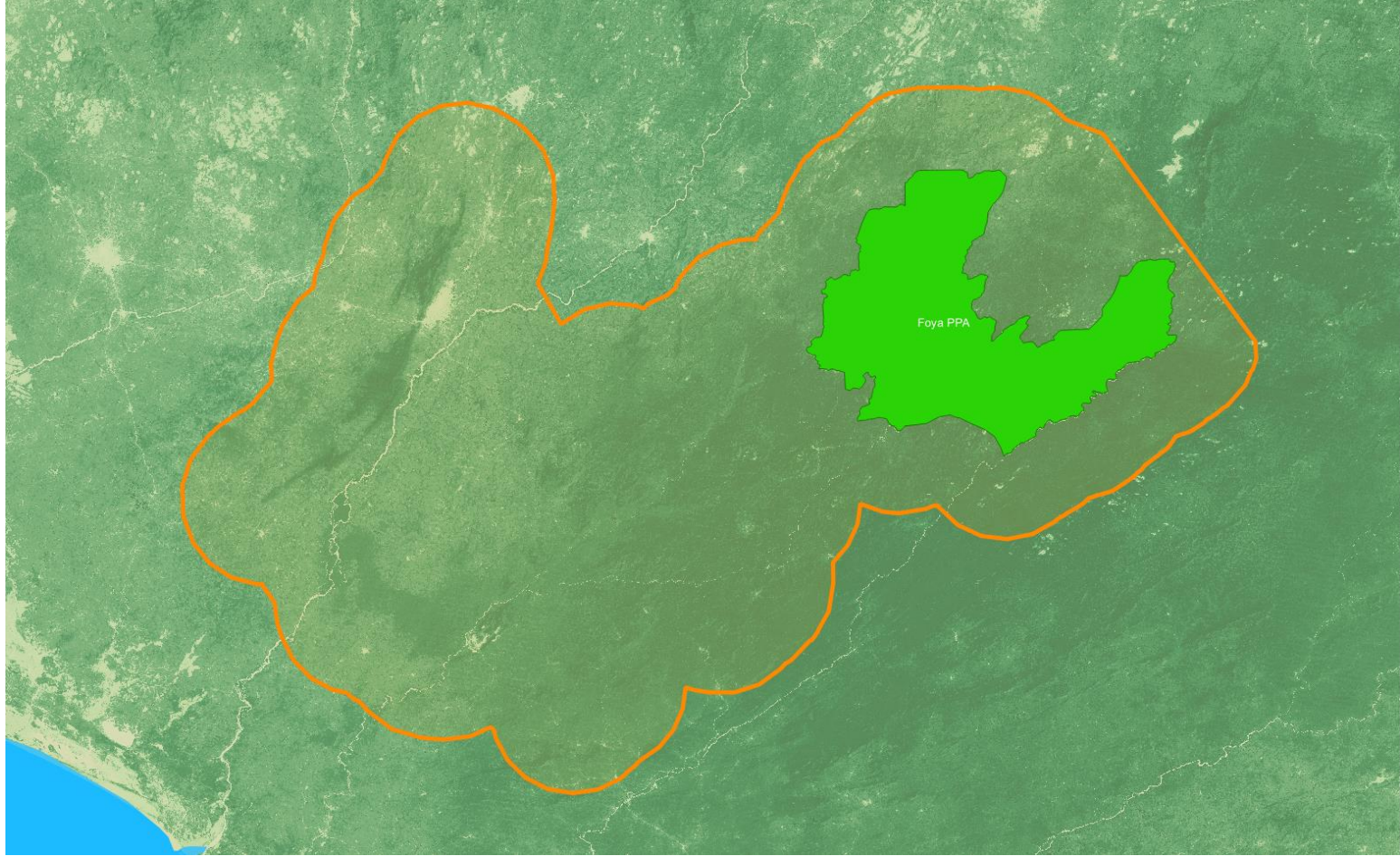
Fig.14: Assessment of the Land-use / Land-cover of the proposed protected area of Foya in 2001, 2007, 2014 and 2020 (statistics calculated on the extents shown in Fig.13 only).

Land-Use / Land-cover of the proposed protected area of Foya between 2001 and 2020
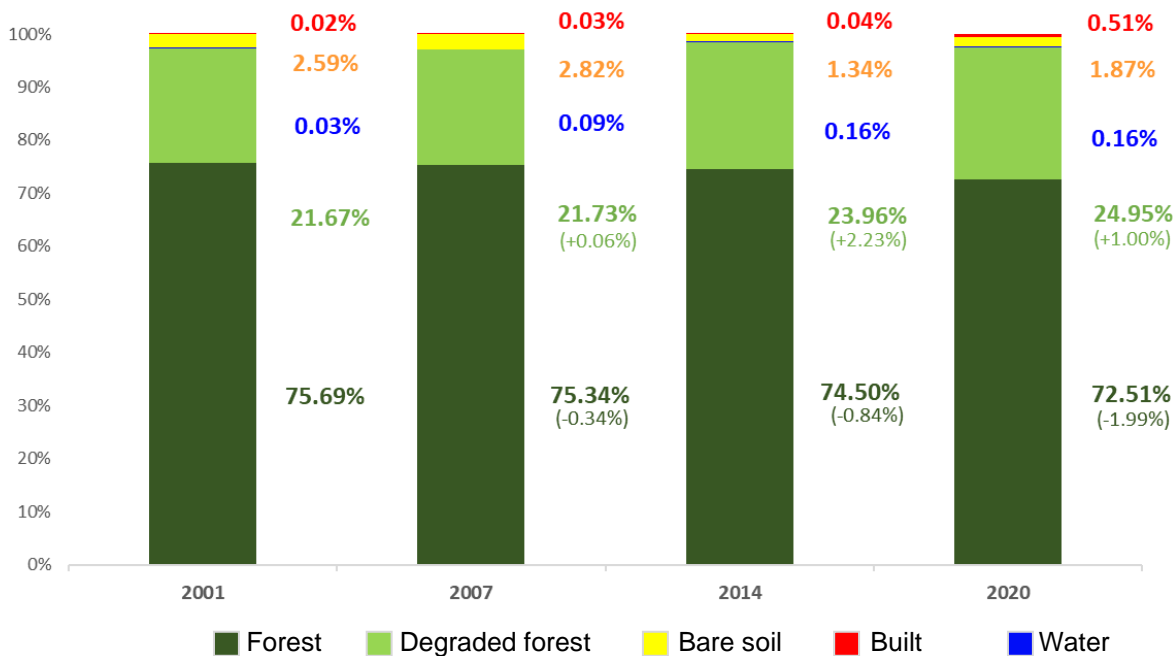
powered by VisioTerra

Fig.15 summarizes deforestation by period in the entire Gola-Foya priority landscape. The areas in grey represent the areas deforested before 2001, the areas in blue are those deforested between 2001 and 2007, the areas in yellow are those deforested between 2007 and 2014 and the areas in red are those deforested between 2014 and 2020. This dominant red testifies to the acceleration of deforestation in the last period.

Fig.16 shows the evolution of forest cover loss by period in the four conservation units: entire landscape, national parks, forest reserves and proposed protected area.

It can be seen that the national parks have been preserved while the forest reserves have suffered an increasing loss of their forests.

Loss of forest cover in the different conservation units of Gola-Foya between 2002 and 2020

Fig.15: Deforestation by periods in the Gola-Foya landscape between 2001 and 2020.

Zone deforested before 2002
Zone deforested between 2002 and 2007
Zone deforested between 2007 and 2014
Zone deforested between 2014 and 2020
Preserved forest cover
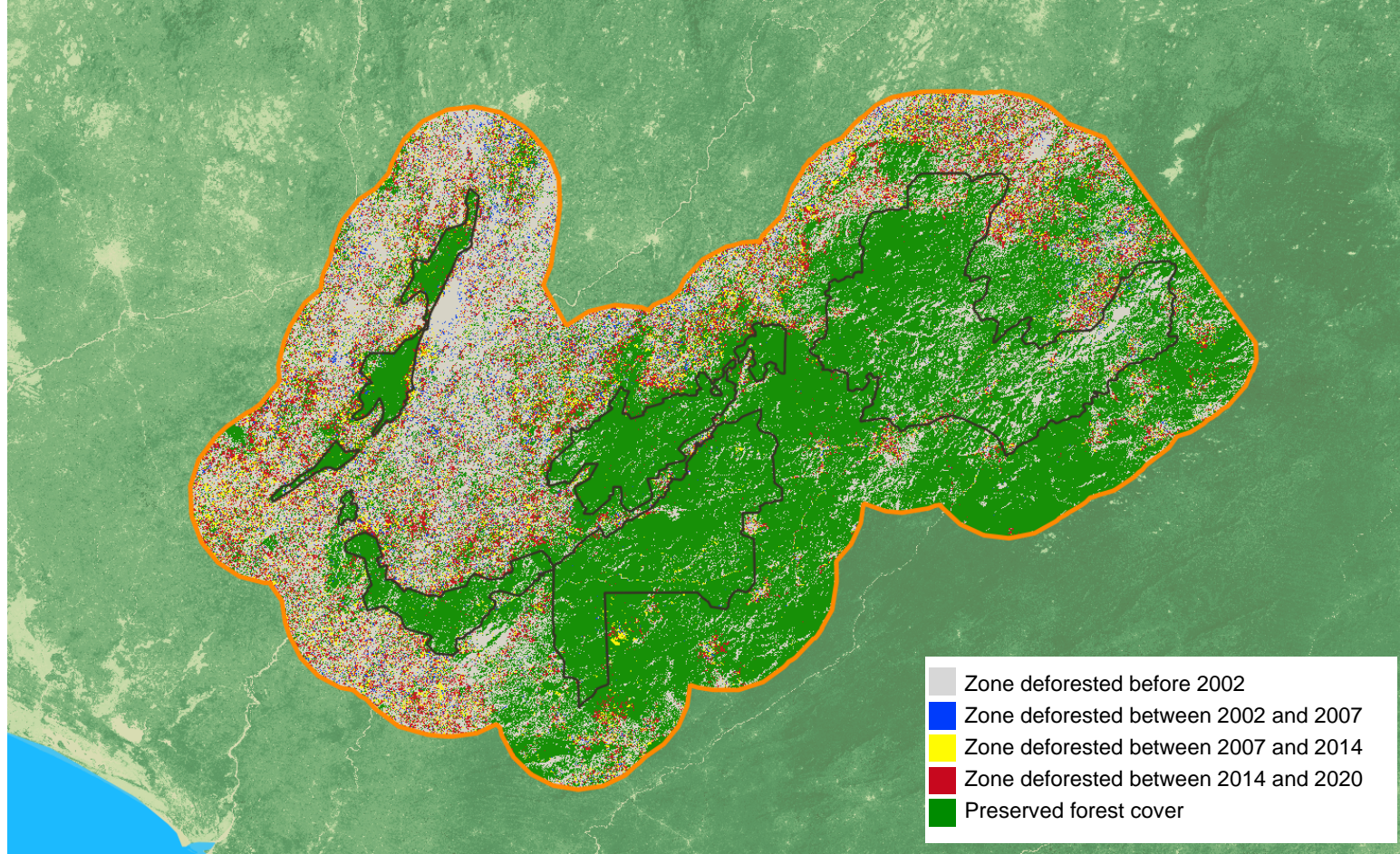
Fig.16: Summary of forest cover loss in the different Gola-Foya conservation units in 2007 (difference between 2007 and 2001), in 2014 (difference between 2014 and 2007) and in 2020 (difference between 2020 and 2014).

