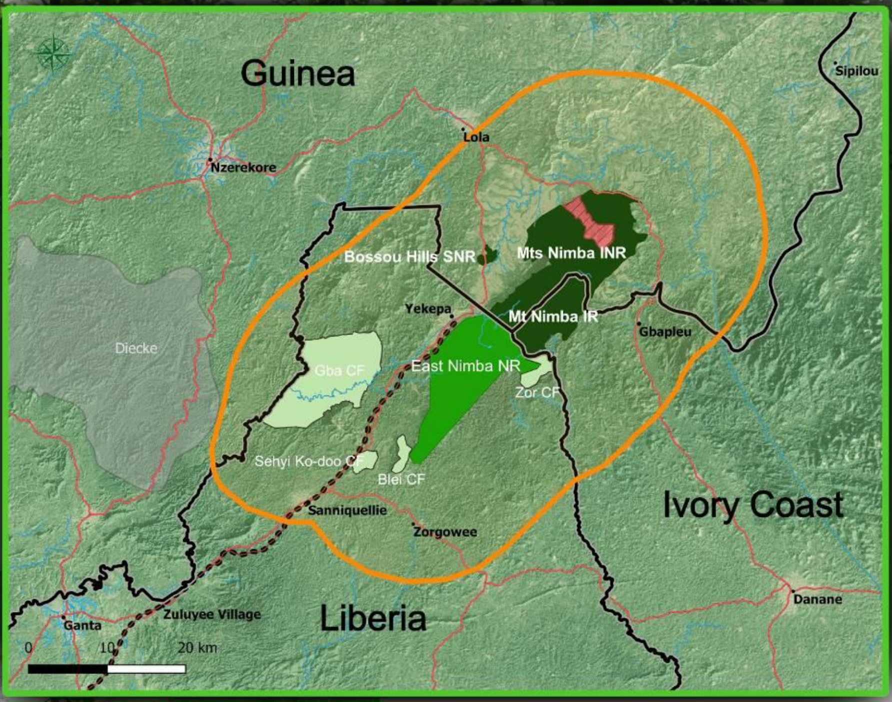
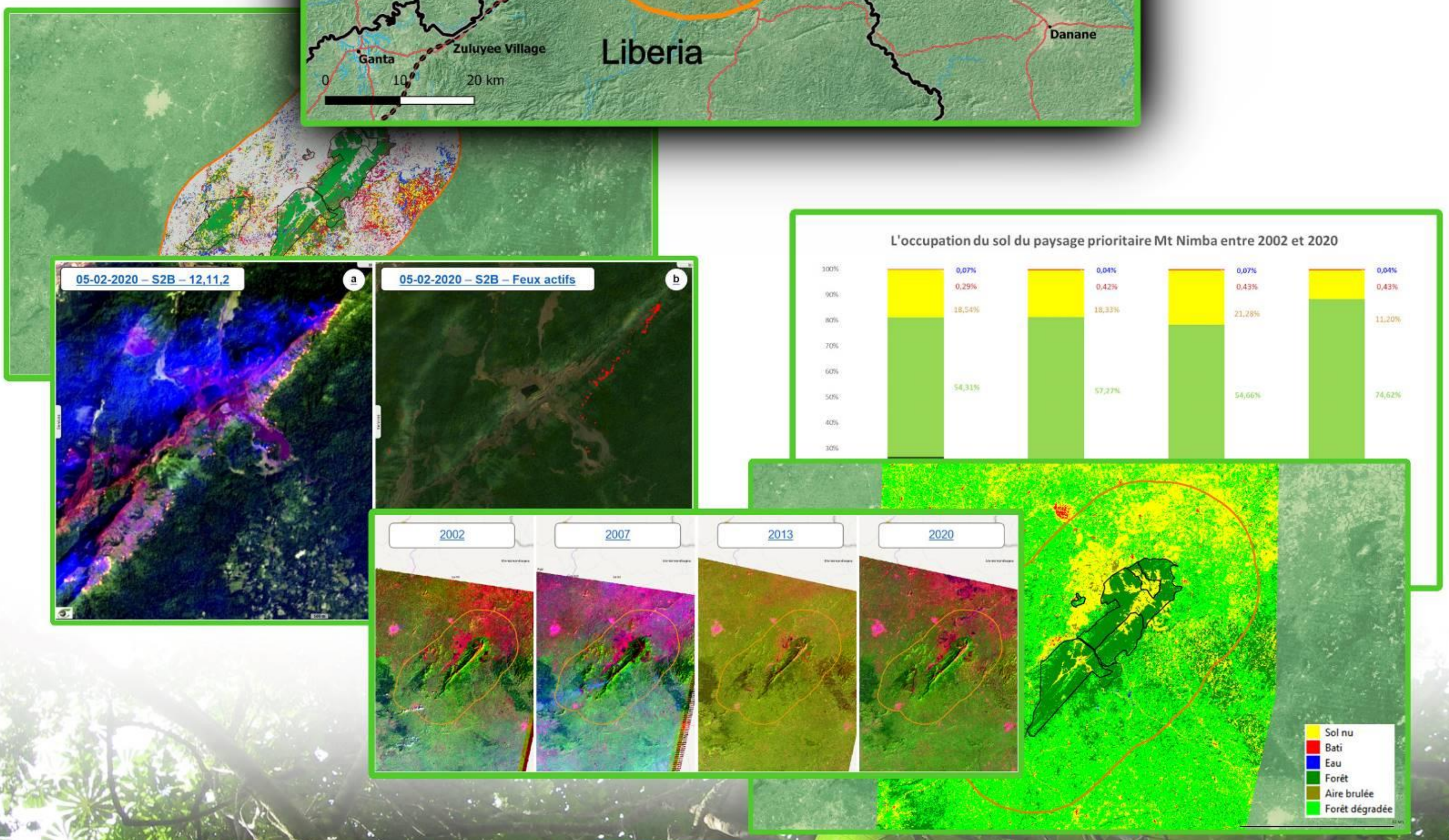
Mount Nimba Priority Landscape





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Shared between Guinea, Côte d'Ivoire and Liberia, the M[t] Nimba Landscape displays an important variety of ecosystems, ranging from lowland Guinean forests to montane forests and Guinean savannas. With altitude ranging from 400 to 1750m, M[t] Nimba is a unique centre of endemism, holding many species of plants, invertebrates, amphibians and mammals not found anywhere else in the world. The Landscape has well-established Protected Areas and is a UNESCO World heritage Site in its northern section.

The landscape encompasses M[t] Nimba Integral Reserve (IR), M[ts] Nimba Integral Nature Reserve (INR), Bossou Hills Strict Nature Reserve (SNR) and East Nimba Nature Reserve (NR). It also encompasses four community forests (CF): Blei, Gba, Sehyi and Zor.

This document shows the evolution of Land Use / Land Cover (LU/LC) in the Landscape between 2002 and 2020 using Landsat-5/7/8 optical satellite images. The study also concerns examples of deforestation, active fires and burnt areas detected by the Sentinel satellites of the European Copernicus program.

Land-use / Land-cover (LU/LC) evolution in M[t] Nimba priority landscape

2D_layer_stack

Fig.1: Map of M[t] Nimba Priority Landscape.

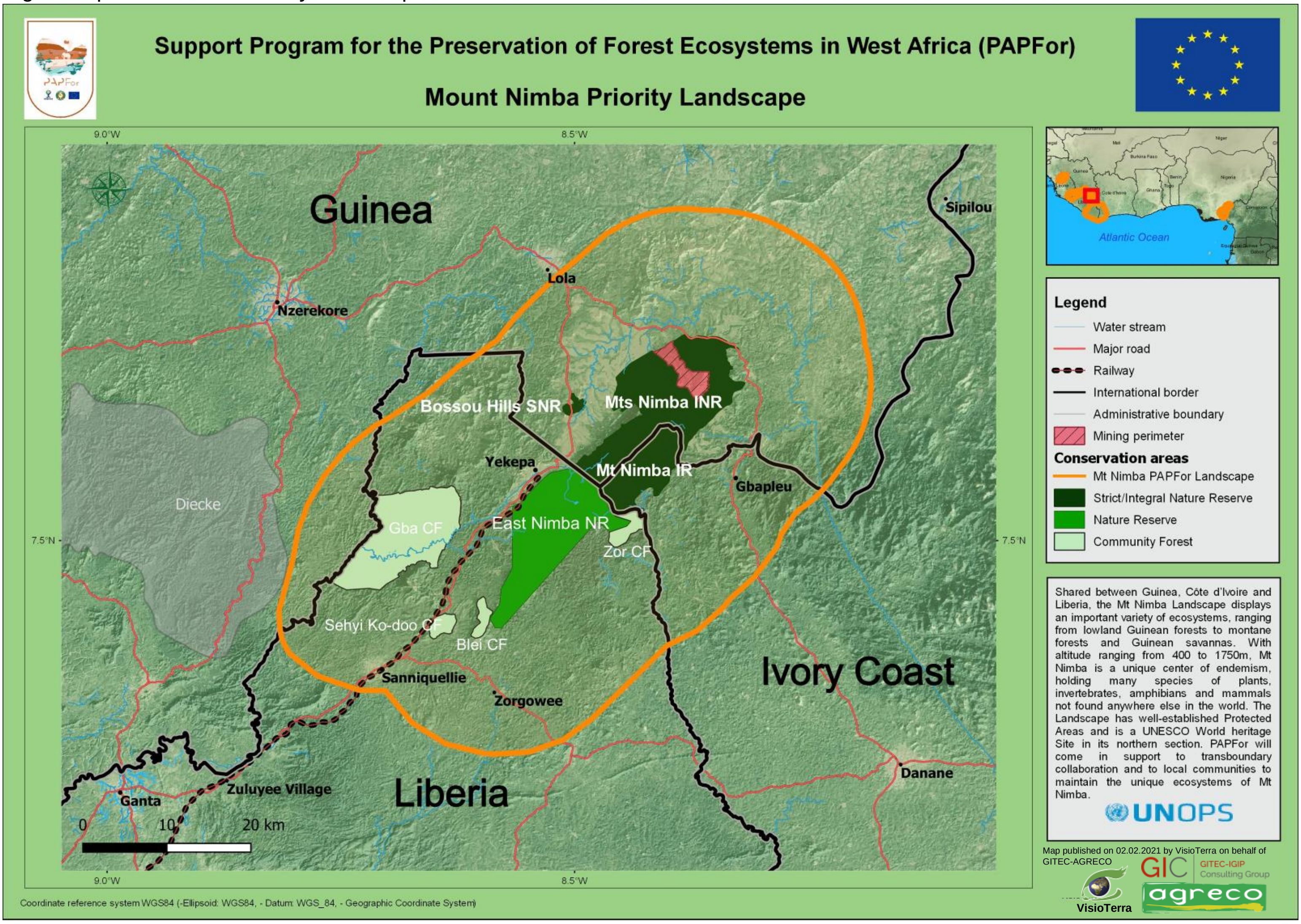
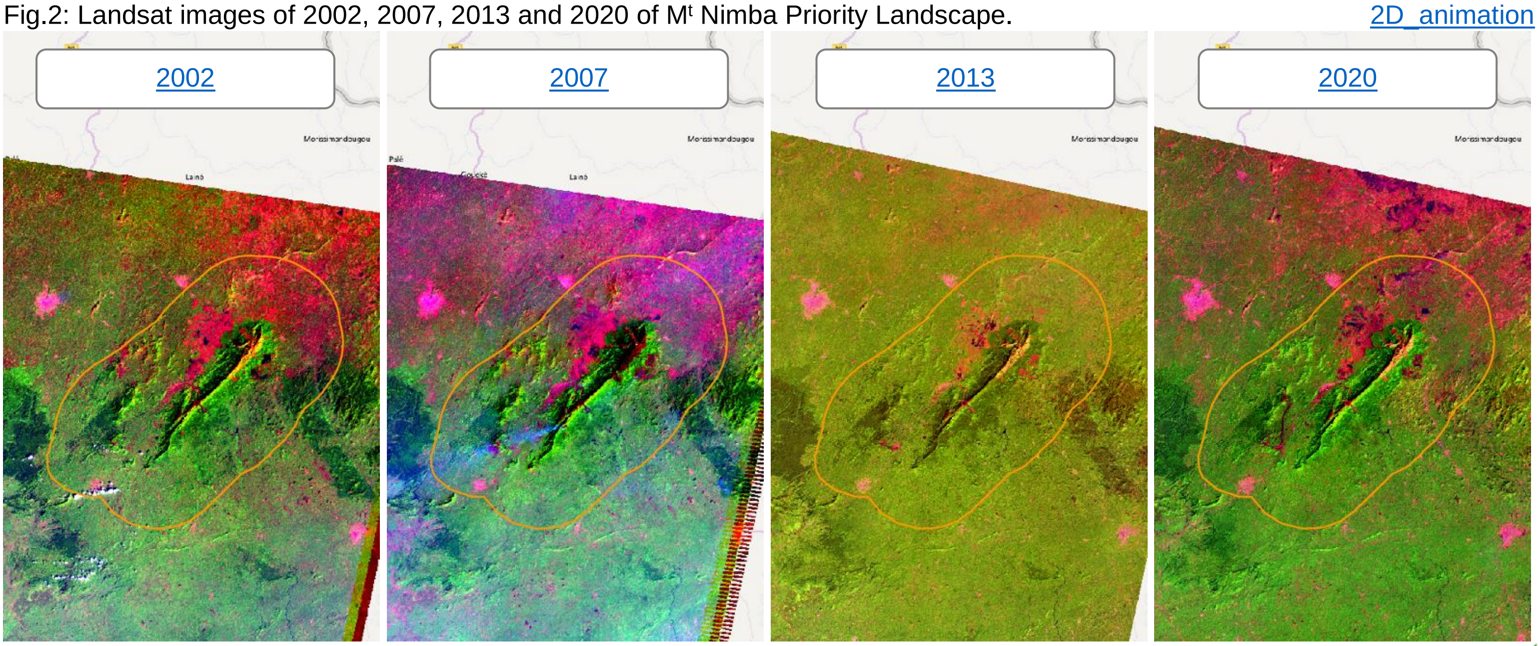


Fig.2: Landsat images of 2002, 2007, 2013 and 2020 of M[t] Nimba Priority Landscape.

2D_animation



The 2002 classification (Fig.3) was calculated from Landsat-7 images.

The land cover classes used are:

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

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

Between 2002 and 2007, it can be seen that the forest cover is quite well preserved. In addition, there is an urban extension of the town of Sanniquellie to the south-west of the landscape.

Land-use / Land-cover (LU/LC) of the M^{t} Nimba Prioritary Landscape between 2002 and 2007

Fig.3: LU/LC map of M^{t} Nimba in 2002.

