CASE STUDY REPORT

Inclusive Development International (IDI) support for communities in Guinea: Compagnie des Bauxites de Guinée (CBG) in the Sangaredi region

Figure 1. High resolution imagery from December 2016 accessed via Google Earth Pro, showing CBG mining activity close to the village of Boundou Wande in Boké, Guinea.

Key Findings

- Analysis of EO imagery from 1974-2019 has been used to demonstrate stages of the mine expansion over time.
- Analysis of EO imagery shows the areas of cropland that were used by communities before being taken for mining activity.
- There is little correlation between mining activity and vegetation health at the coordinates of water sources that local communities report as destroyed or polluted.
- Mine expansion has disrupted tracks and paths visible in EO imagery, restricting mobility and access for local communities in the region.
- Land rehabilitation promised by CBG is visible in satellite imagery from around 2006 to 2016, after which some rehabilitated areas were re-exploited for mining activities.

Executive Summary

Omanos Analytics has conducted EO data analysis on a bauxite mining region in Boké, Western Guinea. This analysis has been provided to international NGO Inclusive Development International (IDI) to aid their support of local communities close to the mining activity. With the assistance of IDI and Guinea-based organisations these communities are beginning mediation procedures with the Office of the Compliance Advisor/Ombudsman (CAO), a recourse mechanism for projects supported by the International Finance Corporation and Multilateral Investment Guarantee Agency of the World Bank Group. Recourse is sought for social and environmental harms suffered as a result of the mining activities. Omanos' EO analysis tracks the mine expansion over time, investigates community reports of lost cropland, dried up rivers, and reduced water access and mobility between villages, and where possible, aims to provide objective verification using EO data.

Mining activity conducted by the Compagnie des Bauxites de Guinée (CBG) mining activity has been described at stages throughout the expansion from satellite imagery from 1973 to 2019. This is used to define the total land area taken for mining activity prior to December 2019. Cropland is identified from satellite imagery from 1973 to 2015, and in most areas this is consistent with the reports by local communities.

We have used the Normalised Differential Vegetation Index (NDVI) as a proxy for water condition as it relies on the differential absorption between the red and near-infrared wavebands by chlorophyll. Little correlation is found between NDVI at a water source and nearby mine activity. If the community reports of impacted water sources are accurate, this may be due to the 30m image resolution hiding smaller scale changes in vegetation health, or due to the sensitivity of native vegetation to water stress.

Tracks and roads that have been destroyed by mining activity are identified using pre-expansion satellite imagery from between 1986 and 2016. Where this has happened mobility and accessibility has been disrupted and large areas of the land between villages are likely to be dangerous for pedestrians, leaving some villages almost completely isolated. Most of the villages assessed have one or more intact water sources within their boundaries; however, depending on village population, demand from nearby communities, or seasonal impacts (i.e. water sources drying up in the dry season), these may not provide a sufficient supply.

Analysis of high resolution imagery shows that around 10-12% of the total mining activity footprint area has undergone some form of rehabilitation since 2006. However, analysis shows that some of these areas were re-exploited for mining from 2016 onwards. It is not clear if rehabilitation has occurred in New Hamdallaye, the resettlement site for the community of Hamdallaye village (under construction at the time of writing, early 2020). Leveling and housing construction visible in satellite imagery is consistent with descriptions in planning documentation, but no rehabilitation of the land left aside for agriculture is seen, as of December 2019.

1. Introduction

1.1. Background

Inclusive Development International (IDI) is supporting 13 local communities in Sangaredi, Boké, Western Guinea, in mediation procedures following submission of a complaint to the Office of the Compliance Advisor Ombudsman (CAO) against the World Bank's private-sector arm, the International Finance Corporation (IFC, World Bank Group), for financial support of Compagnie des Bauxites de Guinée (CBG) (see CAO case Guinea / CBG-01/Sangaredi, including CAO complaint letter[1], and Guinea: Alcoa-Rio Tinto Bauxite Mine[2]). Details of the key actors and organisations involved are given in Appendix 1.