Loss of forest cover in the different conservation units of Gola-Foya between 2001 and 2020

entire landscape   integral/strict nature reserves   nature reserves   community forests
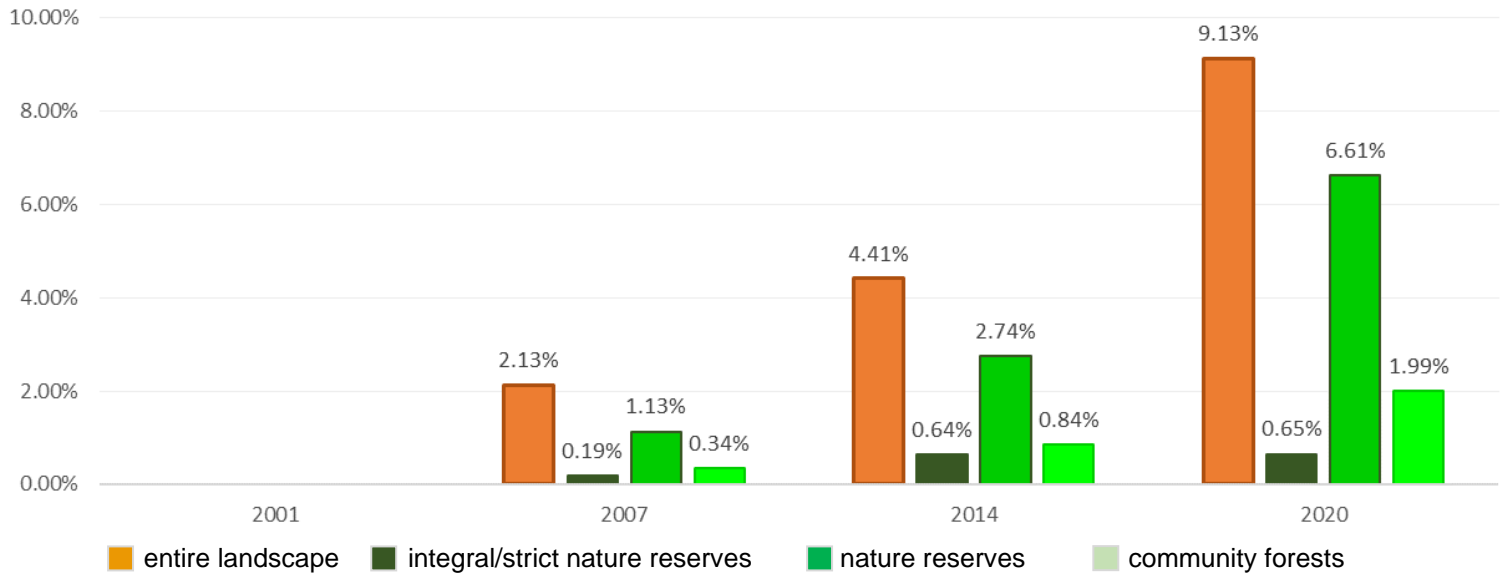
Gola Forest National Park is one of the priority landscape conservation areas of Gola-Foya. It is located in the northwest of Liberia and straddles the two counties of Gbarpolu and Grand Cape Mount.

FLEGT Watch is an automatic detection system to monitor deforestation in Central and West Africa using Sentinel-1 radar satellite images. This section shows three examples of deforestation detected by FLEGT Watch in Gola Forest National Park.

In each of the examples, we will show the Sentinel 1 radar images (1st line) then the Sentinel 2 optical images (2nd line) before (1st column a) and after (2nd column b) the deforestation event detected automatically in the radar image (top right).

In the radar image (Fig.17), there is an extension of deforested areas in the north western part of Gola Forest National Park. Analysis of the Sentinel-2 optical image (Fig.18) confirms that the forest (Fig.18a) was clearly cut in April 2020 (Fig.18b).
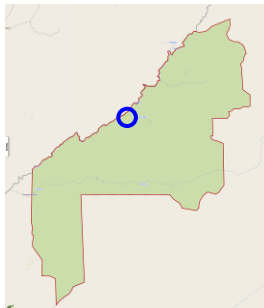
FLEGT Watch in Liberia Gola-Foya landscape

Gola Forest National Park
Event #1341631 - LBR VT01

2D_layer_stack

Fig.17: Sentinel-1A mean 23-02-2020 → 30-03-2020 (a) and 11-04-2020 (b).　　left_view　right_view　animation