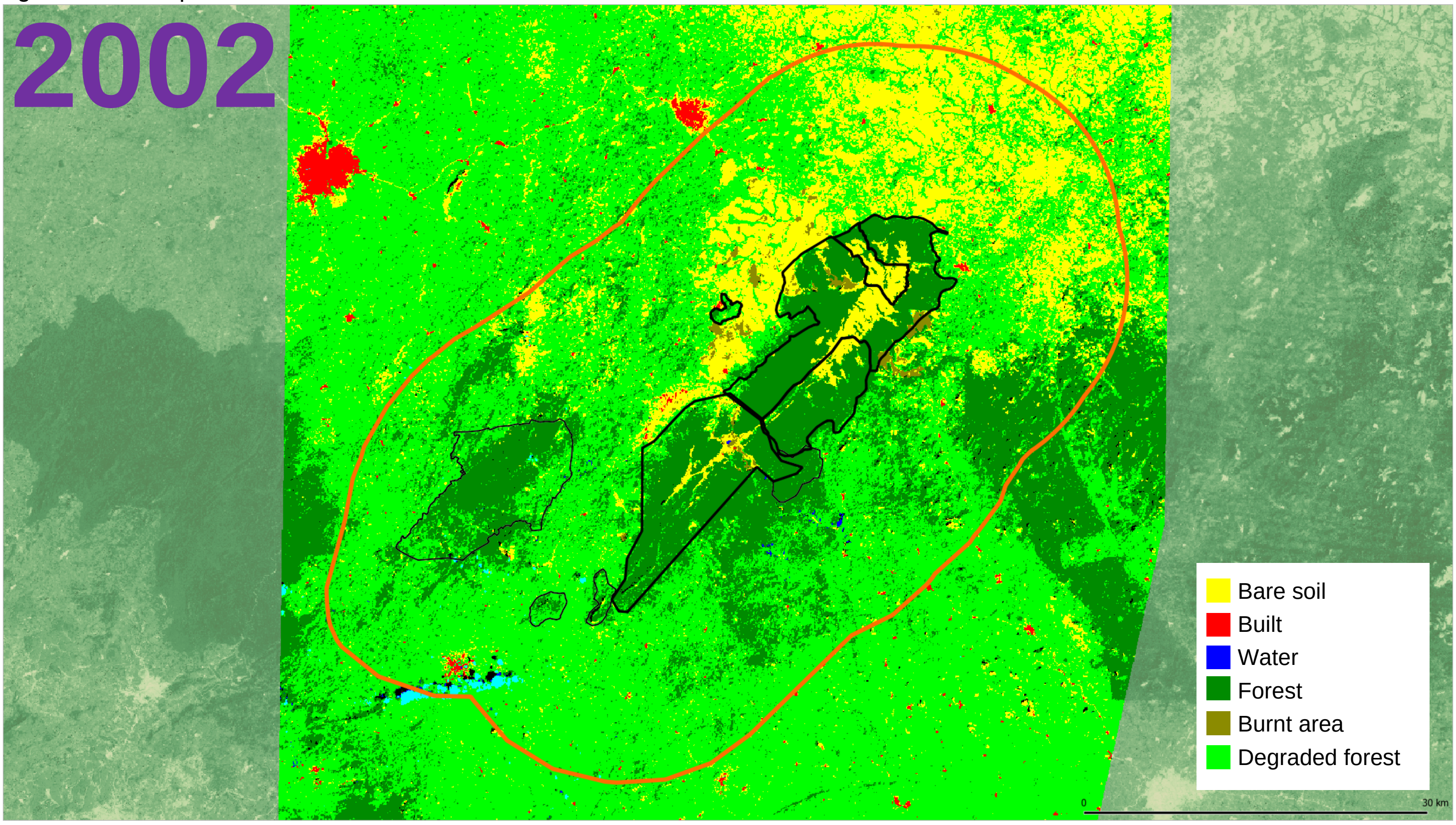
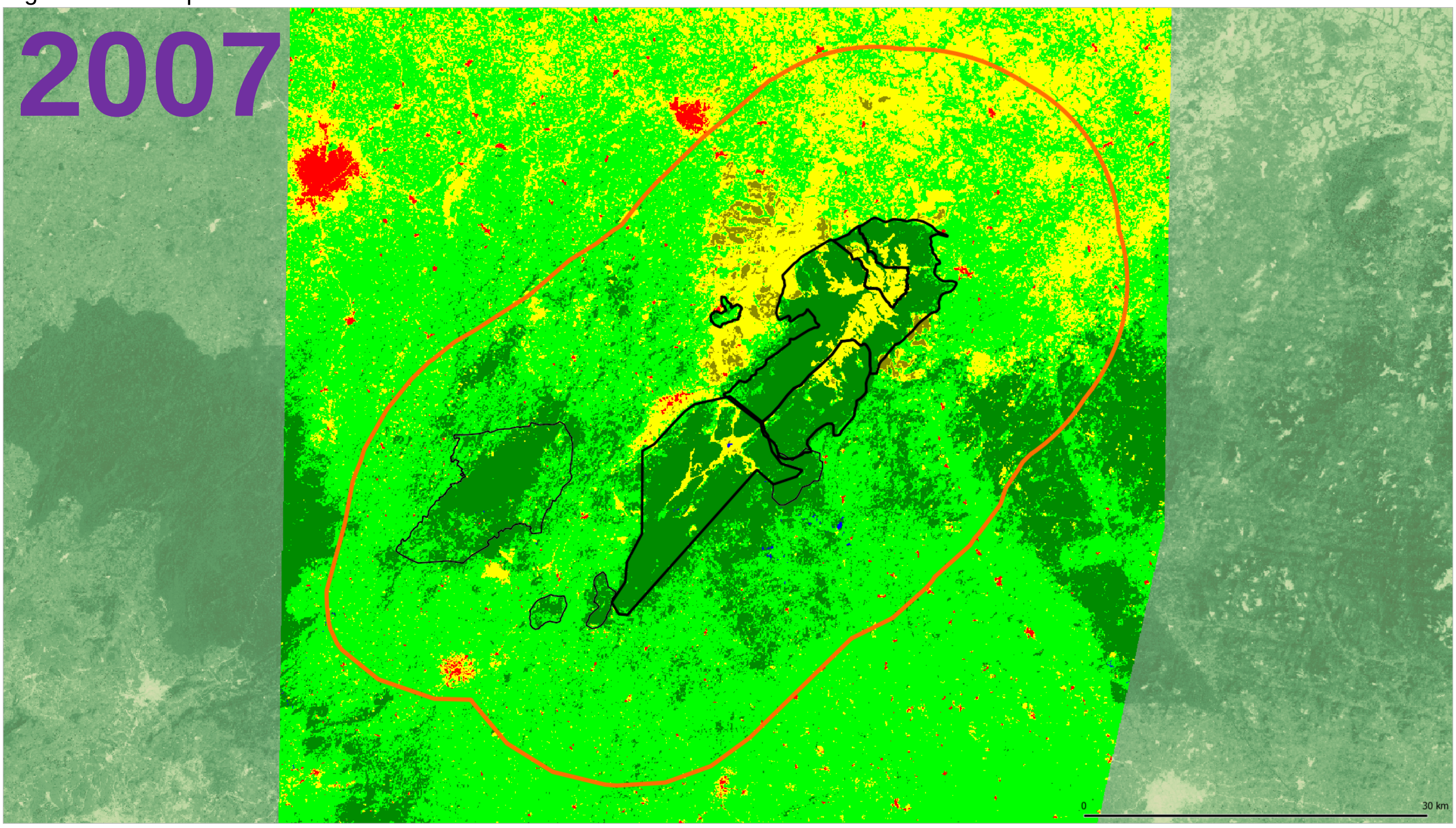


Fig.4: LU/LC map of M^{t} Nimba in 2007.



The 2013 classification (Fig.5) was calculated from Landsat-8 images. The 2020 classification (Fig.6) was also calculated from Landsat-8 images.

There is marked deforestation in the east of the landscape between 2007 (Fig.4) and 2013 (Fig.5).

The comparison of the classifications of 2013 (Fig.5) and 2020 (Fig;6) highlights a clear deforestation in the landscape outside the protected areas for which the forest cover remains preserved.

However, low deforestation should be noted in the community forests to the west of the landscape.

Outside the landscape, there is a pronounced urban expansion of the town of Nzerekore.

Land-use / Land-cover (LU/LC) of the M^{t} Nimba Prioritary Landscape between 2013 and 2020

Fig.5: LU/LC map of M^{t} Nimba in 2013.

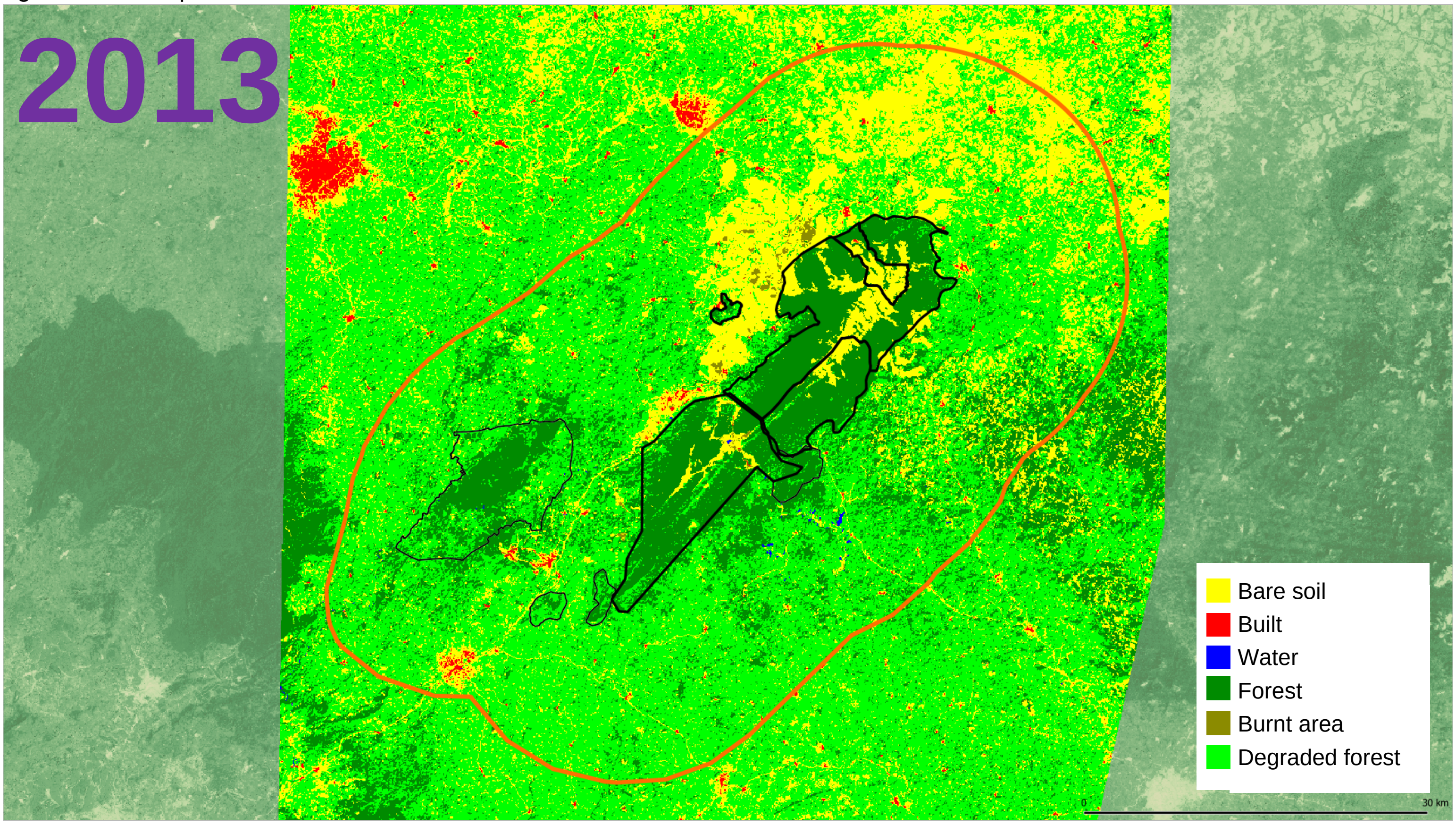
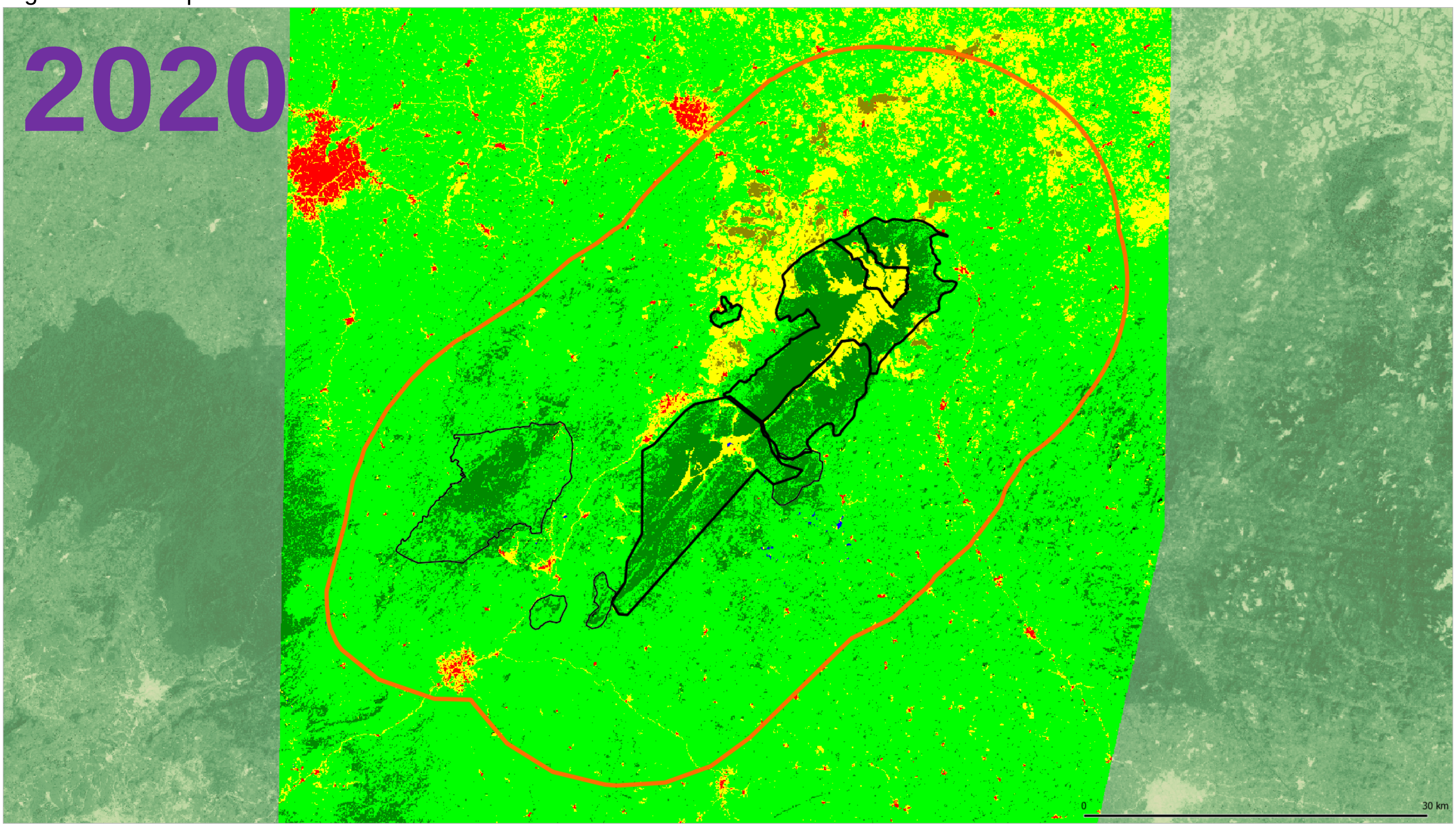


Fig.6: LU/LC map of M^{t} Nimba in 2020.