CBG, formed in 1963, is jointly owned by the Government of Guinea (49%) and by Halco Mining Inc. (51%). Halco Mining Inc. is owned by a consortium of aluminium producers: Alcoa (45%), Rio Tinto (45%) and Dadco (10%)[1]. CBG was granted land concessions by the government for bauxite mining, which began in 1973 following developments of rail and roadways for the transportation of bauxite.

The current CBG expansion project is supported by a loan from the IFC of up to $200 million for expansion of the Sangaredi bauxite mine, processing facilities and infrastructure (IFC, CBG Expansion, Summary of Investment Information[3]). IFC financial support of development projects is granted under the condition of compliance with the IFC Performance Standards[4] which establish requirements for environmental and social sustainability. Since receiving this funding package CBG has taken measures to follow these requirements for environmental and social protection, introducing new environmental and social policies, including compensation for lost lands and resettlement policies.

The complaint, filed with the assistance of IDI, alongside the Centre de Commerce International pour le Developpement (CECIDE) and the Association pour le développement rural et l'entraide mutuelle en Guinée (ADREMGUI), details harms committed against these communities including loss of lands, livelihoods, and destruction of their local environment; in violation of IFC performance standards. Community reports also claim that compensation offered is insufficient, resettlement sites have previously been mined and not adequately rehabilitated, and historic displacement has not been remedied.

IDI personal and independent consultants have worked closely with community representatives and on-the-ground contacts in Boké. They are leading much of the research effort to provide evidence in preparation for the mediation process, and have requested satellite data analysis of the region to show the change in land use since CBG began operations and the footprint of the impacted region over time.

[1] Halco Mining Inc. and Alcoa are registered in the United States, Rio Tinto is registered in the United Kingdom and Australia.

1.2. Scope

Omanos Analytics will provide Earth Observation (EO) data and analysis of the Sangaredi mining region between 1973, shortly after CBG arrived in the area, and mid-2019. Omanos' EO data analysis will augment cartography and GIS participatory mapping by IDI (core team plus long-term consultants) in partnership with on-the-ground representatives. The goal of the analysis is to assess the mining development from EO imagery and provide independent verification of claims made by the local communities. Community accounts of past and current land use and location information on community infrastructure (such as schools, mosques, and points of water access) is provided through the participatory mapping work performed by IDI's consultants (see Section 1.4).

1.3. Data sources

1.3.1. Participatory mapping

Community representatives in Boké include members of the 13 local communities involved in the complaint to the IFC who are assisting IDI and consultants to investigate the impact the mining activity has had on their lives and local environment. This also includes the 540 complainants directly involved in submission of the complaint letter, the identities of whom are kept confidential by IDI and partners due to safety concerns.

IDI consultants, both remote and Guinea-based, have collated existing information on the Sangaredi mining region. This includes existing reports, CBG materials (see Section 1.3.3) and GIS information obtained by Human Rights Watch in 2017 (see Section 1.3.2). In addition participatory maps have been constructed using data collected in the field by the consultants and their on-the-ground contacts.

A brief description of the methodology employed to obtain data for the participatory mapping is provided by the independent consultants. Information on community infrastructure, previous land use and geographical information was obtained during trips to the villages. Community members escorted data collection personnel to areas of importance and the coordinates were measured using GPS equipment. For areas of cropland or fallow land, for example, the extent of the land was obtained by walking the perimeter with GPS equipment. To provide some verification of reports of past land use a single Spot 1 satellite image from 1986 (10-20m resolution) was used to confirm the existence of e.g. a river. Current land use was identified using a single band Spot 7 image from 2015 (1.5m resolution) and a 2019 Sentinel 2 image.

1.3.2. Human Rights Watch

Human Rights Watch (HRW) has conducted investigations into community reports and complaints regarding the actions of CBG during mine expansion activities. A report by Human Rights Watch HRW "What do we get out of it?", hereafter referred to as HRW18[5]), dated October 2018, incorporates over 300 interviews with villagers throughout the Boké region, as well as government officials, environmental scientists and CBG representatives etc. The report covers the bauxite mining activities and practices of CBG as well as La Société Minière de Boké (SMB). Similar concerns are identified for the projects of both companies but we focus on the reports related to CBG. HRW has also provided the results of GIS work performed at the end of 2017. This includes information on the ancestral lands of the village of Hamdallaye, where much of the mining activity is located, and settlement areas and village positions in a large portion of the Boké region. Also included are the areas of bauxite mining in this portion of the Boké region, which appears to show the areas of active bauxite mining or survey.