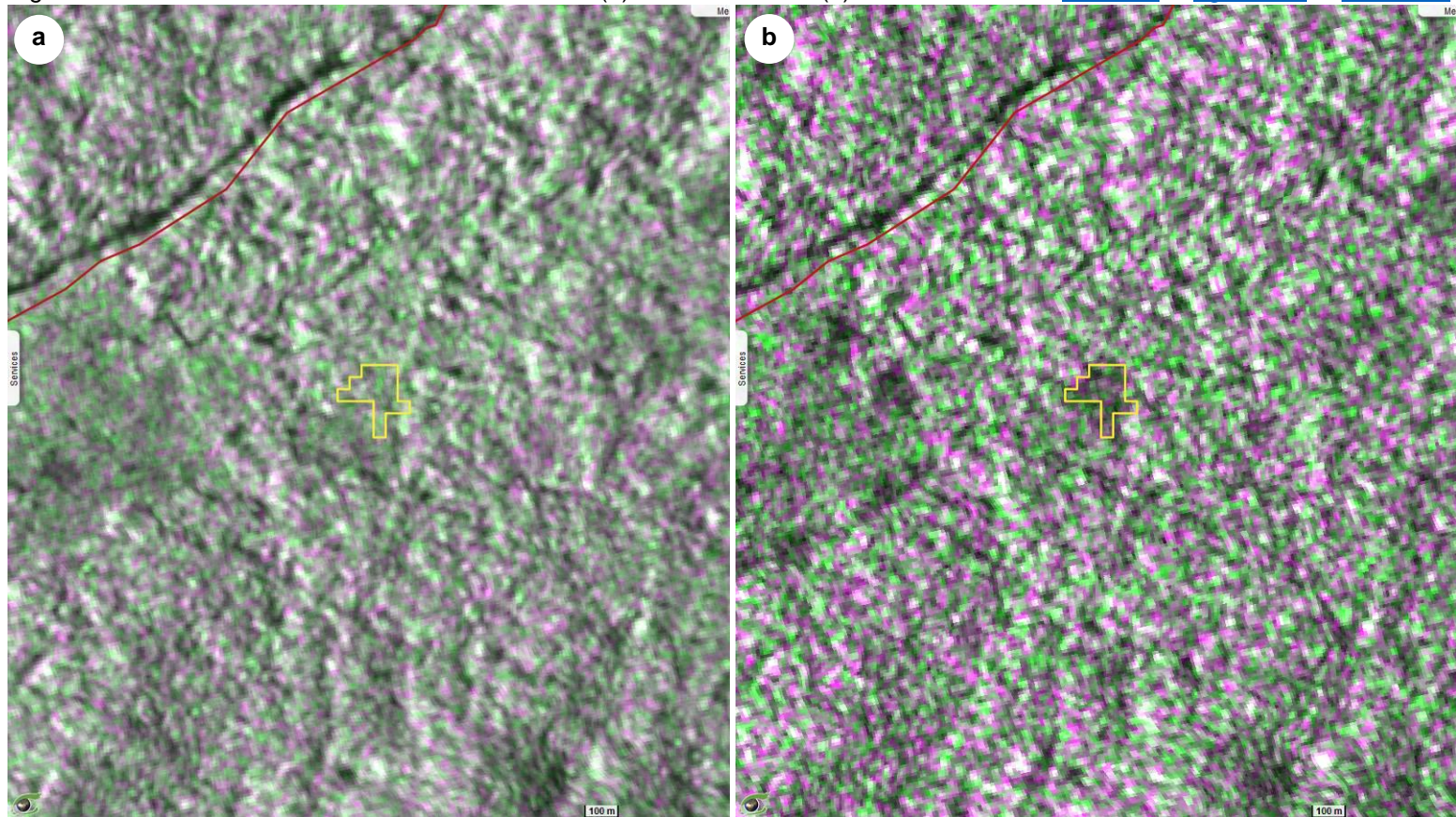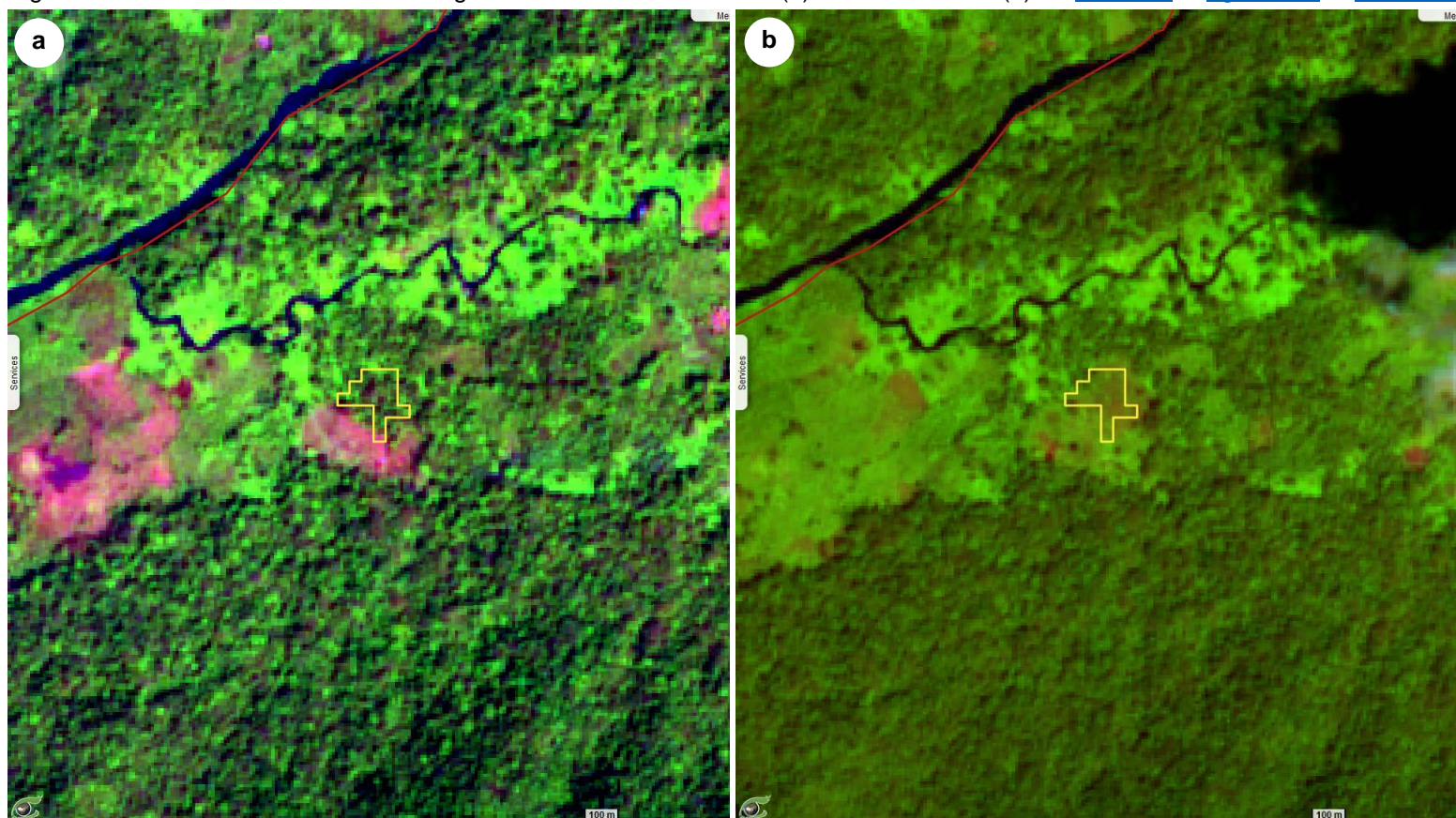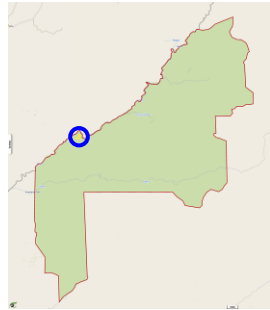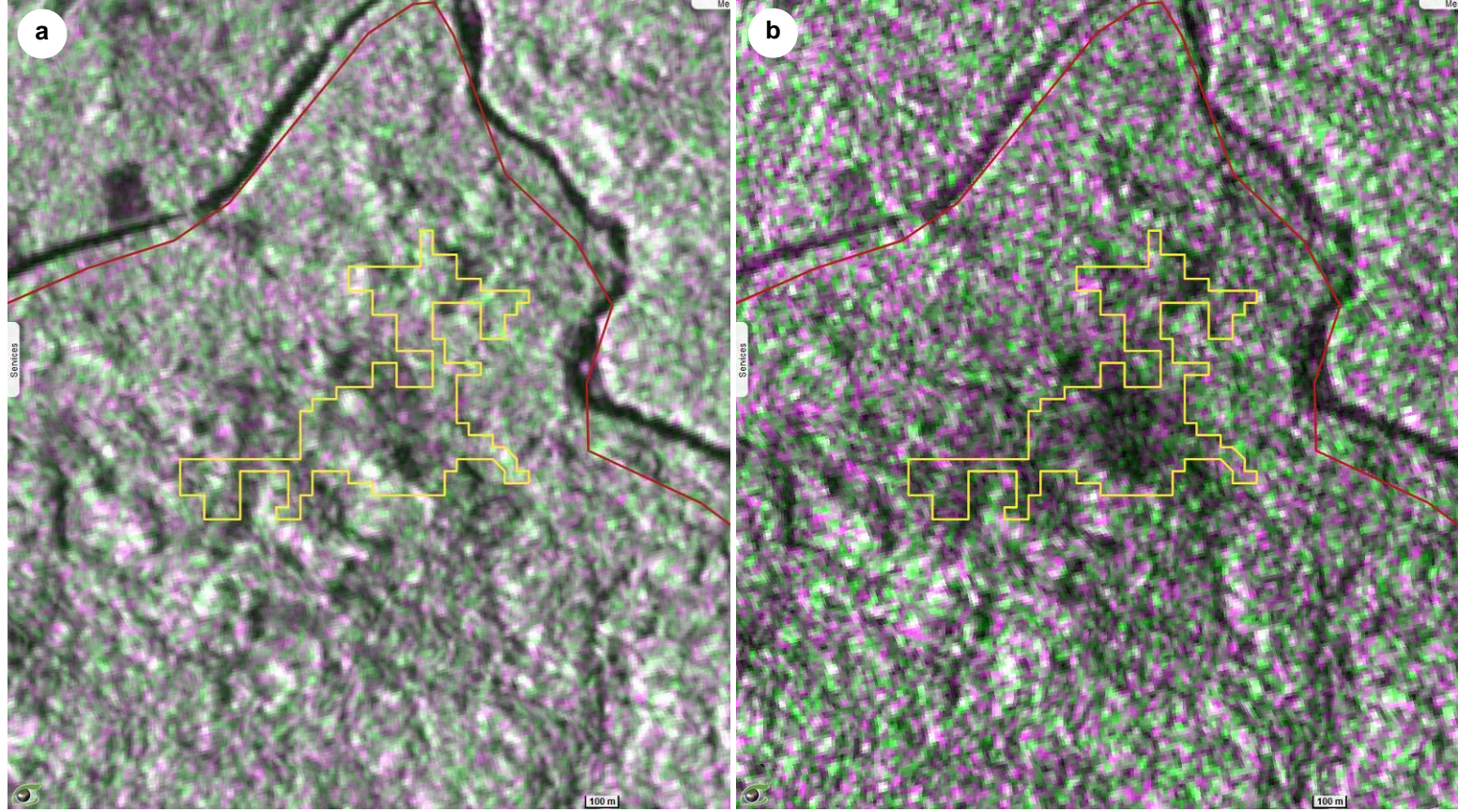Fig.18: Sentinel-2A and Sentinel-2B images observed on 14-01-2020 (a) and 14-11-2020 (b).　left_view　right_view　animation

powered by VisioTerra

As shown in Fig.19, the FLEGT Watch system detected widespread deforestation between April 23 and May 5, 2020. This deforestation occurs in the north western part of Gola Forest National Park, 200 meters southeast of the village of Nyekehun.

Analysis of the Sentinel-2 optical image (Fig.20) confirms that the remnants of forest observed in Fig.20a are no longer present in Fig.20b. It should be noted that the almost permanent cloud cover over the area forced the search for optical data well before the event of May 05, 2020 (first image without clouds on 14.01.2020) and well after the event (first image without clouds on 14.11.2020).