In what follows (pages 4 to 8), we seek to differentiate the statistics for the four spatial areas: entire landscape, integral/strict nature reserves, nature reserves and community forests.

Fig.8 shows the evolution of the different land cover classes in the **entire Mt Nimba priority landscape** (Fig.7) from 2002 to 2020.

It can be seen that the forest cover was relatively preserved between 2002 and 2013. In a second phase, there is a loss of forest cover of **9.85%** during the period 2013 to 2020.

Urban expansion also follows a continuous growth according to statistics ranging from **0.29%** (2002), **0.42%** (2007), **0.43%** (2013) to **0.43%** (2020).

Evolution of Land-Use / Land-cover in the entire Mt Nimba priority landscape

Fig.7: Full view of the Mt Nimba priority landscape showing the extent over which the statistics have been computed.

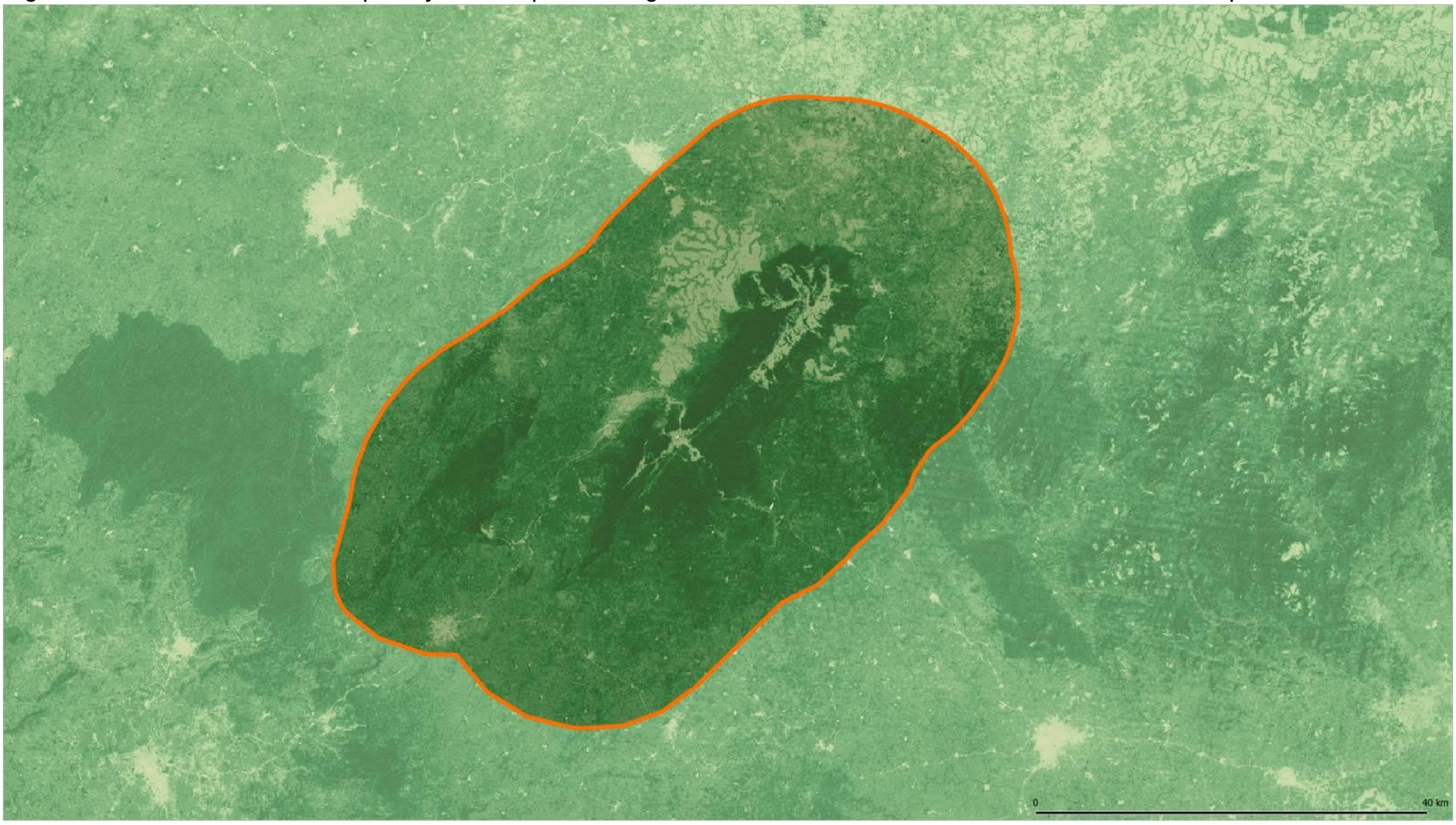


Fig.8: Assessment of the Land-use / Land-cover of the Priority Conservation Landscape (PCL) of Mt Nimba in 2002, 2007, 2013 and 2020 (statistics calculated on the entire landscape).

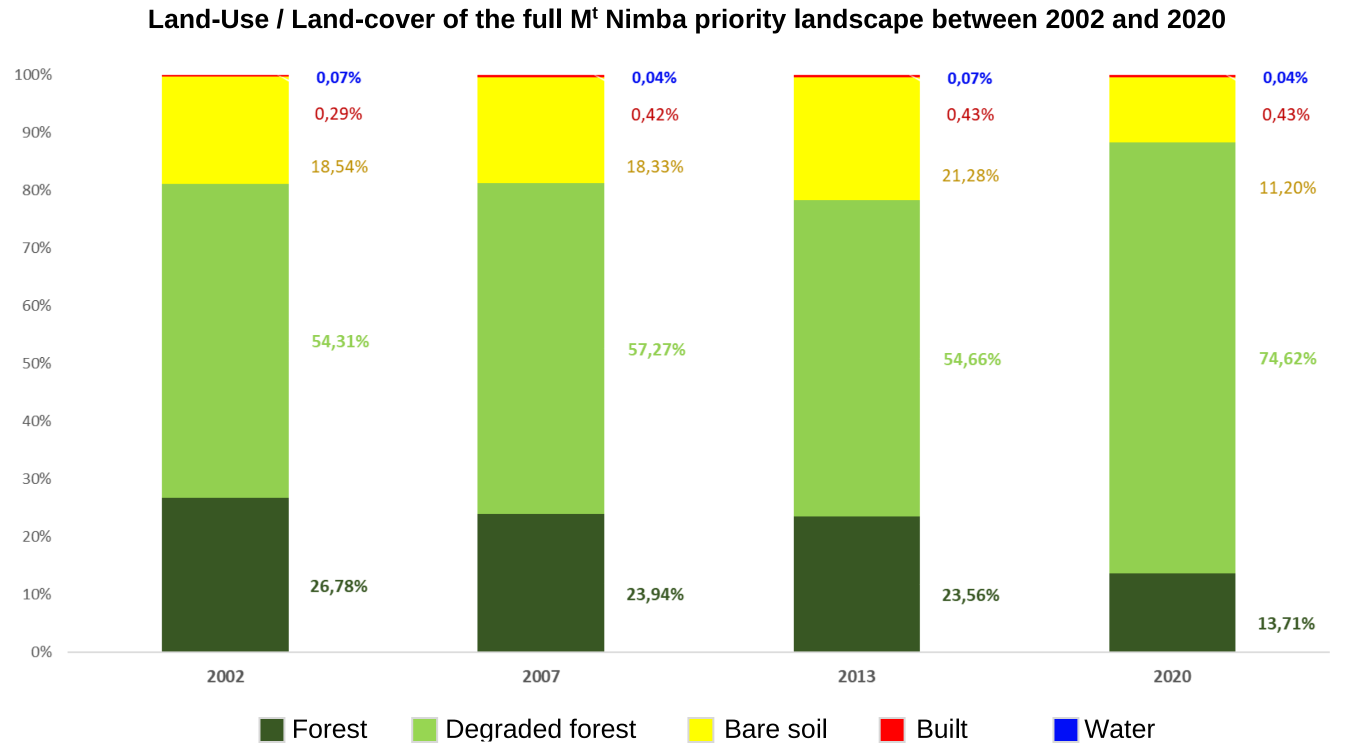


Fig.10 shows the evolution of the different classes of land cover in the **strict and integral reserves of Mt Nimba** (Fig.9) between 2002 and 2020.

These strict and integral reserves are largely occupied by forest (about 70%).

It can be seen that this forest cover was preserved between 2002 and 2013 with low losses (**0.44%** during the period 2002-2007 and **1.69%** during the period 2007-2013). Conversely, a significant loss of **5.42%** was observed during the last period from 2013 to 2020.

There is a total absence of anthropogenic infrastructure in these reserves (0%).

Evolution of Land-Use / Land-cover in the M^t Nimba integral / strict nature reserves

Fig.9: View of the M^t Nimba integral / strict nature reserves showing the extent over which the statistics have been computed.

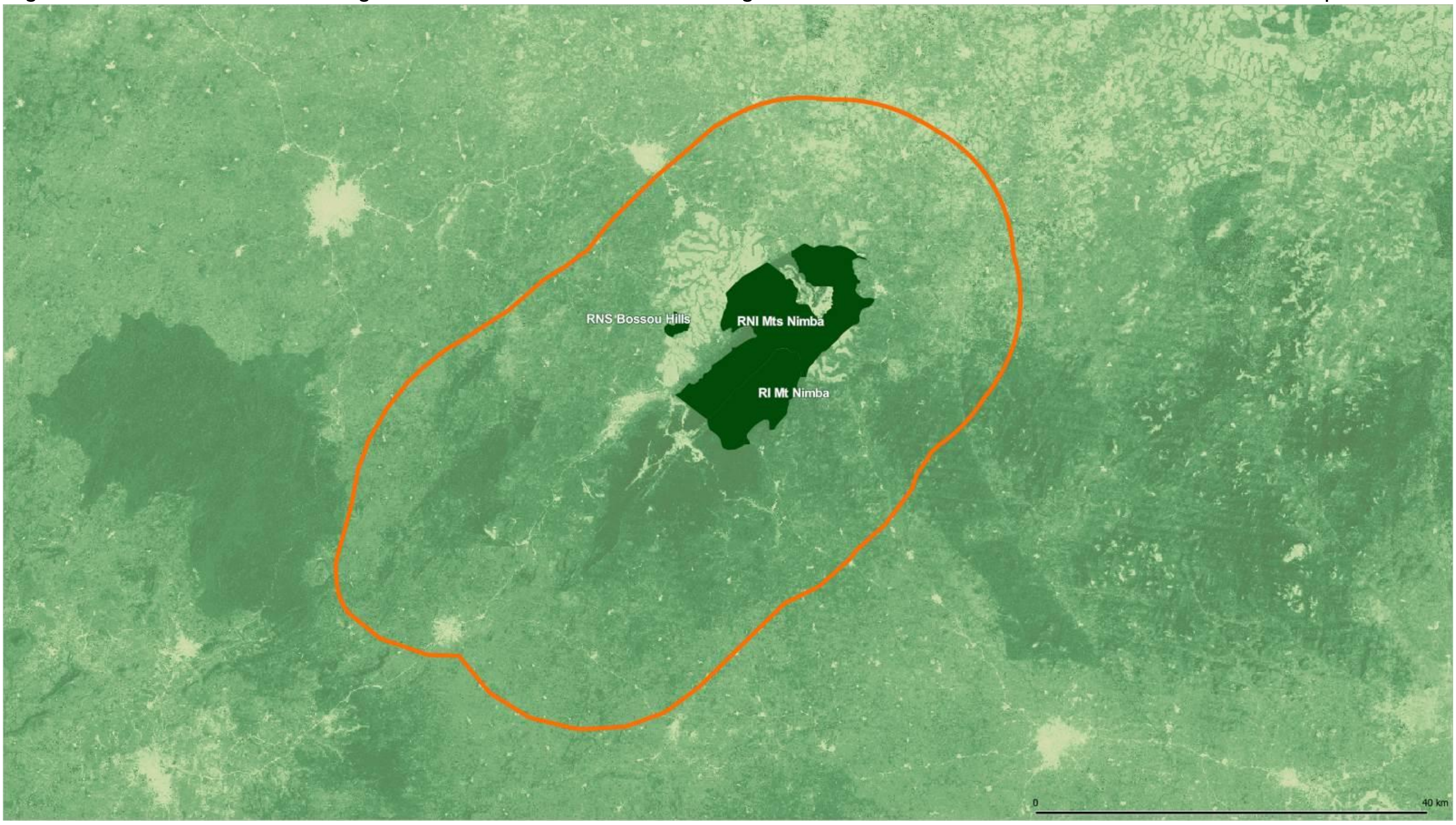


Fig.10: Assessment of the Land-use / Land-cover of the integral / strict nature reserves of M^t Nimba in 2002, 2007, 2013 and 2020 (statistics calculated on the extents shown in Fig.9 only).

Land-Use / Land-cover of the M^t Nimba integral / strict nature reserves between 2002 and 2020

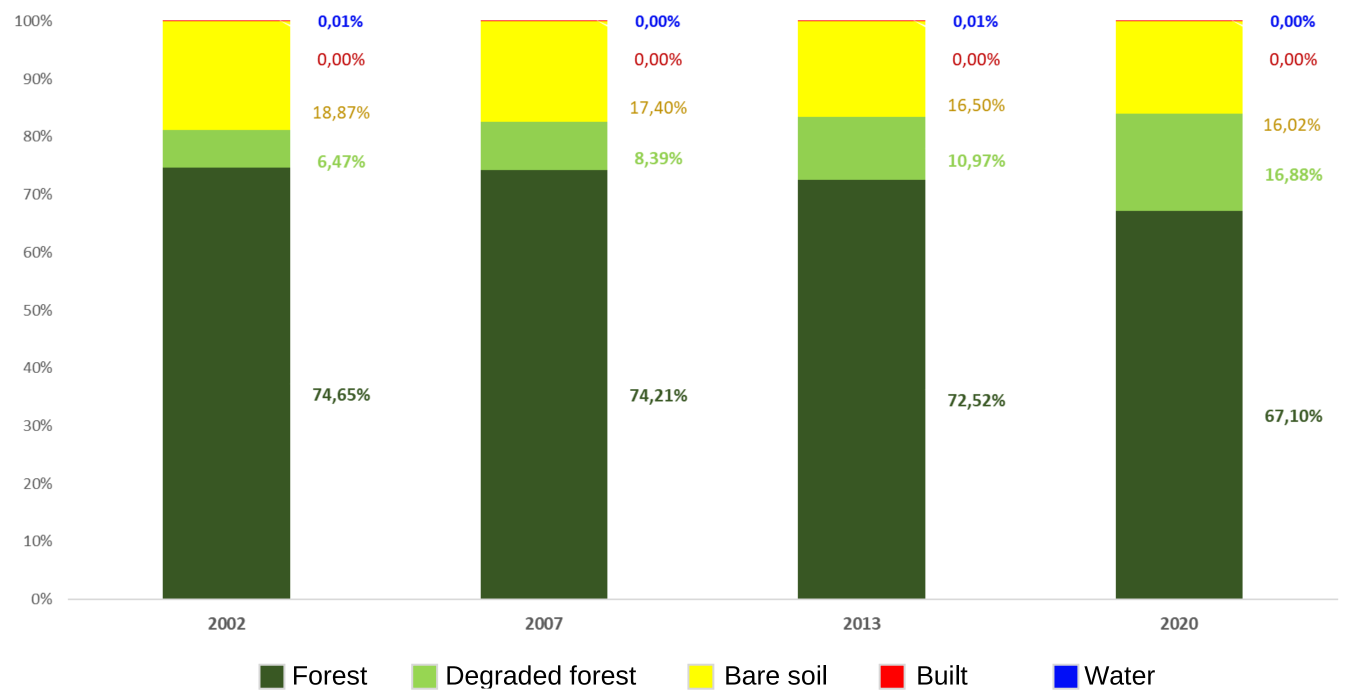


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Fig.12 shows the evolution of the different land cover classes in the **East Nimba Nature Reserve** of the Mt Nimba Priority Landscape (Fig.11) between 2002 and 2020.