1.3.3. CBG materials

During planning for the current expansion programme, CBG conducted public consultations and commissioned studies into the potential social and environmental impact in preparation for launch of the Expansion Project. These materials were prepared by CBG and EEM EHS Management, a Canadian consultancy specialising in environmental health and safety performance, commissioned to perform the Environmental and Social Impact Assessment for the Extension Project. We have not been able to access all documents prepared for the CBG Expansion Project by CBG and EEM. Those available online are annexes and appendices to the supplementary information package for the main Environmental and Social Impact Assessment (ESIA)[6, 7].

Included in available materials, as an annex to the CBG Mine Expansion Project ESIA, are slides titled "Information Presented During Initial Public Consultation"[8], reportedly presented in December 2013 (attendees unknown). This briefly described the planned expansion and the affected areas, and lists potential environmental and social harms that could arise. General impacts include increased noise and dust, damage to surface and groundwater, and displacement of people. Specific issues are discussed, including agricultural land becoming "irreversibly transformed by mining activity", reduced land for grazing cattle, reduced water retention capacity of soil, and degradation of water quality. A communication plan is also outlined, including stakeholder and community engagement and a grievance mechanism.

1.3.4. EO imagery

The bulk of the analysis will rely on Landsat data (see Section 1.3.4.1) due to the temporal coverage from the start of the mining activities in the Sangaredi region in 1973. Recent mining developments are assessed using Sentinel 2 imagery (Section 1.3.4.2), available from late 2015. For feature identification at higher resolution we use imagery accessed via Google Earth Pro (see Section 1.3.4.3).

1.3.4.1. Landsat

The Landsat satellites provide imagery of the Sangaredi region from late 1972. Imagery of the region from between 1972 and 1986 used here was taken with the Multispectral Scanner[9] (MSS) instrument on Landsat 1-5. Landsat 1-5 MSS imagery has a resolution of around 60-80m and covers wavelengths from 0.5μm to 1.1μm (green to near-infrared (NIR)) over 4 bands.

Imagery of the region between 1986 and 2013 is provided by Landsats 4-5 and Landsat 7. The Landsat 4-5 Thematic Mapper (TM) instrument gives a resolution of 30m from a wavelength coverage of 0.45μm to 2.35μm in six bands (an additional thermal band of 10.41-12.5μm has a resolution of 120m but is not used here). Imagery of the region between 2000 and 2003 is from Landsat 7 which failed in May 2003. The Enhanced Thematic Mapper Plus[10] (ETM+) on Landsat 7 has a resolution of 30m with six wavebands from 0.45μm to 2.35μm (a seventh thermal band of 10.41-12.5μm and 60m resolution, and an eighth panchromatic band, are not used here). After 2013 imagery is provided by Landsat 8 with the onboard Operational Land Imager[11] (OLI) instrument giving a resolution of 30m and a wavelength coverage of 0.435μm to 2.294μm over nine bands, including a panchromatic band, and a band for the detection of high altitude clouds. The OLI bands used here are consistent with the Landsat 4-5 and Landsat 7 bands.

Imagery is shown in waveband combinations displayed as red, green, blue (RGB) composite images either in true colour or false colour. In a true colour image the red, green, and blue wavebands are displayed in RGB, as visible by the human eye. In a false colour image the NIR, red, and green wavebands are displayed as RGB, highlighting vegetation in red. True colour images are made using bands [3, 2, 1] for Landsat 4-5 and Landsat 7, and bands [4, 3, 2] for Landsat 8. False colour images are made using bands [4, 3, 2] for Landsat 4-5 and Landsat 7, and bands [5, 4, 3] for Landsat 8. As Landsat 1-5 MSS has no blue band, Landsat 1-5 MSS imagery is displayed in the RGB combination of bands [4, 2, 1] to approximate the false colour display for Landsats 5-8.