FLEGT Watch in Liberia
Gola-Foya landscape

Gola Forest Nationalle Park
Event #1341647 - LBR VT01

2D_layer_stack

Fig.19: Sentinel-1A mean 18-03-2020 → 23-04-2020 (a) and 05-05-2020 (b).   left_view   right_view   animation

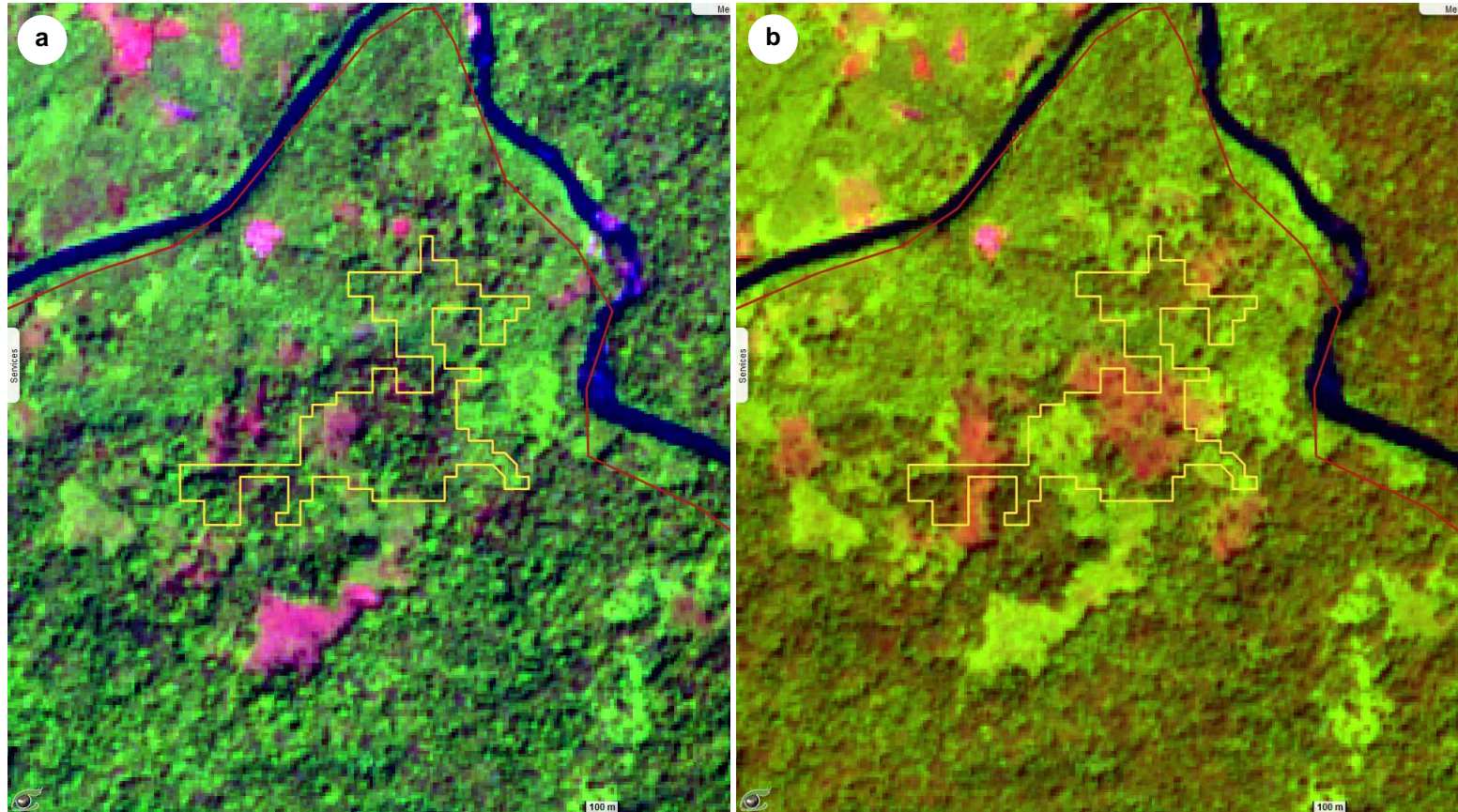Fig.20: Sentinel-2A and Sentinel-2B images observed on 14-01-2020 (a) and 14-11-2020 (b).   left_view   right_view   animation


HYP-119-Sentinels-F (p.11)

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In the radar image (Fig.21), a clear cut is observed that occurred between May 5 and May 17, 2020. This deforestation occurs in the north western part of Gola Forest NP, 400 meters south of the village of Morta.

Analysis of the Sentinel-2 optical image (Fig.22) confirms that the forest (Fig.22a) has been clearly cut (Fig.22b) revealing a clearing of just under one (1) hectare.

This phenomenon of "nibbling" around parks is common; especially when it occurs near villages.

Note here the proximity of the border between Liberia and Sierra Leone.
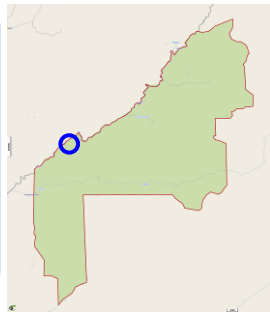
Fig.21: Sentinel-1A mean 30-03-2020 → 05-05-2020 (a) and 17-05-2020 (b).   left_view   right_view   animation
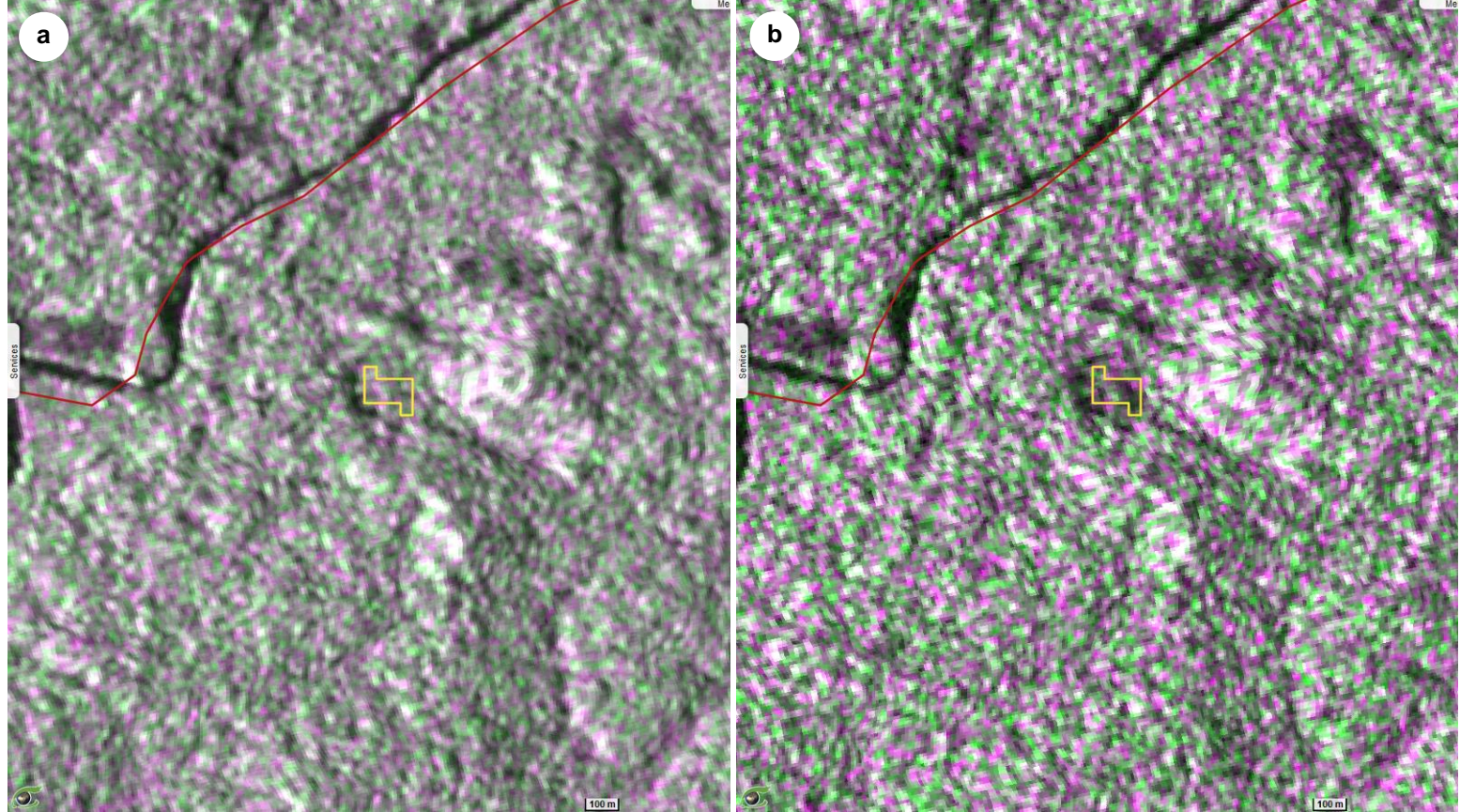
Fig.22: Sentinel-2A and Sentinel-2B images observed on 14-01-2020 (a) and 14-11-2020 (b).   left_view   right_view   animation
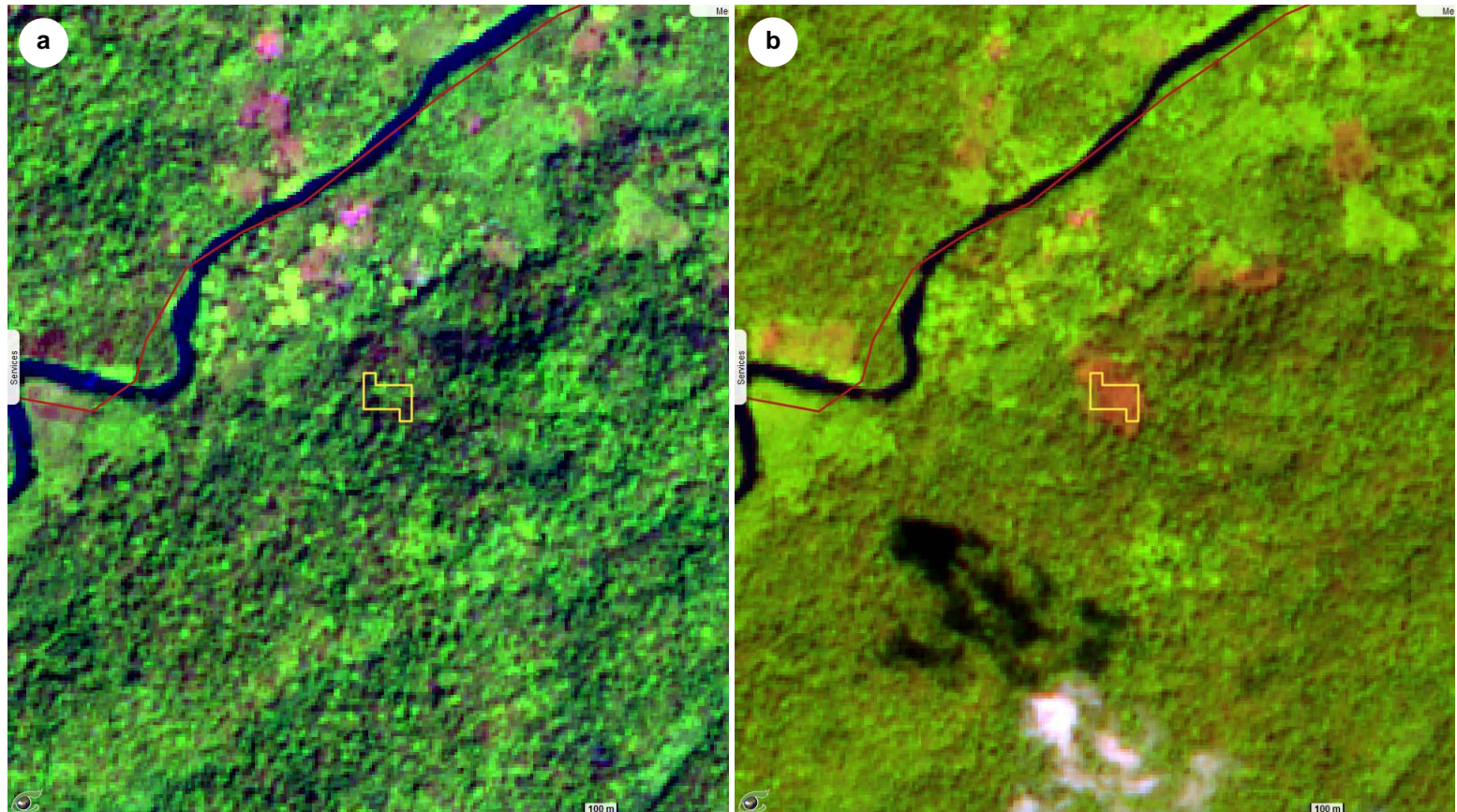