This nature reserve is also essentially occupied by forest (about 80%).

It can be seen that the forest cover suffered a progressive degradation between 2002 and 2013 with an acceleration between 2013 and 2020. Indeed, the losses of the forest cover amounted to **4.41%** from 2002 to 2007, **8.15%** from 2013 to 2020.

These losses are more pronounced than those observed in strict and integral reserves (see Fig.9 and Fig.10).

Evolution of Land-Use / Land-cover in the East Nimba nature reserve

Fig.11: View of the East Nimba nature reserve showing the extent over which the statistics have been computed.

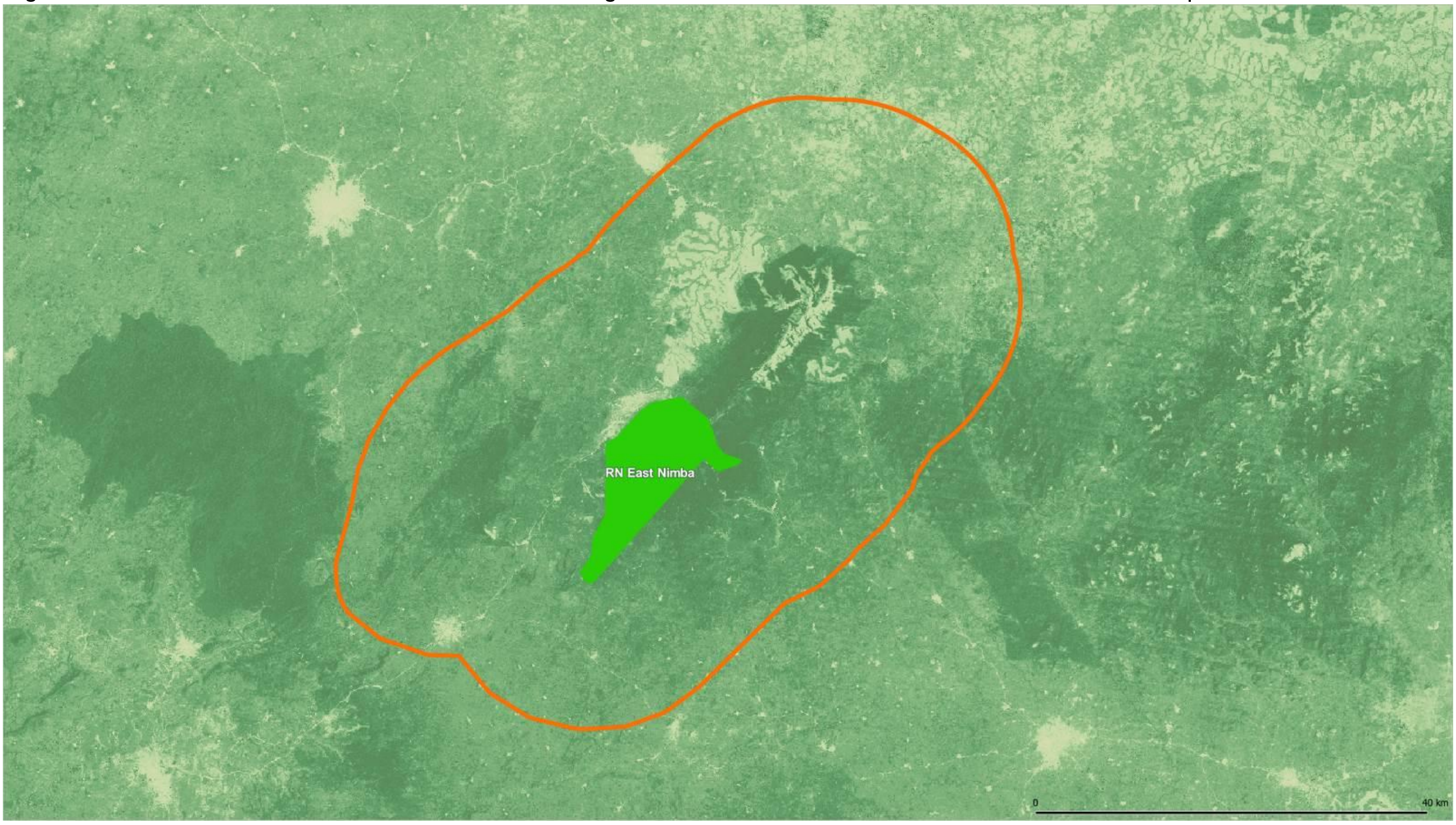

Fig.12: Assessment of the Land-use / Land-cover of the East Nimba nature reserve in 2002, 2007, 2013 and 2020 (statistics calculated on the extents shown in Fig.11 only).

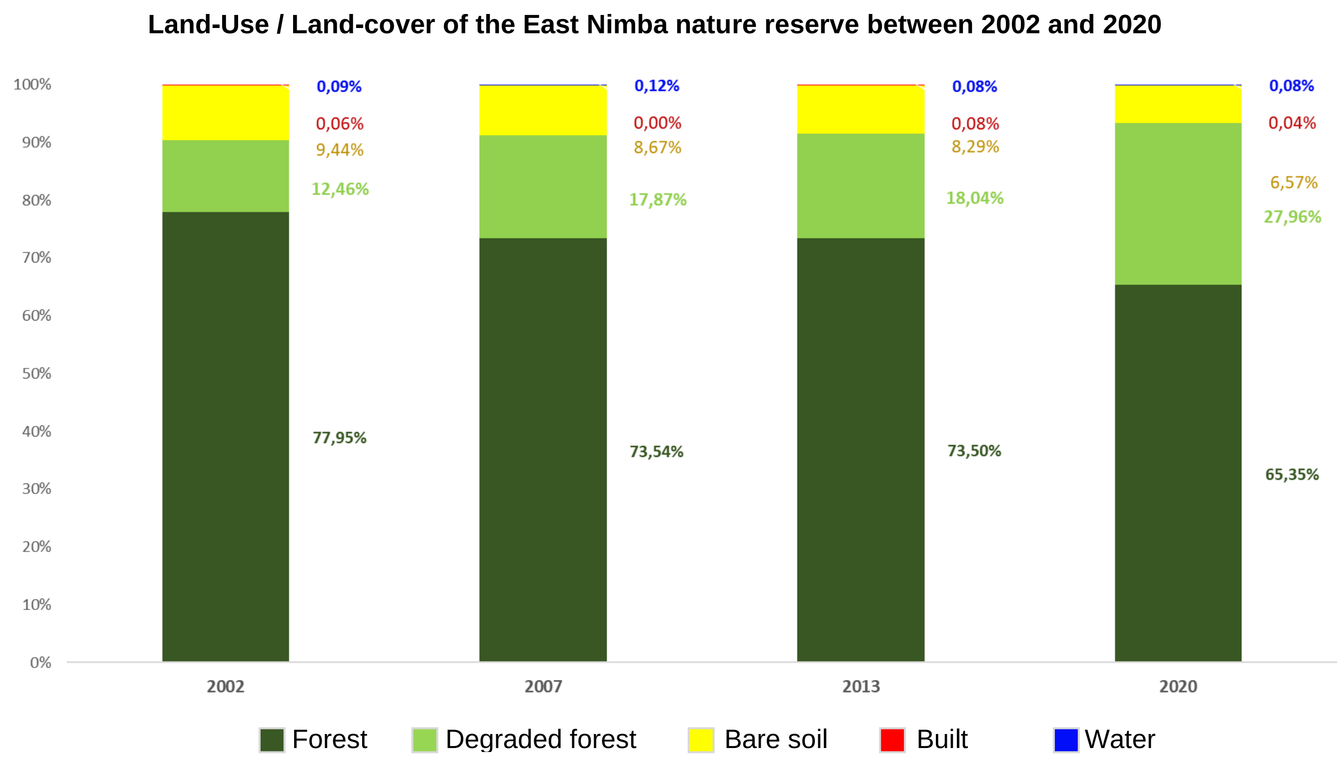

Fig.14 shows the evolution of the different classes of land cover in the **community forests** of the priority landscape of Mt Nimba (Fig.13) between 2002 and 2020.

Compared to strict and integral reserves (Fig.9 and Fig.10) and natural reserve (Fig.11 and Fig.12), community forests offer less forest cover at about **60%**.

It can be seen that this forest cover was preserved between 2002 and 2007. There are nevertheless very significant losses of: **12.40%** during the period from 2007 to 2013 and **11.76%** during the period from 2013 to 2020.

Note: The short-lived slight increase in forest cover between 2002 and 2007 can be explained by the effect of seasonality and cloud cover. Indeed, for the year 2007, several Landsat-7 images acquired during different seasons were mosaicked to circumvent the problems of cloud cover.

Evolution of Land-Use / Land-cover in the M^t Nimba community forests

Fig.13: View of the M^t Nimba community forests showing the extent over which the statistics have been computed.

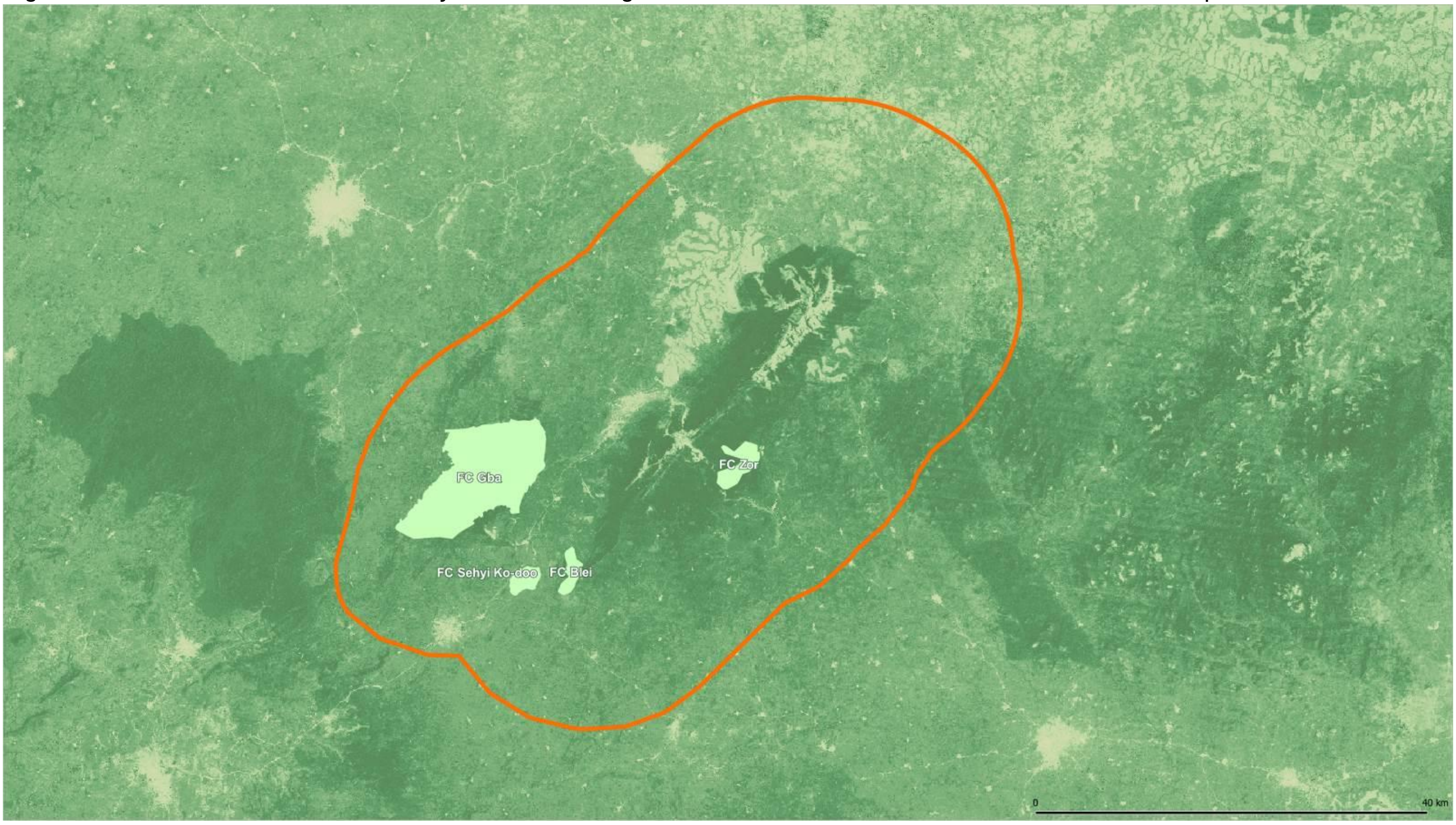

Fig.14: Assessment of the Land-use / Land-cover of the M^t Nimba community forests in 2002, 2007, 2013 and 2020 (statistics calculated on the extents shown in Fig.13 only).