Landsat 5-8 data has recently been made available via Sentinel Hub services and web apps. However, we have downloaded Landsat imagery from Earth Explorer to allow consistent data processing from 1973 (Landsat 1-4 not available via Sentinel Hub) and calculation of NDVI maps. Processing, visualisation and analysis of Landsat imagery is performed primarily in QGIS which also allows visualisation of GIS data provided by IDI consultants, and measurement of pixel values.

1.3.4.2. Sentinel 2

The Sentinel 2 satellites provide worldwide land coverage imagery from late 2015 at resolutions from 10m (depending on waveband). Sentinel 2 satellites observe at optical and near infra-red wavelengths: 443nm to 2202nm in 13 wavebands.

Sentinel 2 imagery is viewed via Sentinel Hub browser-based applications EO Browser and Sentinel Playground, which provide quick access to processed imagery in standard and customisable waveband combinations. Sentinel Hub web services provides access to the data in a format that can be used for further processing, such as use in QGIS. Processing of Sentinel 2 data files has also been performed using SNAP (the Sentinel Application Platform - a GUI containing toolboxes for the reading, processing and plotting of Sentinel data).

1.3.4.3. High resolution

High resolution imagery from a number of commercial sources is accessed free of charge via Google Earth Pro. The timelapse feature allows imagery to be viewed from past timeframes. Over the Sangaredi mine region Google Earth Pro provides high resolution imagery from 2007, 2010, 2011, 2016, and 2019, with varying spatial coverages. The date and source of the images are given but the exact resolution of each is not provided.