HYP-119-Sentinels-F (p.12)

Fig.23 shows the periodic bulletin generated by a geoservice monitoring burned areas and active fires in the Gola-Foya priority landscape between 2015 and 2021. This periodic bulletin was produced by the CAFWS platform developed by VisioTerra.

The first and second sections of the periodic bulletin provide information on the name of the geoservice, the site, the indicator(s) to be calculated (active fires, burnt areas, etc.) and the period of time during which the geoservice will operate. The third section allows the user to choose the period for which the results are to be displayed (the period here is annual). The fourth section concerns the results of the spatial aggregation of burned areas. The red curve shows the presence (value 255 on the y-axis) or absence (value 0 on the y-axis) of burned area in the study area during the defined period. The fifth section shows the results of the temporal aggregation of burned areas. The areas where a burnt area was detected at least once during the study period are rendered in red. Here, for example (Fig.23), the burned areas are those detected in 2017.

Fig.24 shows in red the burned areas detected automatically in 2020 and 2021.

Burnt areas – Periodic bulletin
Gola-Foya landscape

2D_layer_stack

Fig.23: View of the periodic bulletin showing the burnt areas per year between 2015 and 2021.
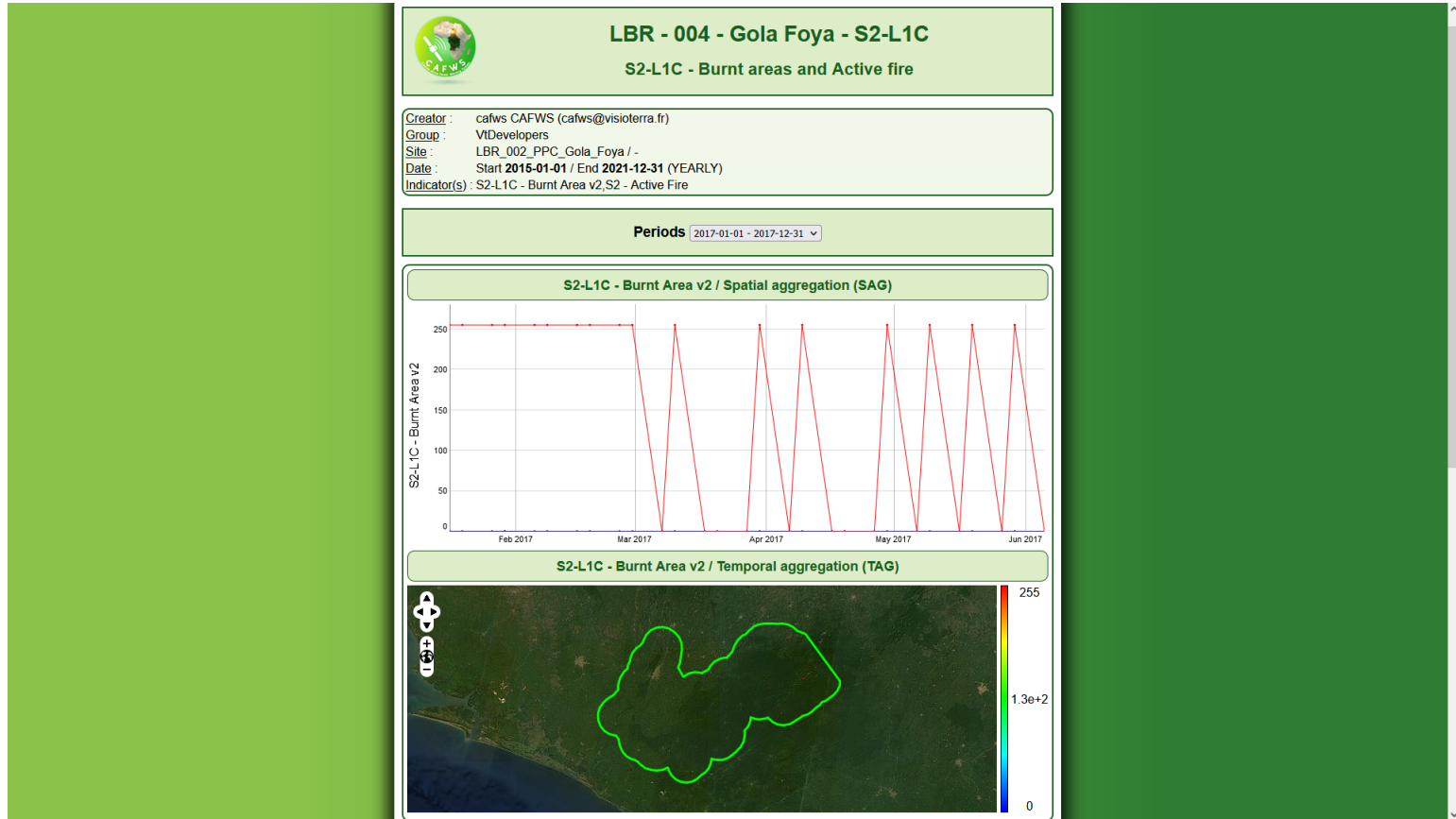
periodic_bulletin