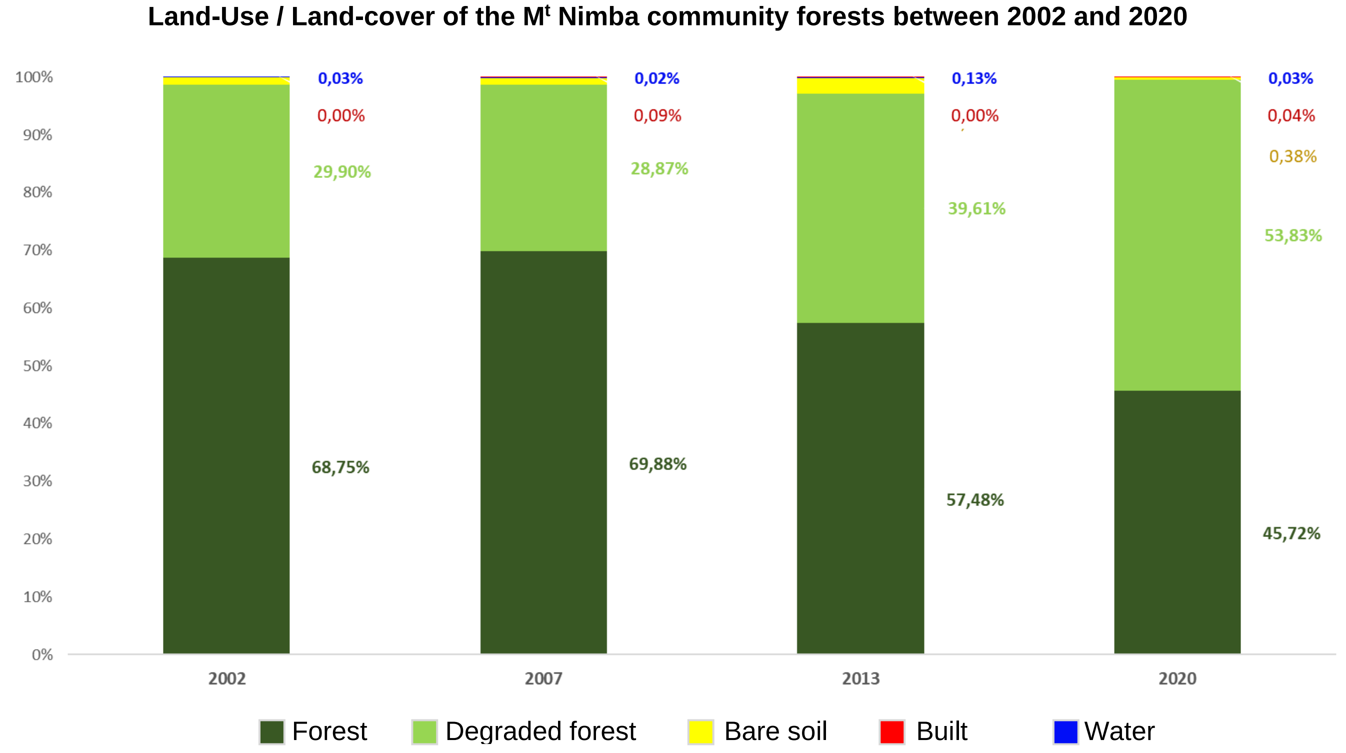

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Fig.15 summarizes deforestation by period across the entire Mt Nimba priority landscape. The areas in grey represent the areas deforested before 2002, the areas in blue are those deforested between 2002 and 2007, the areas in yellow are those deforested between 2007 and 2013 and the areas in red are those deforested between 2013 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, strict / strict nature reserves, nature reserves and community forests.

It can be seen that the integral / strict nature reserves have been preserved, while the nature reserve and the community forests have suffered a greater loss of their vegetation cover, particularly during the last period.

Loss of forest cover in the different conservation units of Mt Nimba between 2002 and 2020

Fig.15: Deforestation by periods in the Mt Nimba landscape between 2002 and 2020.

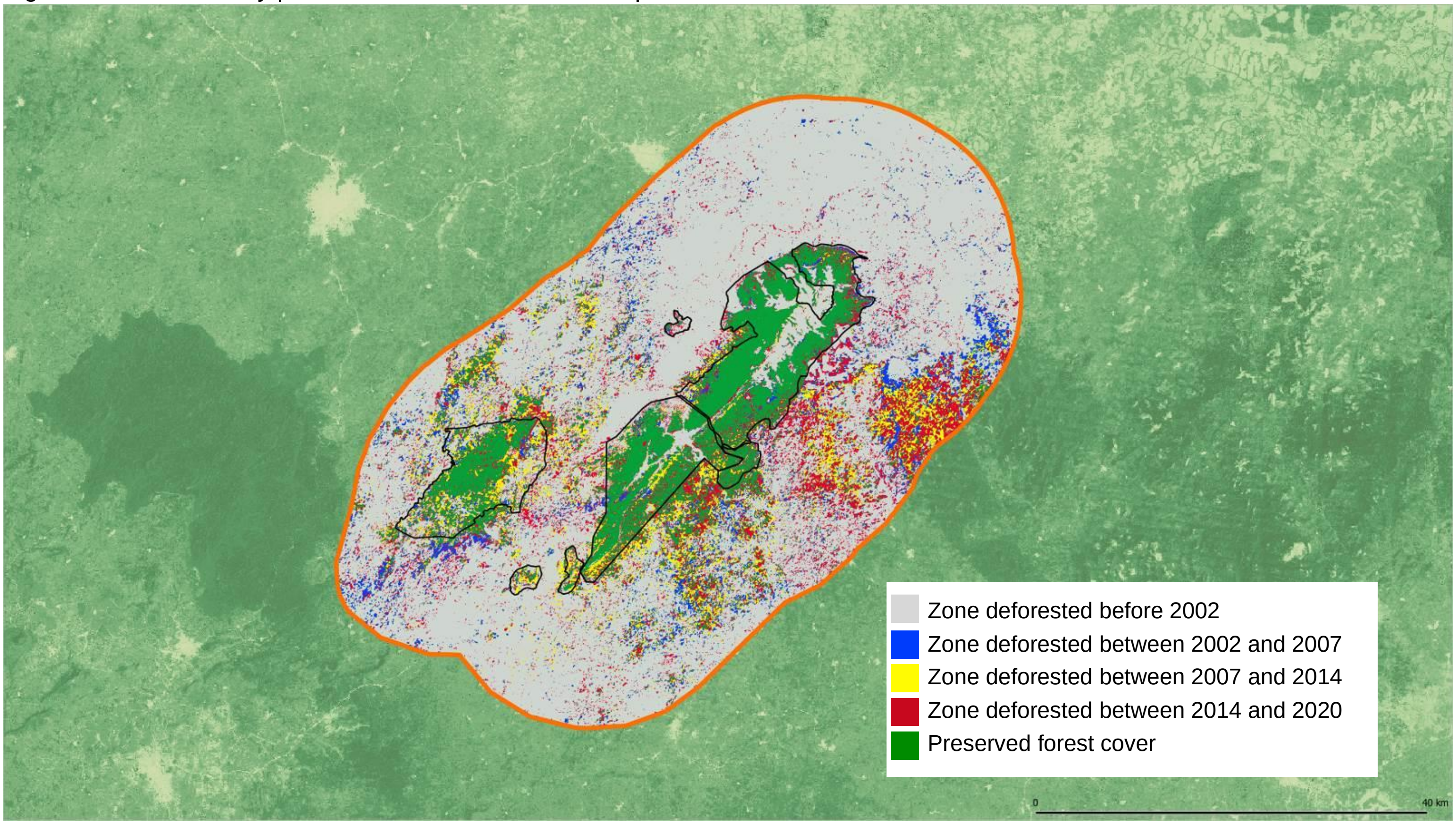
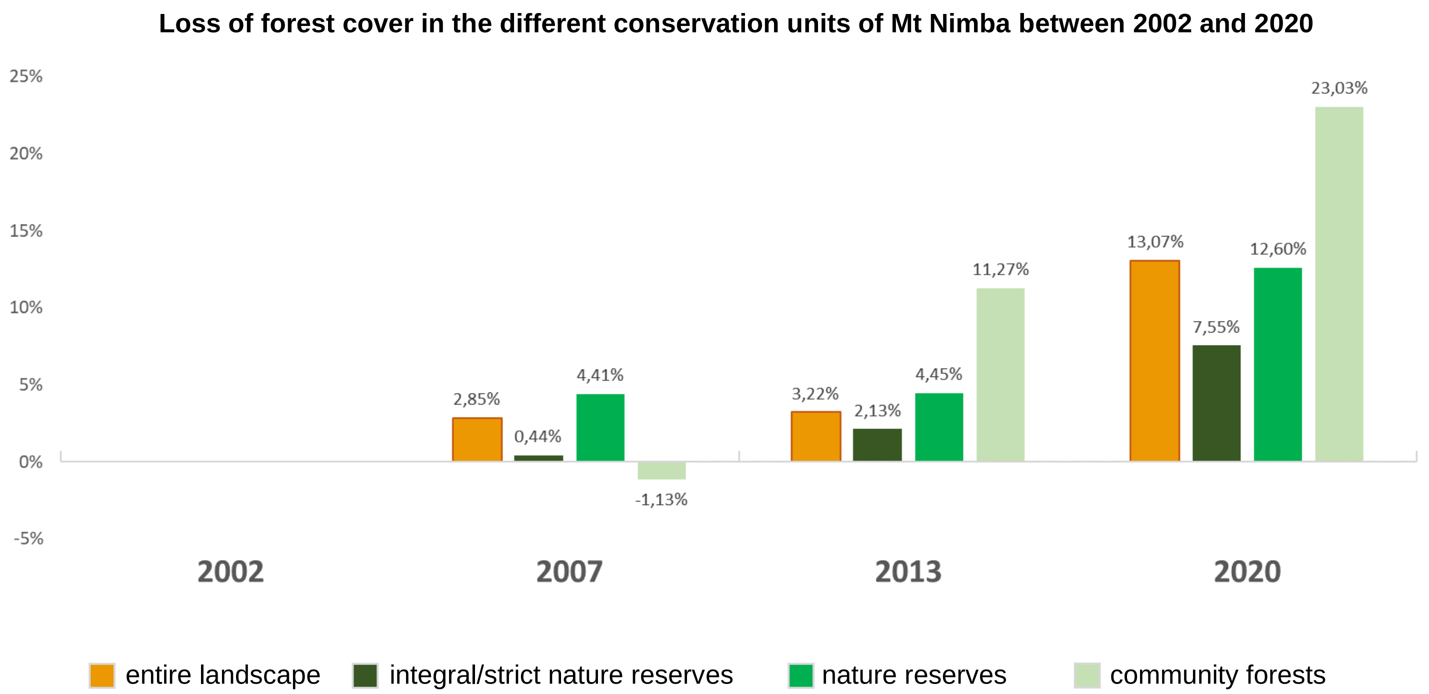


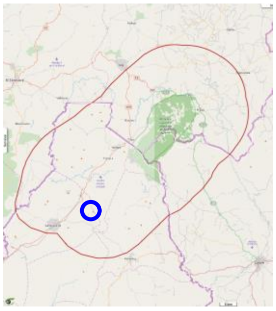
Fig.16: Summary of forest cover loss in the different Mt Nimba conservation units in 2007 (difference between 2007 and 2002), in 2013 (difference between 2013 and 2007) and in 2020 (difference between 2020 and 2013).



FLEGT Watch is an automatic detection system for deforestation in Central and West Africa using images of the Sentinel-1 radar satellites. This section shows two examples of deforestation detected by FLEGT Watch in the Mt Nimba Conservation Priority Landscape.

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 (image top-right).

In the radar image (Fig.17), there is an extension of deforested areas south of the strict Mt Nimba Strict Nature Reserve. Analysis of the Sentinel-2 optical image (Fig.18) confirms that the forest (Fig.18a) was clearly cut in March 2020 (Fig.18b).



FLEGT Watch in Liberia Mt Nimba landscape

Event #2006847 - LBR VT02

2D_layer_stack

Fig.17: Sentinel-1A mean 06-02-2020 → 13-03-2020 (a) and 25-03-2020 (b). left_view right_view animation

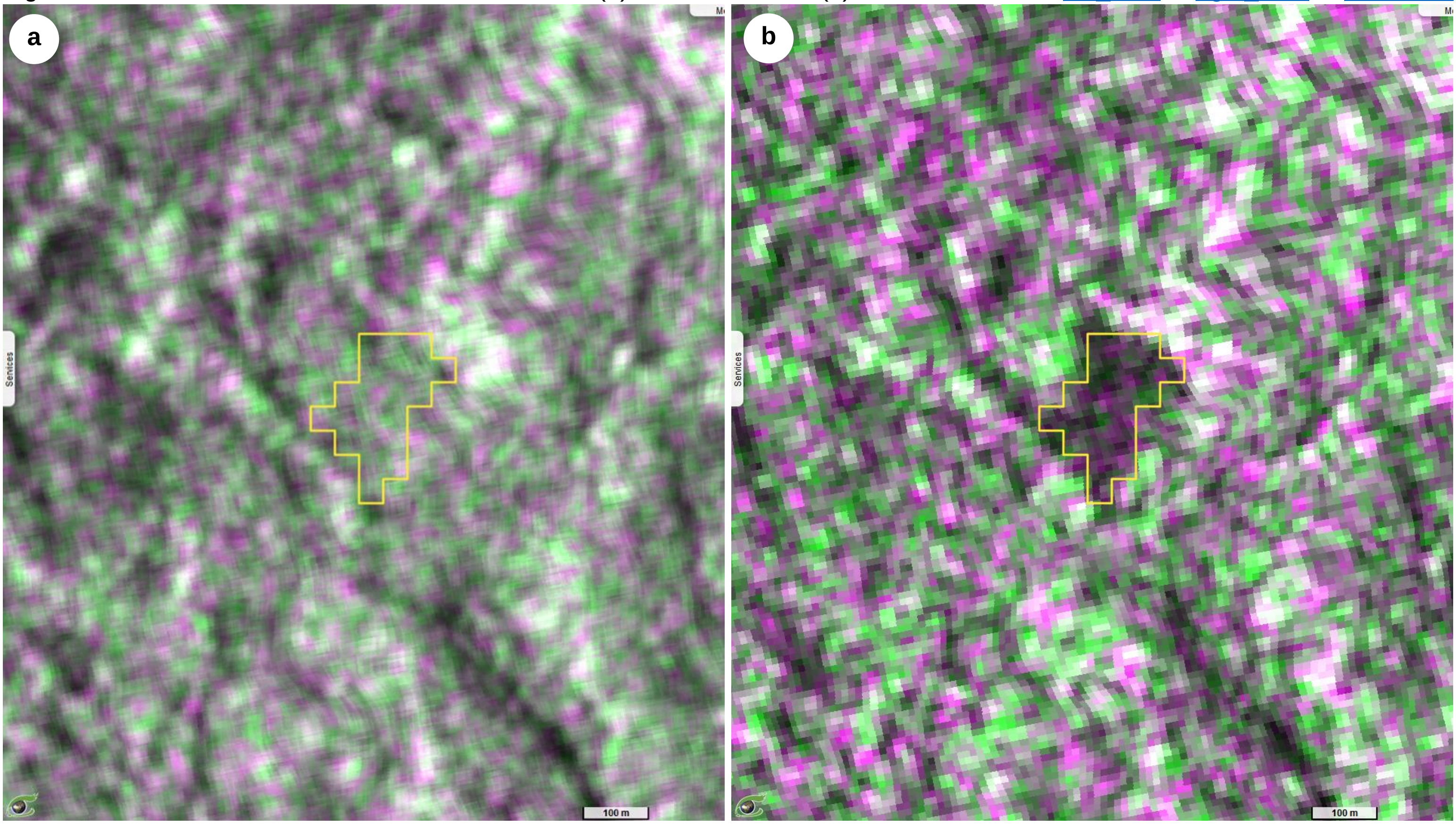
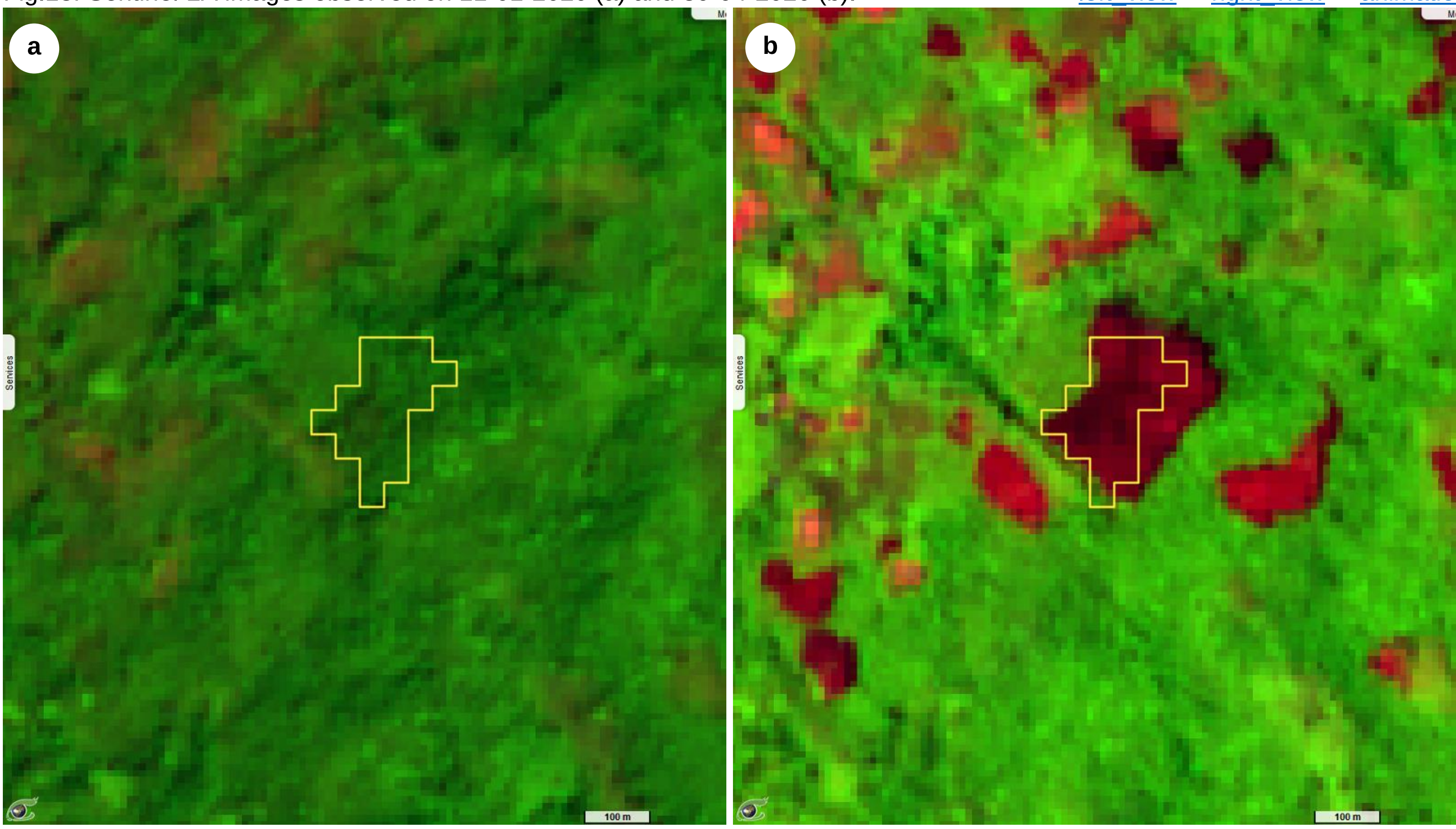