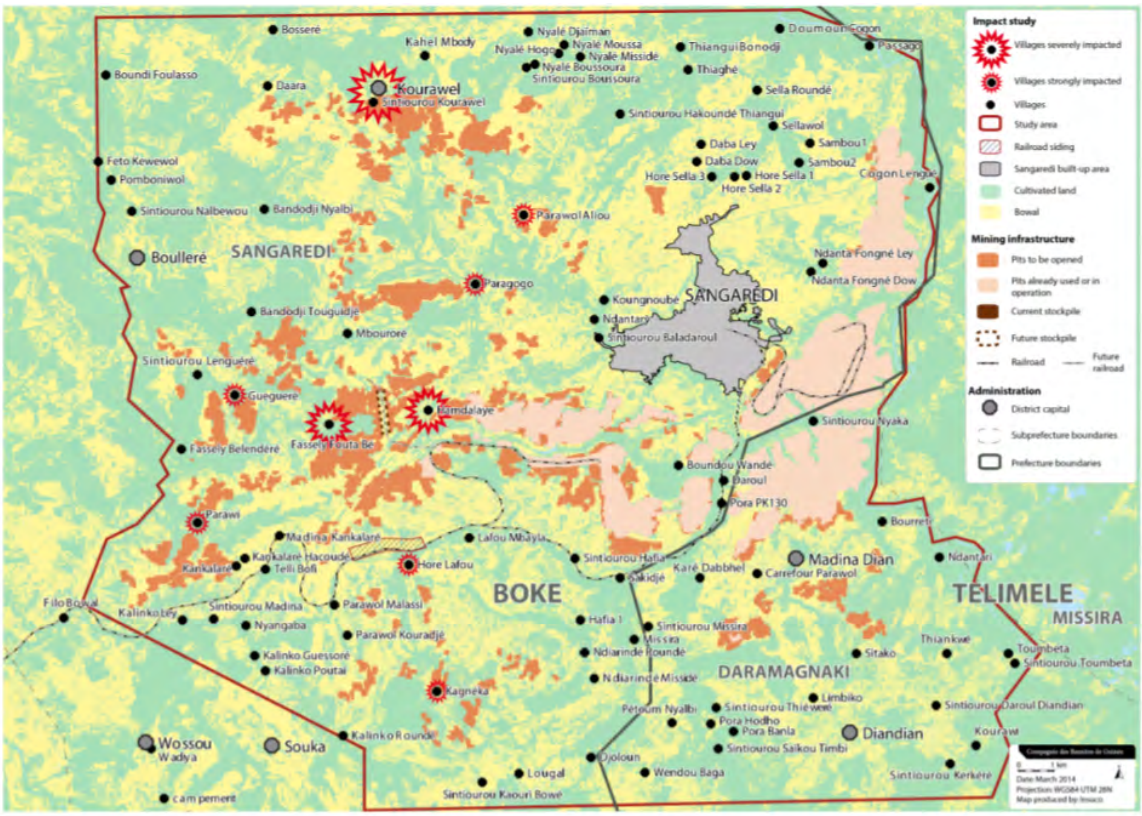


Figure 2. Map of the Sangaredi mining region taken from “Resettlement and Livelihoods Restoration Policy Framework”, an appendix to the “Supplementary Information Package (SIP) to the ESIA of the CBG Expansion Project”. In this document the map is labelled as “Mine zone villages with the greatest potential impact on land and housing (27.5 MTPA in 2022)”.

2. Region of Interest

2.1. Concession areas

Most of the mining activity close to Sangaredi is within a land concession granted to CBG for bauxite mining prior to 1973. Further concession areas were granted to CBG in 2006. A concession contract (in French) dated 13th January 2006 details the coordinates of two additional regions. These are overlaid onto a Landsat image in Appendix 1. All of the villages involved in the IFC complaints process are located within the main Sangaredi mining area (referred to as the “original CBG territory” in the 2006 concession contract document). The analysis conducted by Omanos focuses on the mining activities that have taken place in this region and close to the locations of the complainant villages.

The coordinates for the Sangaredi mining site concession area are not made explicitly clear in any documentation we were able to access. Maps found in CBG materials, such as that in Figure 2 (from “Resettlement and Livelihoods Restoration Policy Framework”, an appendix to the “Supplementary Information Package (SIP) to the ESIA of the CBG Expansion Project”), indicate a study area which may represent the whole of the original concession site.

2.2. Village coordinates

There are approximately 30 villages in the region in some way impacted by the mining activity, and whose lands make up a large proportion of the study region. IDI requested Omanos to conduct an analysis focusing on the 13 villages whose community members contributed to the participatory mapping and who are involved in the complaint procedure. The names of these villages are included in the complaint letter.

- Hamdallaye
- Fassaly Foutabhè
- Boundou Wandè
- Kogon Lengué
- N’danta Fognè
- Bourorè
- Samayabhè
- Paragögö
- Parawi
- Parawol
- Sinthiourou Lafou
- Lafou Mbaïla
- Horè Lafou

Most of these villages are included in data from HRW, or marked on maps from HRW and found in CBG materials, such as that in Figure 2, from an appendix to the Supplementary Information Package (SIP) to the ESIA of the CBG Expansion Project. Further annexes (16-17) to the CBG Mine Expansion Project ESIA include a table of the sites of cultural importance within the planned expansion area detailing coordinates, site descriptions, and associated village. Comparing locations from these sources with high resolution imagery from Google Earth, allowed coordinates to be estimated for 11 of the 13 villages.

Care is taken to consider possible differences in spelling of village names between documents. In particular, the village listed as N’Danta Fognè in the complaint letter is assumed to be the village Ndanta Fongne included in maps and tables in CBG materials. CBG materials do not list coordinates for the village of Sinthiourou Lafou, although it is mentioned in some documents (spelt Sintiourou Lafou). Similarly, no coordinates are found in CGB materials for the village of Samayabhè, although it is possibly mentioned under the spellings Samayaghe and Samayabe.