Fig.24: Burnt areas automatically detected in 2020 and 2021.
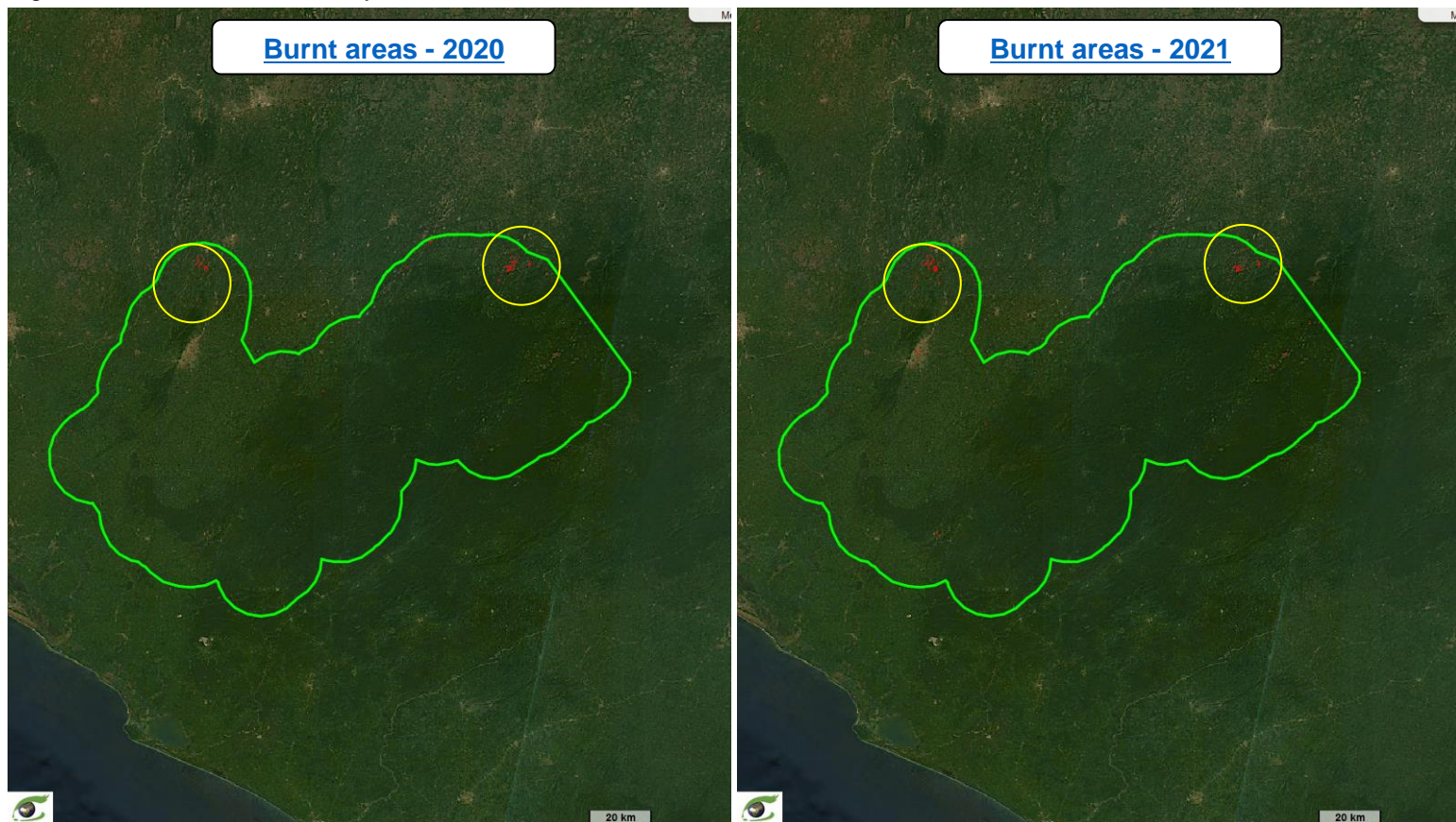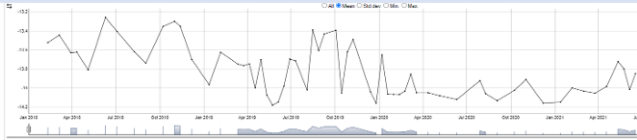
animation

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Fig.25 shows a Sentinel-2 image which exploits the richness of the spectral bands of its multispectral instrument MSI. Here, bands 11, 8 and 2 correspond to mid-infrared, near-infrared and blue. These three bands 11, 8, 2 have been assigned to the red, green and blue planes respectively.

The Sentinel-2 tile (Fig.25) was acquired in the dry season on January 14, 2020.

Fig.26 shows in brown the result of the segmentation of the burnt areas observed on the image Fig.25. From this segmentation, we can calculate the occurrences of burned areas over time as illustrated in the graph below.

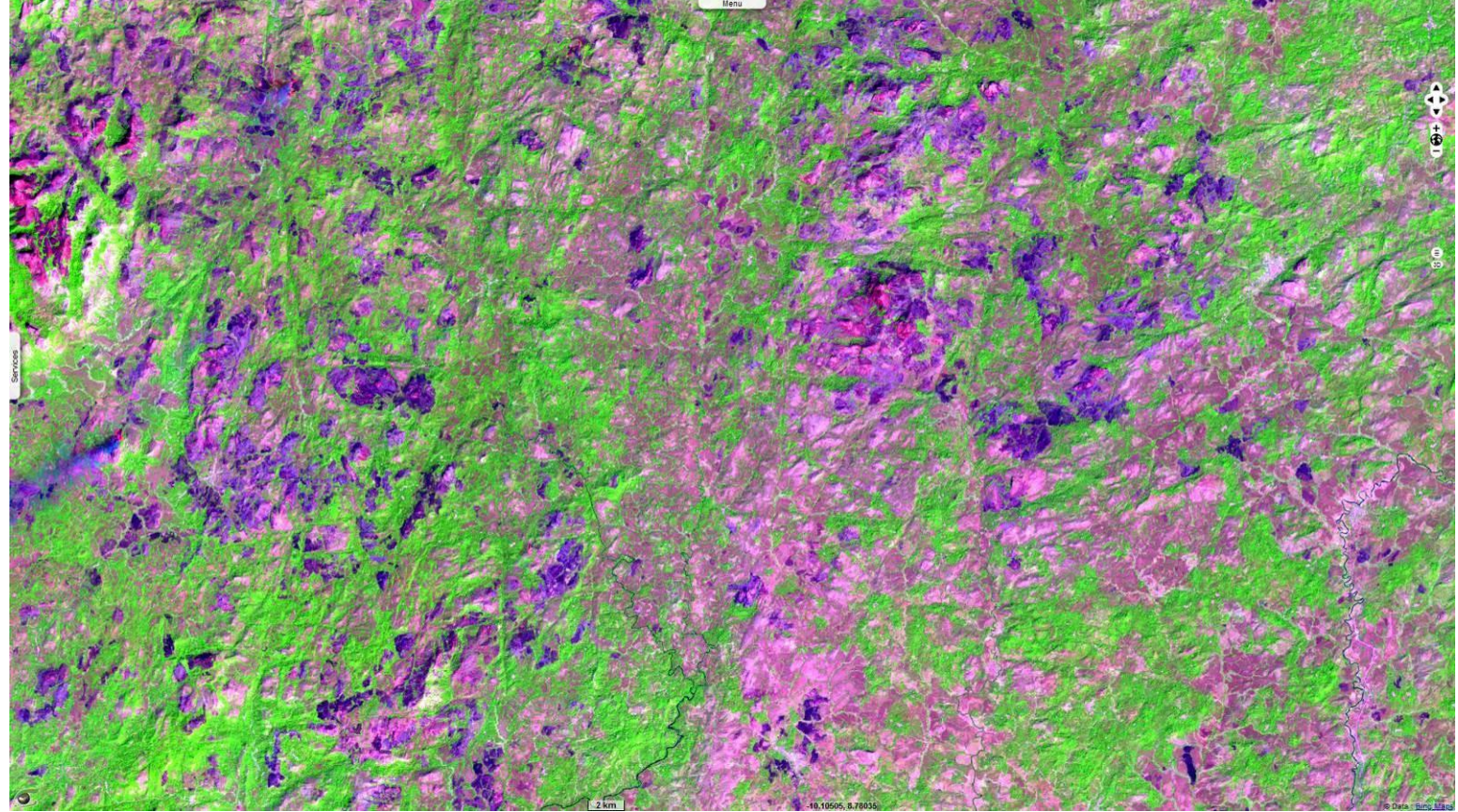Fig.25: Sentinel-2A image observed on 14-01-2020 showing the burnt areas.   2D_view   animation

Fig.26: Burnt areas automatically extracted from the Sentinel-2A image observed on 01-14-2020.   2D_view
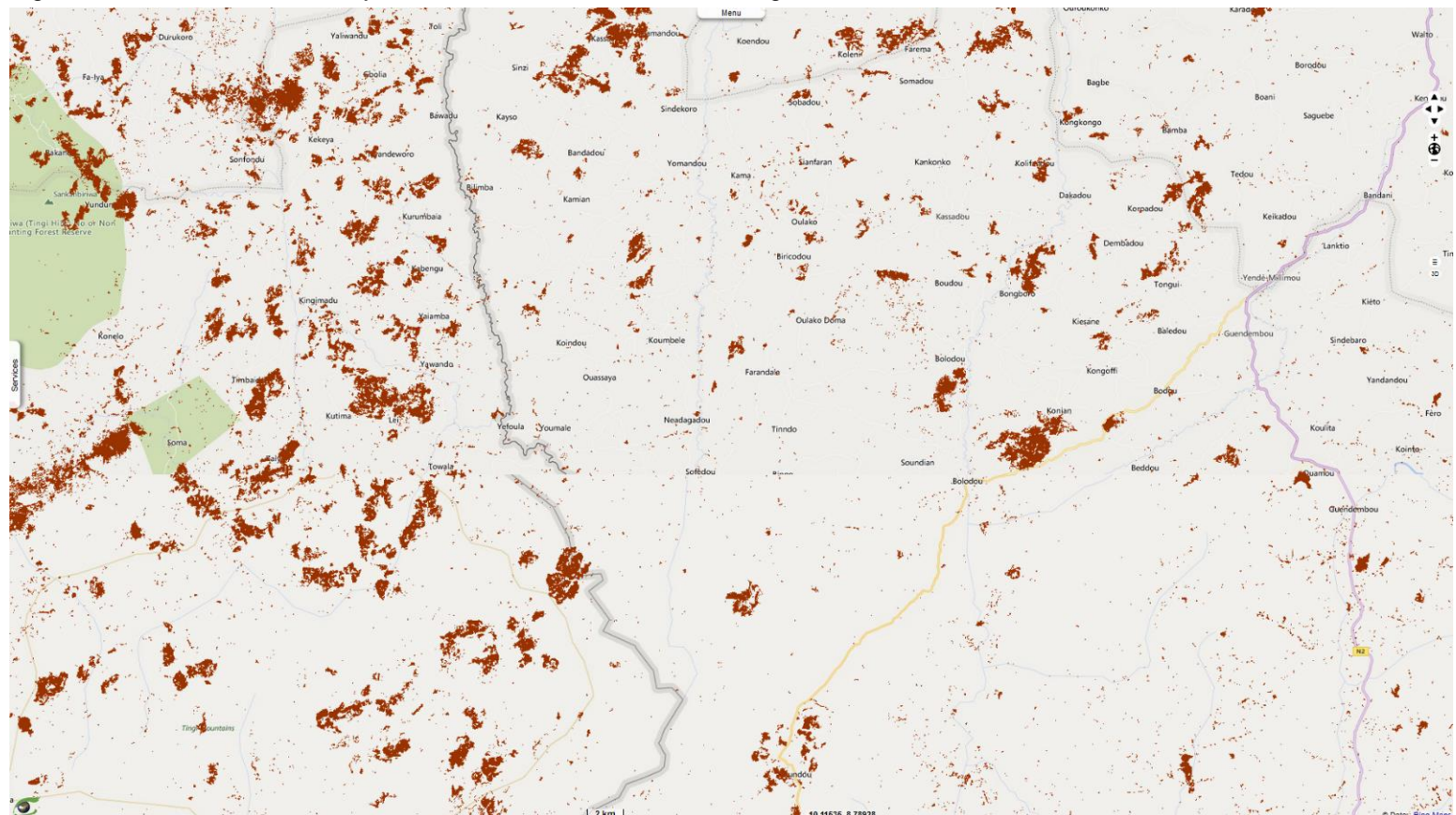
Fig.27 shows the periodic bulletin generated by the same geoservice monitoring **burnt areas and active fires** in the priority landscape of Gola-Foya between. Monitoring is performed from 2015 to 2021 with the indicator of active fires. The red areas in the temporal aggregation section image represent areas where an active fire front was observed at least once during the study period.