Fig.18: Sentinel-2A images observed on 11-01-2020 (a) and 30-04-2020 (b). left_view right_view animation



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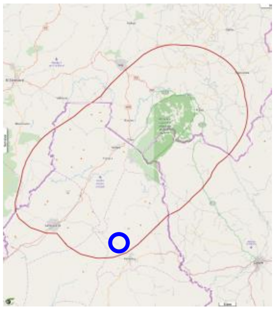
As shown in Fig.19, the FLEGT Watch system detected deforestation between May 2 and May 14, 2022. This deforestation occurs in the southern part of the landscape.

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.



FLEGT Watch in Liberia

M^{t} Nimba landscape

Event #2015663 - LBR VT02

[2D_layer_stack]

Fig.19: Sentinel-1A mean 27-03-2022 → 02-05-2022 (a) and 14-05-2022 (b). [left_view] [right_view] [animation]

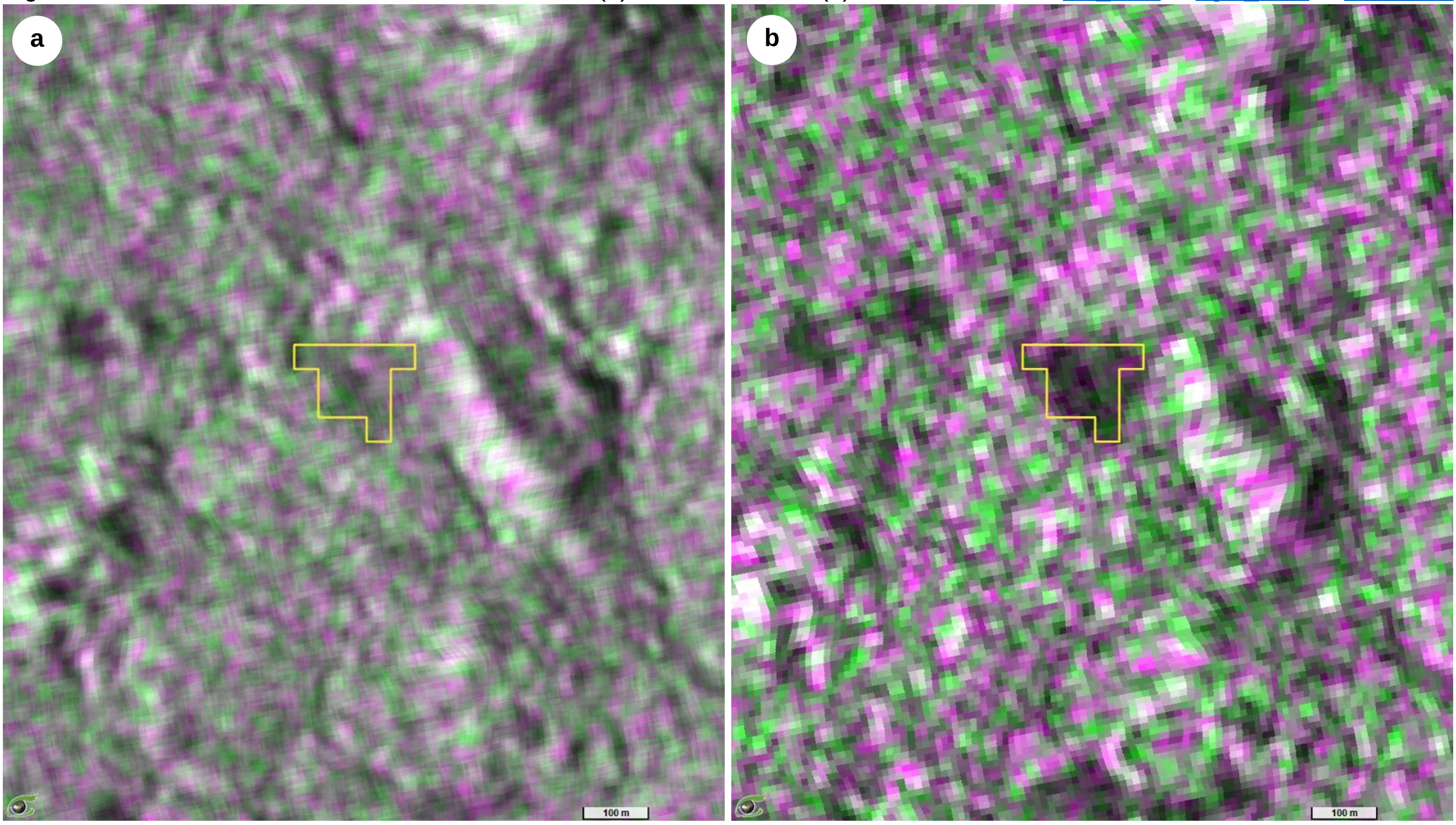


Fig.20: Sentinel-2B images observed on 05-01-2022 (a) and 04-06-2022 (b). [left_view] [right_view] [animation]

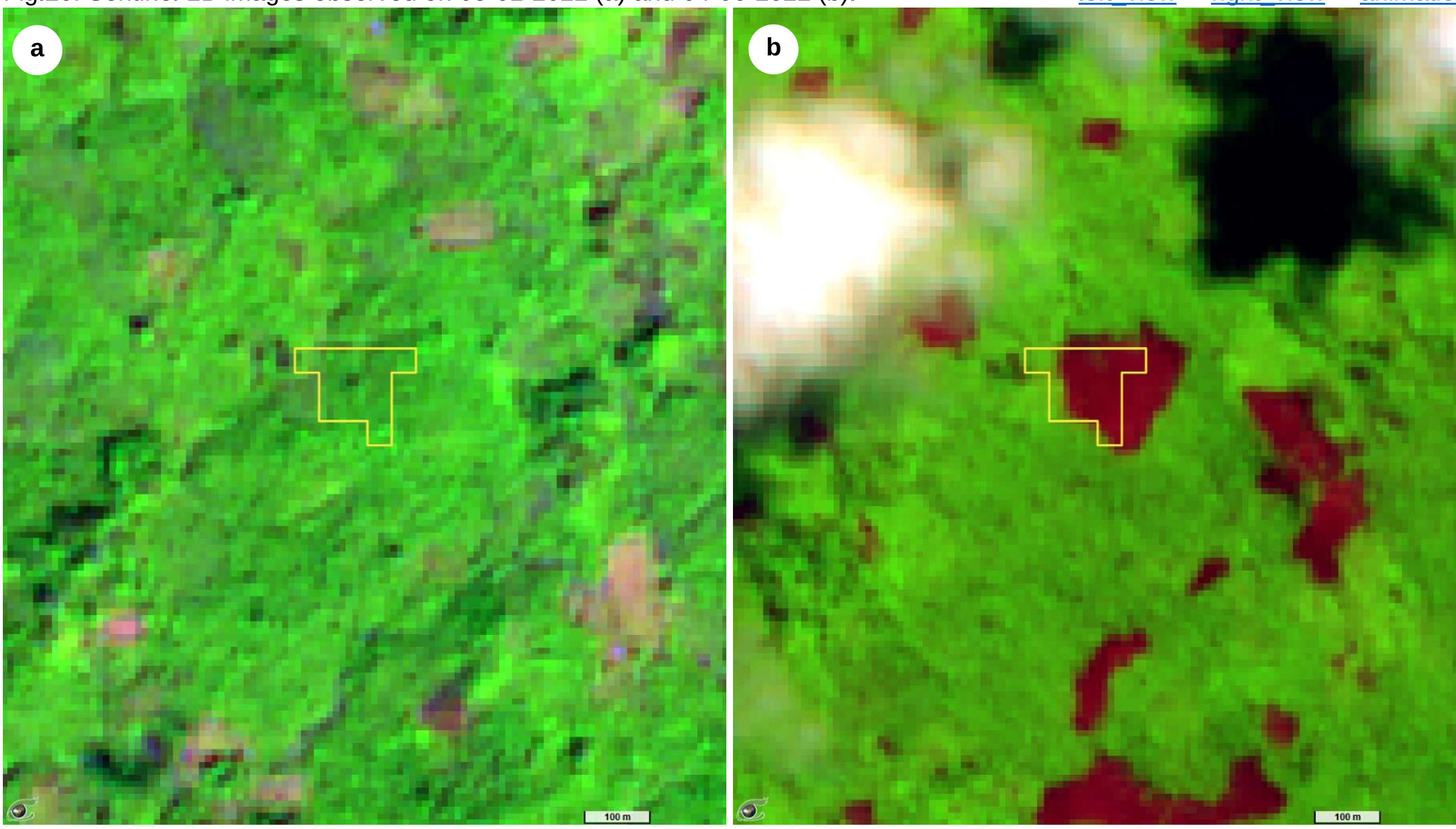


Fig.21 shows the periodic bulletin generated by a geoservice monitoring burnt areas and active fires in the priority landscape of M^{t} Nimba between 2015 and 2021. This periodic bulletin was produced by the CAFWS platform developed by VisioTerra.

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 burnt areas.

The red curve shows the presence (value 255 on the y-axis) or absence (value 0 on the y-axis) of burnt area in the study area during the defined period. The fifth section shows the results of the temporal aggregation of burnt areas. Zones where a burnt area was detected at least once during the study period are rendered in red. Here, for example (Fig.21), the burnt areas are those detected in 2019.

Fig.22 shows in red the burnt areas detected automatically in 2020 and 2021.

Burnt areas
Periodic bulletin
M^{t} Nimba landscape

2D_layer_stack

Fig.21: View of the periodic bulletin with the burnt areas detected by year between 2015 and 2021. periodic_bulletin