Village coordinates are also provided through the participatory mapping conducted by IDI consultants, which have been used to validate/confirm CBG data. For 10 of the 11 villages with position information found in CBG materials the coordinates agree very well with those from the participatory mapping, and we use the coordinates for Sinthiourou Lafou and Samayabhè from the participatory maps. The coordinates for Parawi village do not agree between CBG materials and participatory maps, with a discrepancy of over a kilometre. High resolution imagery of the two coordinates shows a village at the coordinates from HRW and CBG materials but no village close to the participatory map coordinates. The later coordinates appear to coincide with the junction of a main road with the access track for the village at the former coordinates. We therefore use the coordinates from HRW and CBG materials for Parawi village. Village coordinates are given in the table in Appendix 2 which includes the estimates made using CBG maps and material, and the coordinates provided through the participatory mapping. Where these coordinates differ significantly we use the coordinate that lies closest to the village centre visible in the high resolution imagery.

3. EO Analysis

The impacts reported by the villagers in the IFC complaint letter, participatory maps, and in interviews conducted by HRW are investigated in the following sections. It should be noted that the claims made cover a wide range of social and environmental harms and we focus on those that can be investigated via satellite imagery, aiming to provide objective verification.

Our analyses rely on imagery from the Landsat satellites which provides temporal coverage across CBG mining activities in the Sangaredi region. In Section 3.1 we focus on characterising mine expansion over time and the footprint of the impacted area. We have developed metrics for the identification of cropland from Landsat imagery using comparisons to high resolution imagery, allowing cropland lost to mine expansion to be shown in the context of crop rotation practices by the community (see Section 3.2). In Section 3.3 we detail the methodology used to investigate community reports of dried up water sources. The region exhibits dense vegetation around rivers and tributaries, preventing direct observation of water sources from EO imagery. To assess the condition of water sources that communities have reported as destroyed or polluted by mining activity, we use the health of nearby vegetation as a proxy by calculating the Normalised Difference Vegetation Index (NDVI). In Section 3.4 we describe our assessment of the socio-environmental impact of the mining activity. Analysis of high resolution imagery of the area prior to mine expansion alongside community reports demonstrates where mining activity has cut off access routes between villages and restricted access to water. In Section 3.5 we investigate areas of the region in which mining has stopped and rehabilitation of the land has been attempted. This discussion includes an assessment of an area currently being prepared for the resettlement of the Hamdallaye village community.

Unless otherwise stated, the EO imagery in the following analysis is taken during December and January. These months are used as they fall at the beginning of the dry season, decreasing the likelihood of cloud cover in the imagery. In addition, healthier vegetation at the beginning of the dry season (compared with later in the dry season) results in a higher contrast between cultivated and uncultivated land.