Fig.28 shows in red the active lights detected automatically in 2017 and 2020.

The active fire indicator is calculated from Sentinel-2 optical data using the BAIS2 index (*Burnt Area Index for Sentinel-2*).

$$BAIS2 = \left(1 - \sqrt{\frac{B06 * B07 * B8A}{B4}}\right) * \left(\frac{B12 - B8A}{\sqrt{B12 + B8A}} + 1\right)$$

Active fires – Periodic bulletin
Gola-Foya landscape

2D_layer_stack

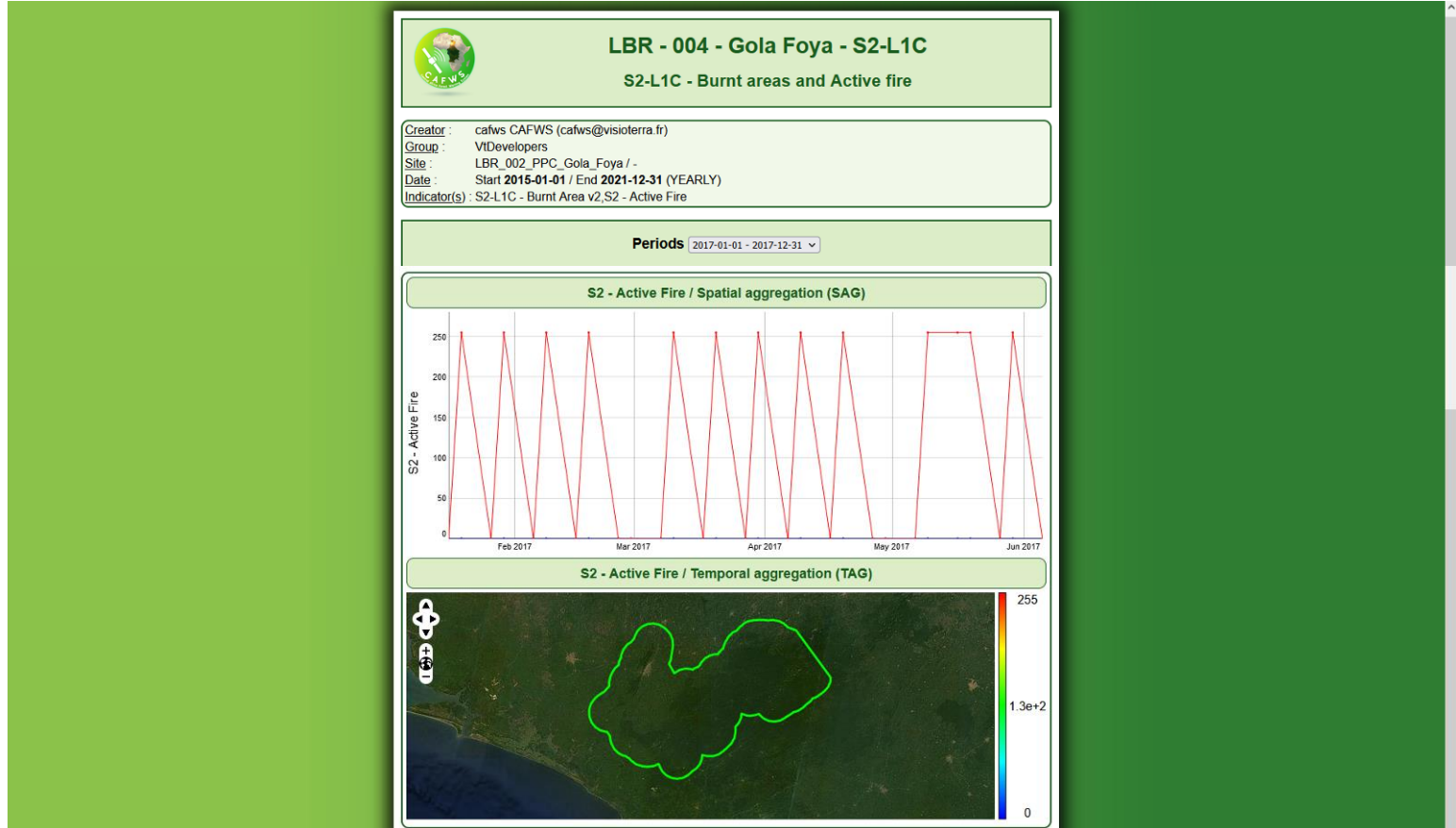Fig.27: View of the periodic bulletin with active fires detected by year between 2015 and 2021.   periodic_bulletin

Fig.28: Active fires automatically detected in 2017 and 2020.   animation

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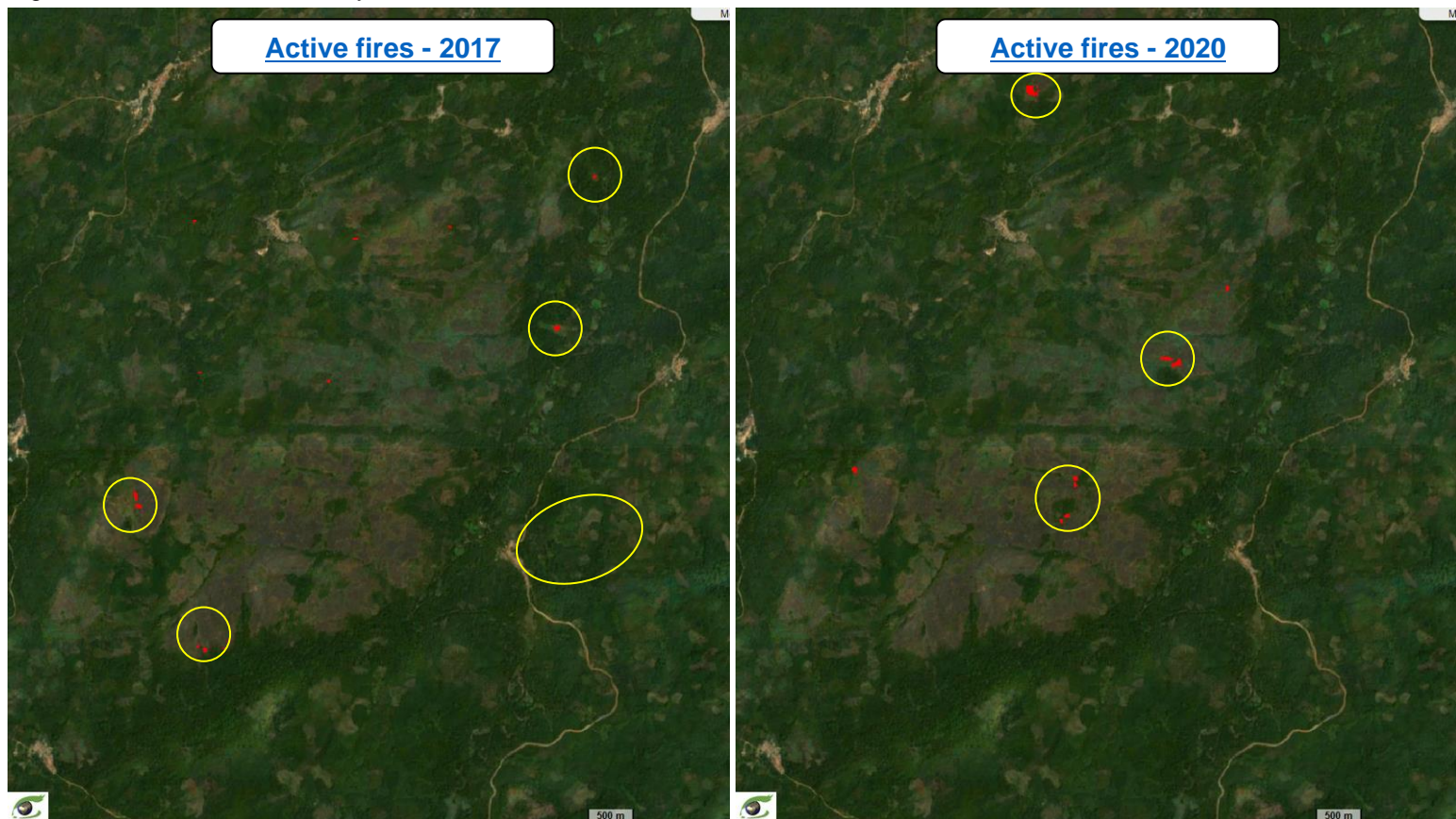Fig.29 shows a Sentinel-2 image in 12-11-2 colour composition acquired on January 14, 2020 in the dry season as evidenced by the daily precipitation graph below. Active fire fronts appear as orange-yellow colour.