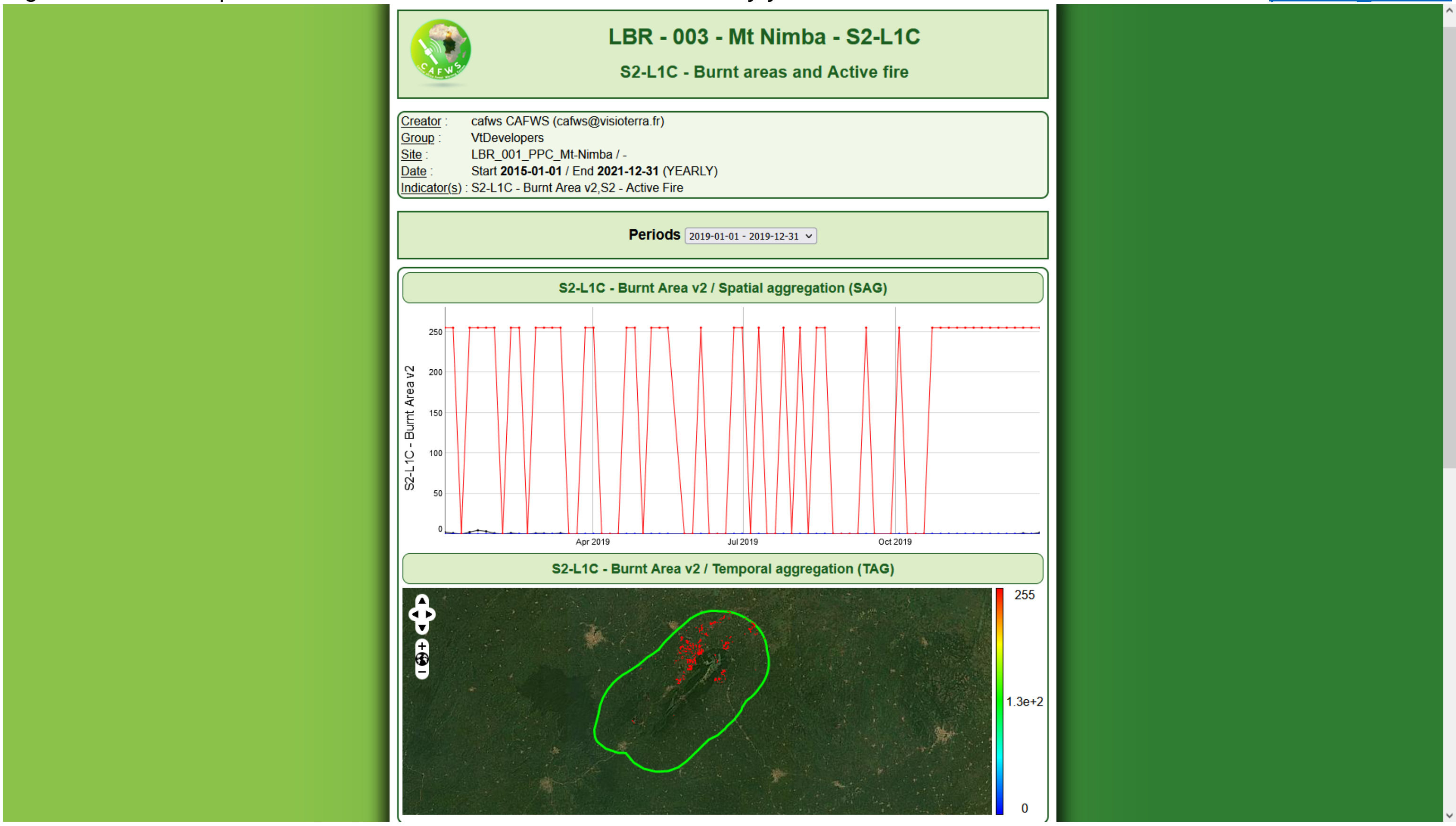


Fig.22: Burnt areas automatically detected in 2020 and 2021. animation

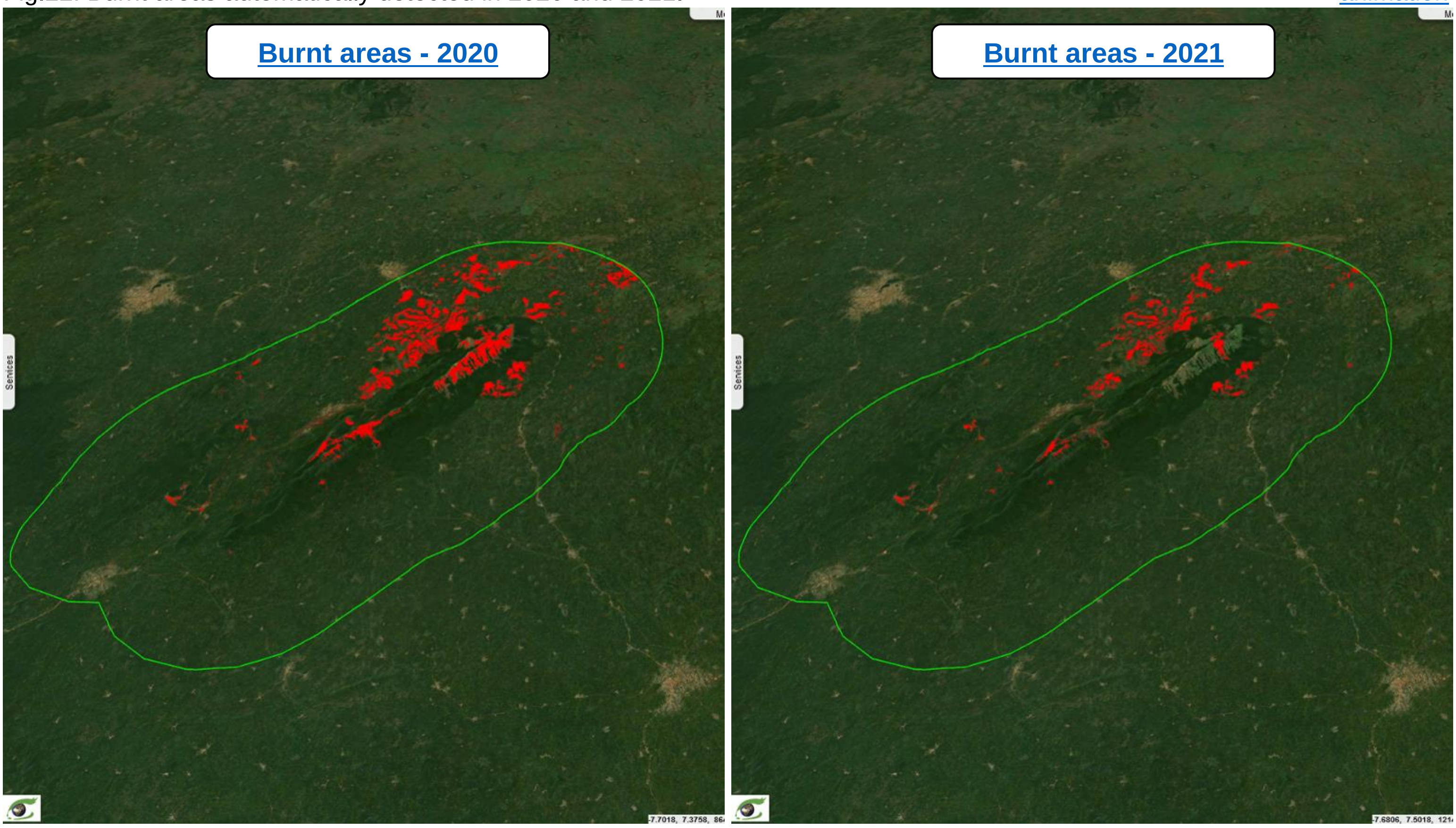


Fig.23 shows a Sentinel-2 image that exploits the richness of the spectral bands of its multispectral instrument MSI. Here, bands 11, 8 and 2 correspond to shortwave-infrared, near-infrared and blue respectively. These three bands 11, 8, 2 have been assigned to the red, green and blue planes.

The Sentinel-2 tile (Fig.23a) was acquired in the dry season on January 21, 2019. Burnt areas are detected automatically and are rendered in red (fig.23b).

The burnt area indicator is calculated from Sentinel-2 optical data using an algorithm derived from a classification analysis making use of "Machine Learning" methods.

Fig.24 shows a closer view of Fig.23 to the northwest of the landscape where there are extensive burnt areas.

Burnt areas – Examples

M^t Nimba landscape

2D_layer_stack

Fig.23: Sentinel-2B image observed on 21-01-2019 (a) and burnt areas automatically detected (b).

animation

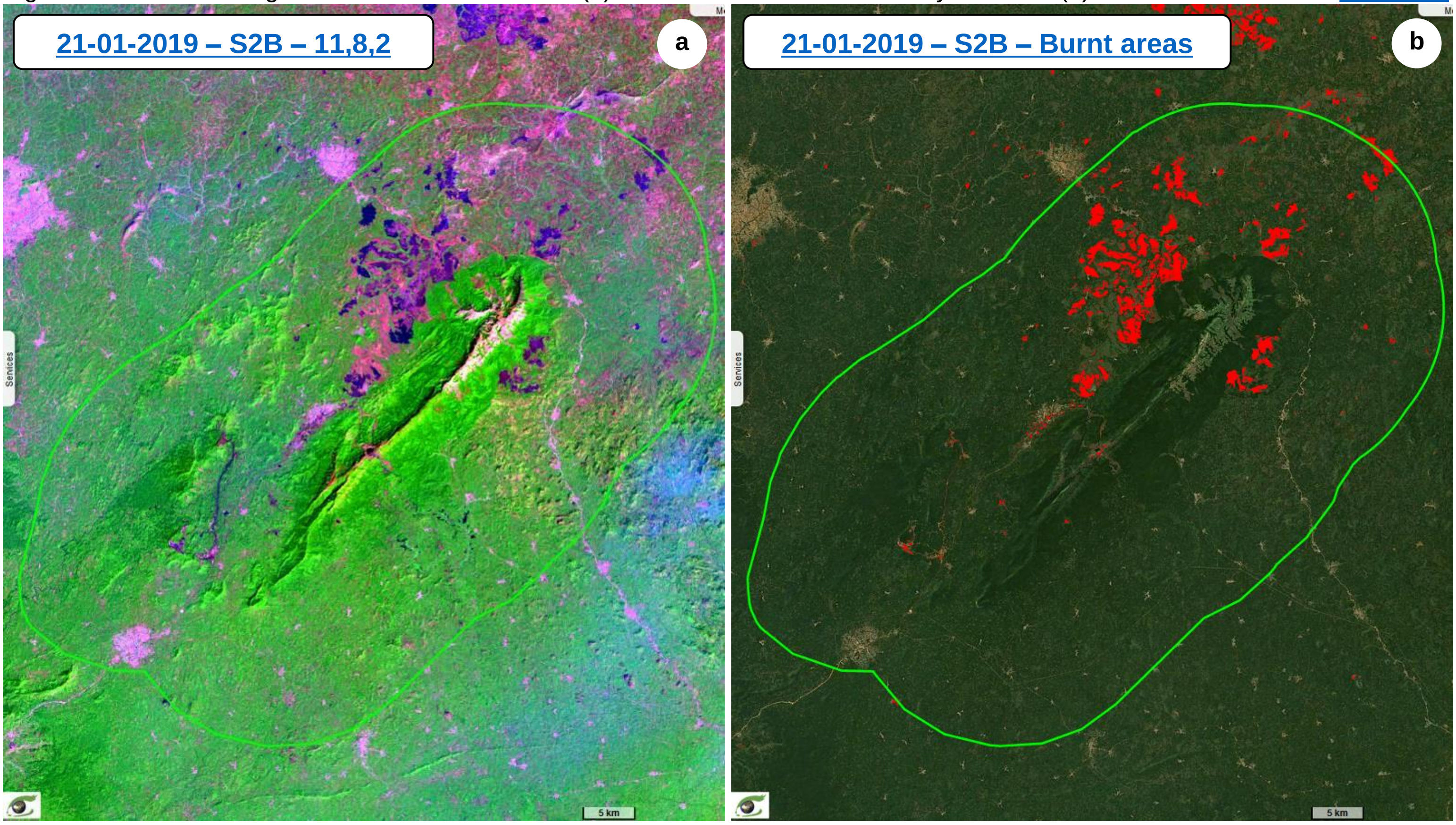


Fig.24: Close view of Fig.23.a (a) and burnt areas automatically detected (b).

animation

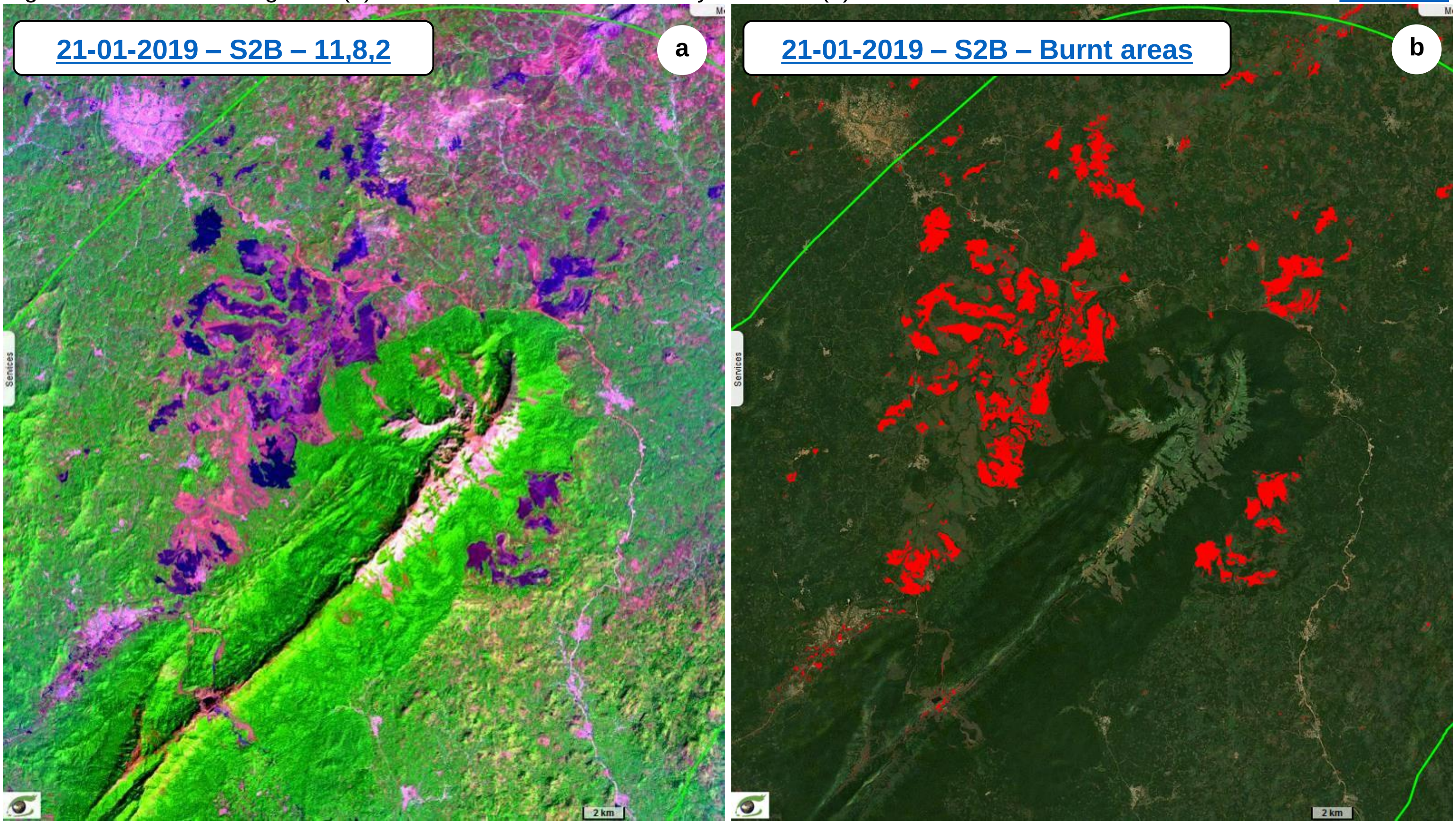


Fig.25 shows the periodic bulletin generated by the same geoservice monitoring burnt areas and active fires in the priority landscape of Mt Nimba between. Monitoring is performed from 2015 to 2021 with the indicator of active fires. The red areas in the temporal aggregation section image represent areas where an active fire front was observed at least once during the study period.

