Gola-Foya Priority Landscape

VisioTerra

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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.

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

Fig. 2: Landsat images of 2001, 2007, 2014 and 2020 of Gola-Foya Priority Landscape.
The 2001 classification (Fig.3) was calculated from Landsat 7 images. The land cover classes used are:
- Bare soil
- Water
- Burnt area
- 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.

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

**Fig.4:** LU/LC map of Gola-Foya in 2007.

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

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

Fig.6: LU/LC map of Gola-Foya in 2020.
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. 7 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. The 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.

![Gola-Foya priority landscape map](image)

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).

<table>
<thead>
<tr>
<th>Year</th>
<th>Forest</th>
<th>Degraded forest</th>
<th>Bare soil</th>
<th>Built</th>
<th>Water</th>
</tr>
</thead>
<tbody>
<tr>
<td>2001</td>
<td>67.59%</td>
<td>25.17%</td>
<td>0.12%</td>
<td>0.16%</td>
<td>0.96%</td>
</tr>
<tr>
<td>2007</td>
<td>65.46%</td>
<td>28.82% (+3.65%)</td>
<td>0.25%</td>
<td>0.23%</td>
<td>5.24%</td>
</tr>
<tr>
<td>2014</td>
<td>61.05%</td>
<td>28.82% (+4.29%)</td>
<td>0.34%</td>
<td>0.67%</td>
<td>4.83%</td>
</tr>
<tr>
<td>2020</td>
<td>51.92%</td>
<td>28.82% (+8.48%)</td>
<td>0.38%</td>
<td>1.31%</td>
<td>41.59%</td>
</tr>
</tbody>
</table>

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HYP-119-Sentinels-F (p.5)
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).

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 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).

Evolution of Land-use / Land-cover in the Gola-Foya forest reserves between 2001 and 2020

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

- 2001: 92.75% Forest, 0.01% Degraded forest, 1.50% Bare soil, 1.05% Built, 0.05% Water
- 2007: 91.62% Forest, 0.02% Degraded forest, 1.29% Bare soil, 0.10% Built, 5.70% Water
- 2014: 88.87% Forest, 0.54% Degraded forest, 1.15% Bare soil, 0.13% Built, 9.31% Water
- 2020: 82.26% Forest, 1.16% Degraded forest, 1.25% Bare soil, 0.13% Built, 15.20% Water

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 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).

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.

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

- **Forest**: 75.69% (2001), 75.34% (2007), 74.50% (2014), 72.51% (2020)
- **Degraded forest**: 0.02% (2001), 0.03% (2007), 0.04% (2014), 0.51% (2020)
- **Bare soil**: 0.03% (2001), 2.82% (2007), 0.16% (2014), 1.87% (2020)
- **Water**: 1.34% (2001), 0.9% (2007), 0.16% (2014), 0.16% (2020)
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.

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**

It can be seen that the national parks have been preserved while the forest reserves have suffered an increasing loss of their forests.
FLEGT Watch in Liberia
Gola-Foya landscape
Gola Forest National Park
Event #1341631 - LBR VT01

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).

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

Fig.18: Sentinel-2A and Sentinel-2B images observed on 14-01-2020 (a) and 14-11-2020 (b).
As shown in Fig. 19, the FLEGT Watch system detected widespread deforestation between April 23 and May 5, 2020. This deforestation occurs in the northwestern part of Gola Forest National Park, 200 meters southeast of the village of Nyekahun.

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).

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

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

Fig. 22: Sentinel-2A and Sentinel-2B images observed on 14-01-2020 (a) and 14-11-2020 (b).
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 CAPWS 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 burnt areas are those detected in 2017.

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

Fig. 26: Burnt areas automatically extracted from the Sentinel-2A image observed on 01-14-2020.
Active fires – Periodic bulletin
Gola-Foya landscape

Active fires detected by year between 2015 and 2021.

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

\[
BAIS2 = \left( 1 - \sqrt{\frac{B06 + B07 + B8.A}{B4}} \right)^2 \left( \frac{B12 - B8.A}{\sqrt{B12 + B8.A}} + 1 \right)
\]

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

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

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

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The study is:

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❖ presented in collaboration with