Fig.30 shows in red the result of the segmentation of the active fire fronts observed on the image Fig.29.

These active fires can be reported as an alert.
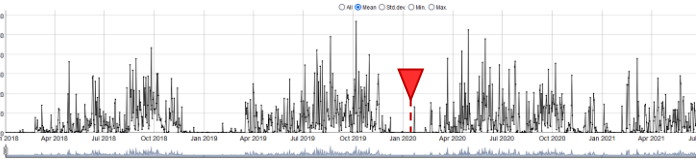
Fig.29: Sentinel-2A image observed on 14-01-2020 showing active fire fronts.   2D_view   animation
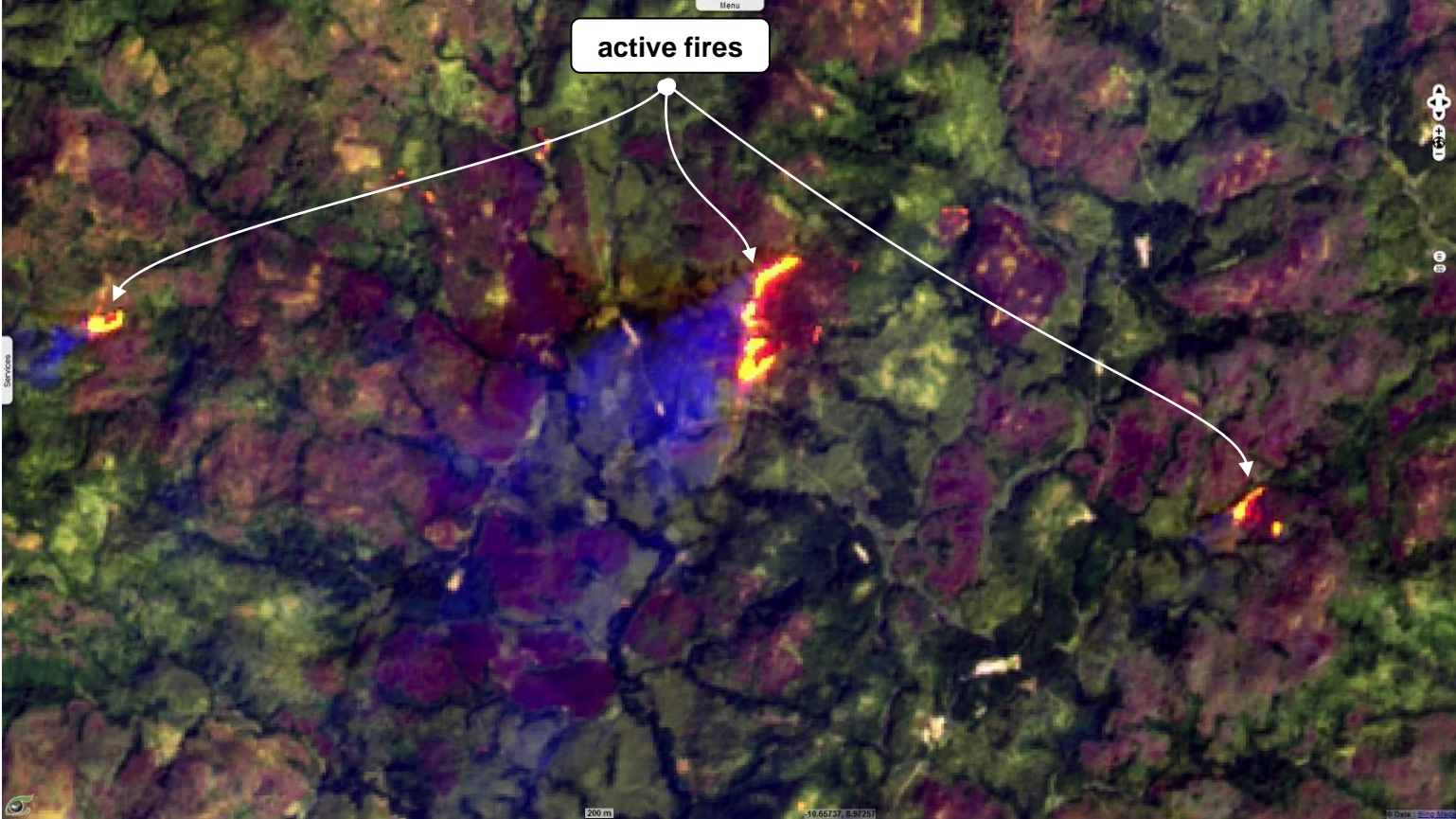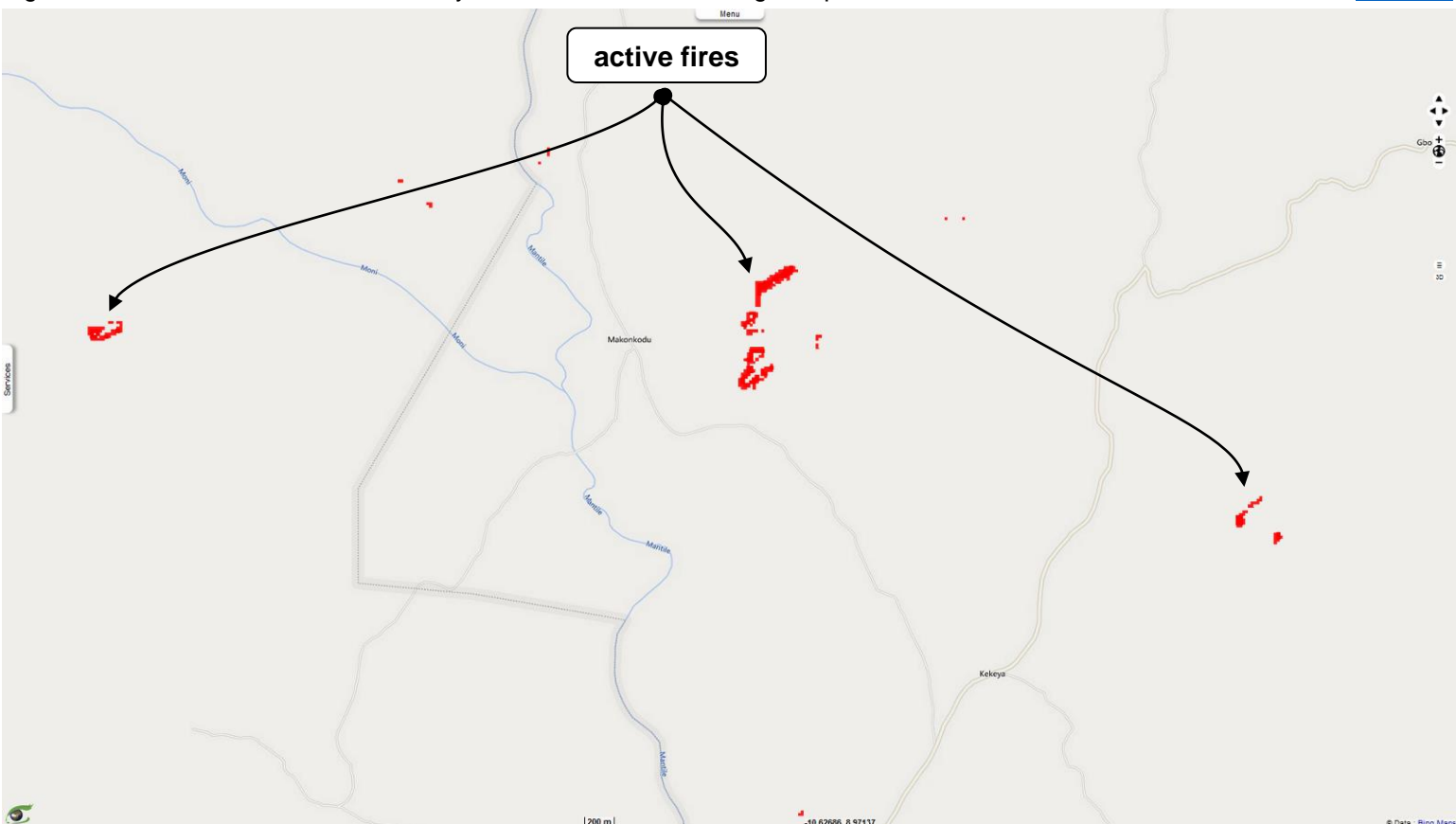

active fires

Fig.30: Active fires detected automatically from the Sentinel-2A image acquired on 14-01-2020.   2D_view

active fires

This study is carried out within the framework of the **PAPFor** programme (*Programme d'Appui à la Préservation des Ecosystèmes Forestiers en Afrique de l'Ouest*) financed by the European Union under the 11th EDF and implemented by the AGRECO-GITEC consortium. VisioTerra mobilised its expertise for the analysis of the evolution of the occupation of the priority landscapes of Mount Nimba and Gola-Foya, two of the six landscapes funded by PAPFor.

The results of the analysis are presented at the African Protected Areas Congress (APAC) organised by IUCN in Kigali (Rwanda) from 18 to 23 July 2022. This presentation is made in collaboration with the **OBAPAO** project (Observatory for Biodiversity and Protected Areas in West Africa), an initiative of the BIOPAMA Programme, also funded by the European Union, to improve the long-term conservation and sustainable use of natural resources in protected areas and surrounding communities in African, Caribbean and Pacific countries.

PAPFor is:

- ❖ funded by the European Union

- ❖ implemented by

  in association with

The study is:

- ❖ performed by

- ❖ presented in collaboration with