Fig.26 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
M^t Nimba landscape

2D_layer_stack

Fig.25: View of the periodic bulletin with active fires detected by year between 2015 and 2021. periodic_bulletin

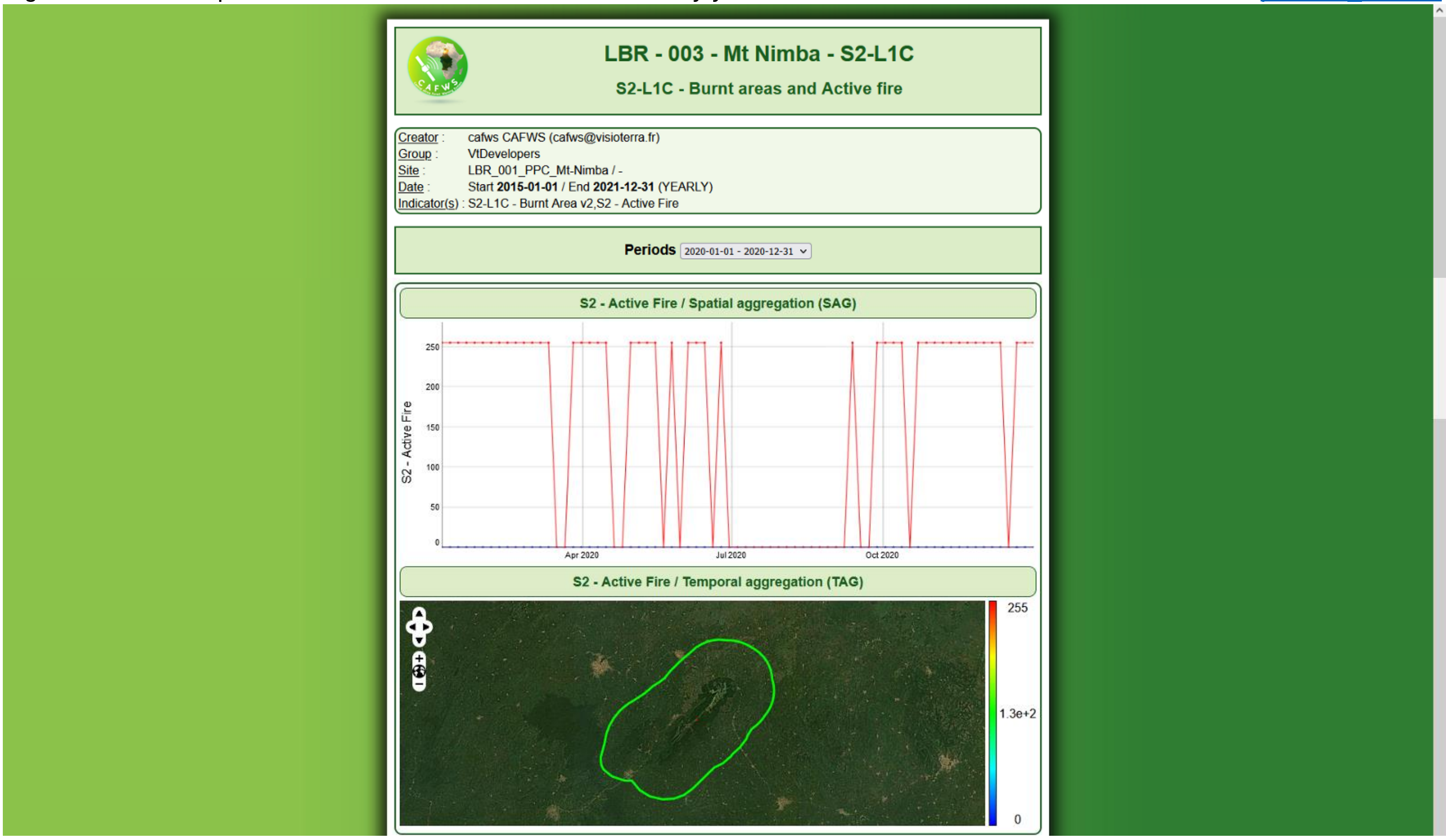


Fig.26: Active fires automatically detected in 2017 and 2020. animation

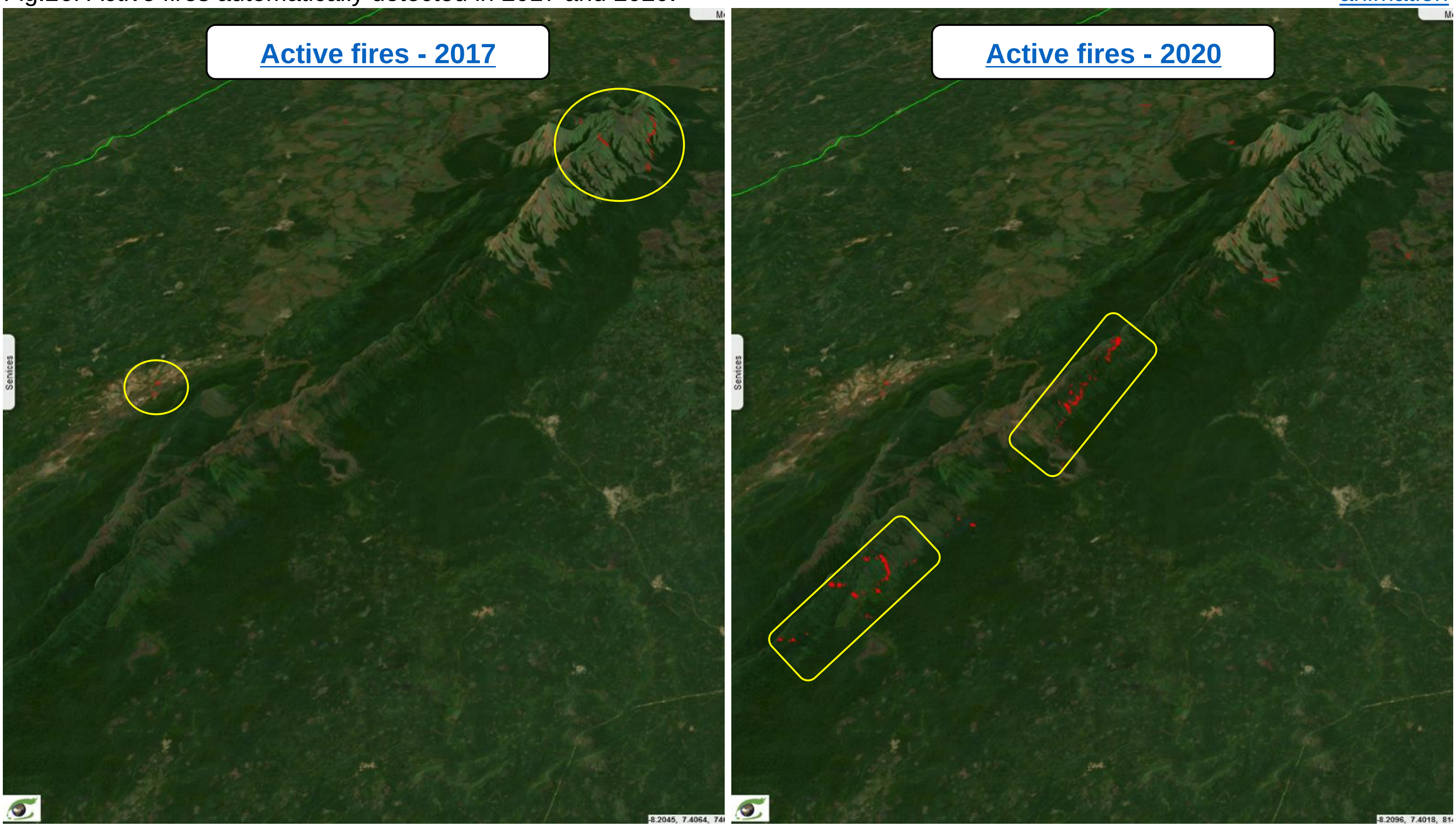


Fig.27 shows a Sentinel-2 image in 12-11-2 colour composition acquired on February 05, 2020 (fig.27a) and the result of active fires automatically detected for the same date, rendered in red (fig.27b).

Fig.28 shows a zoomed view of fig.27 which highlights active fire fronts.

Active fires – Examples

M^{t} Nimba landscape

2D_layer_stack

Fig.27: Sentinel-2B image observed on 05-02-2020 (a) and active fires automatically detected (b). animation

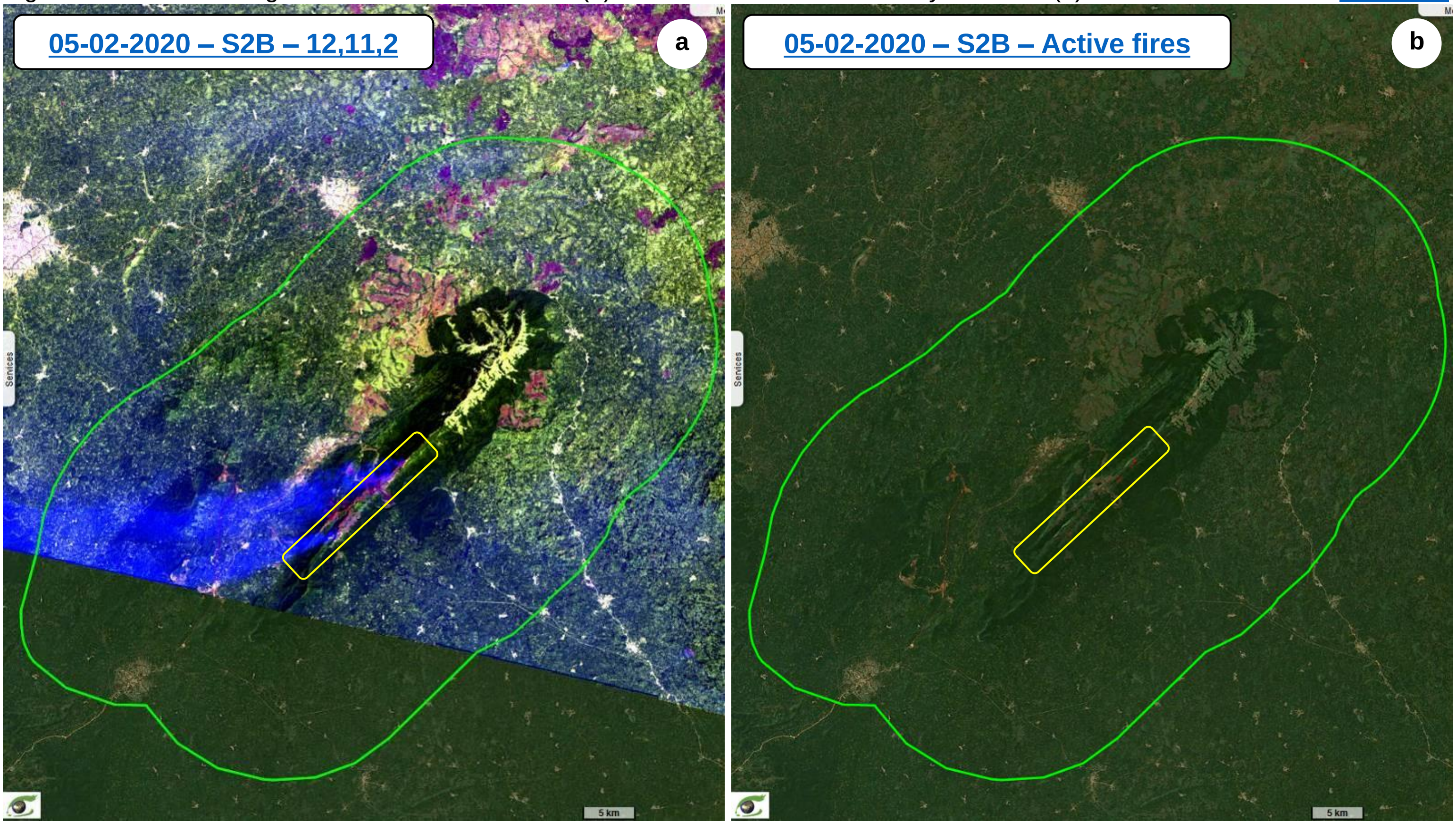
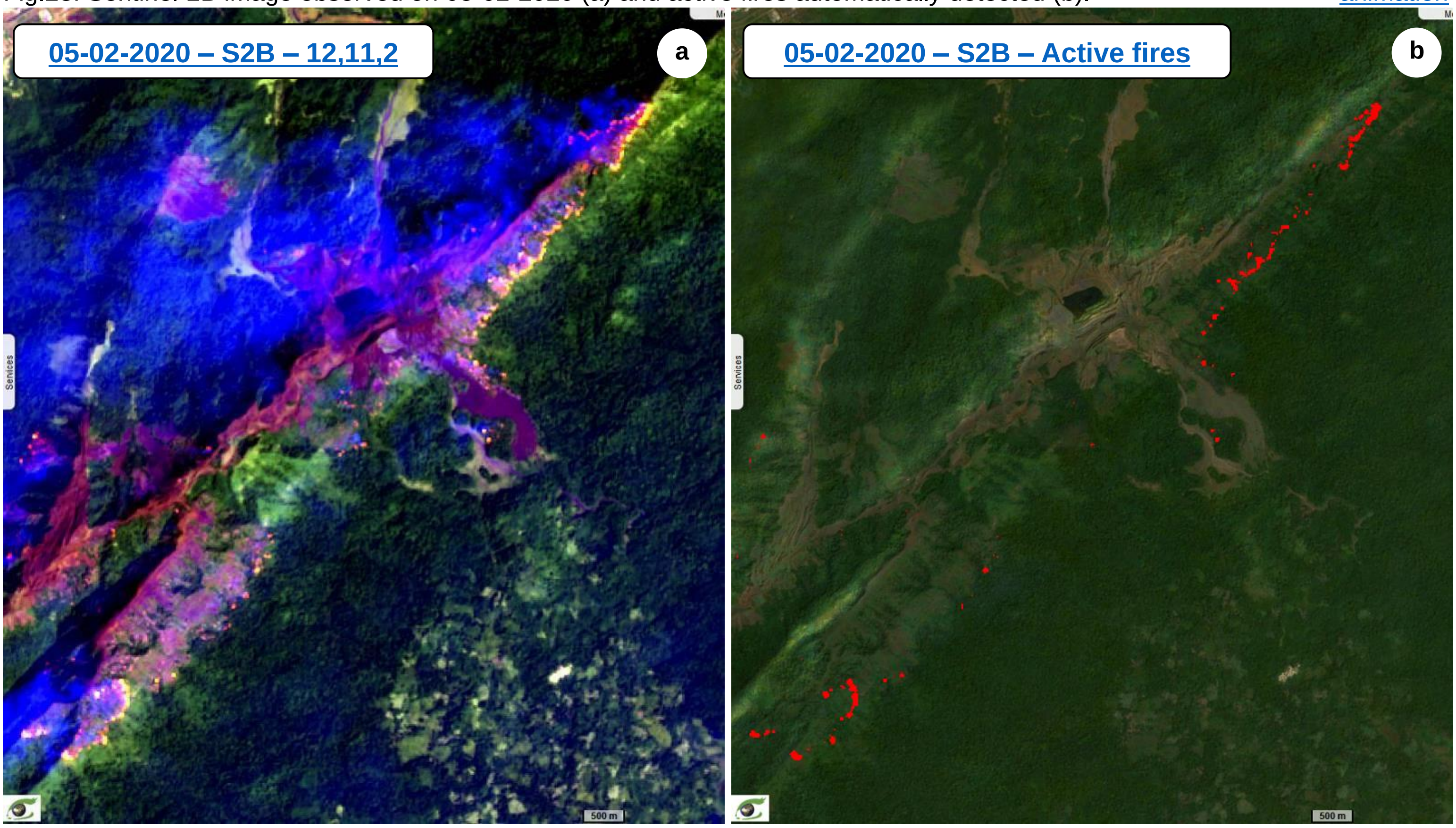


Fig.28: Sentinel-2B image observed on 05-02-2020 (a) and active fires automatically detected (b). animation



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