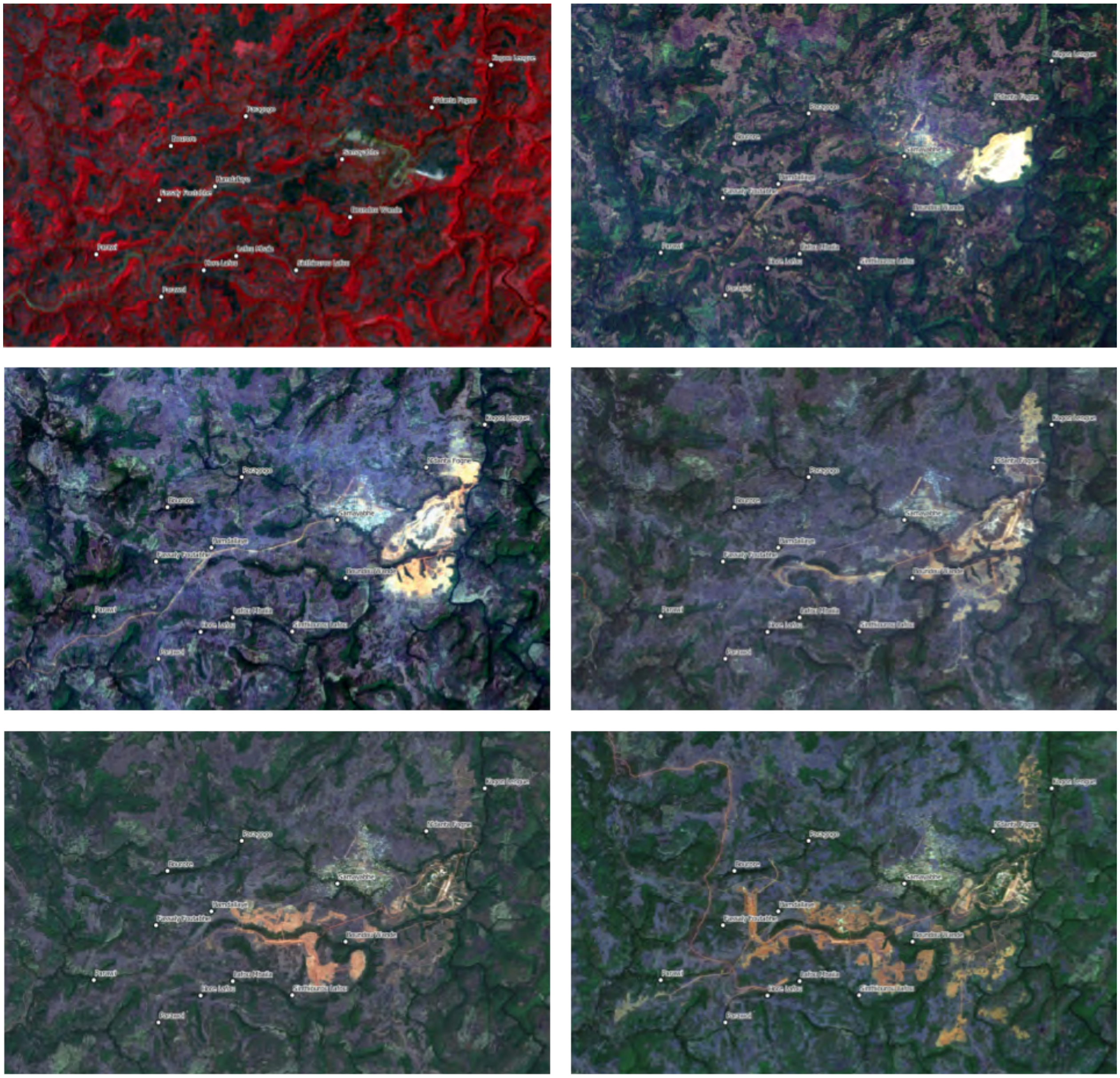


Figure 3. Landsat imagery of the Sangaredi region showing to mine expansion from 1973 (top left panel) to 2018 (bottom right panel). The positions of the 13 villages being support by IDI are marked on the images.

3.1. Mine footprint

Bauxite mining activities in the Sangaredi region have expanded from 1973 to 2019. As described in Sections 1 and 2, the concession areas granted to CBG cover large portions of land throughout Western Guinea, (see Appendix 1). The main Sangaredi mining site, in the concession area granted before 1973, is where most of the mining activity has taken place.

Before the development of the mine began in 1973, CBG constructed supporting infrastructure of rail and roadways for the transportation of bauxite from the mines to facilities at the port in Kamsar. The first community lands lost to CBG activities, reported in the complaint letter, were due to this development. This infrastructure is visible in the earliest Landsat imagery of the region available (see Figure 3). The expansion of the mining activity in the region is shown in Figure 3, which gives images showing Landsat 1 imagery from January 1974 (top left, in which the road and railways are visible), Landsat 5 imagery from December 1988 (top right), Landsat 7 imagery from January 2000 (middle left), Landsat 5 imagery from December 2006 (middle right), Landsat 8 imagery from December 2013 (bottom left), and Landsat 8 imagery from December 2018 (bottom right). The 13 villages involved in the CAO dispute resolution process are marked on the images (coordinates used are discussed in Section 2.2).

The expanding mine footprint is further visualised in Figure 4. The images in Figure 3 are used to derive mine footprint polygons (done through visual inspection using QGIS). Figure 4 shows the mine footprint polygons overlaid onto a Sentinel 2 image from December 2018. In addition to Landsat derived mine extent overlays, the beige areas show mining activity before 2017 obtained by Human Rights Watch. Those outside the Landsat derived overlay are largely bauxite survey areas not visible at 30m resolution.

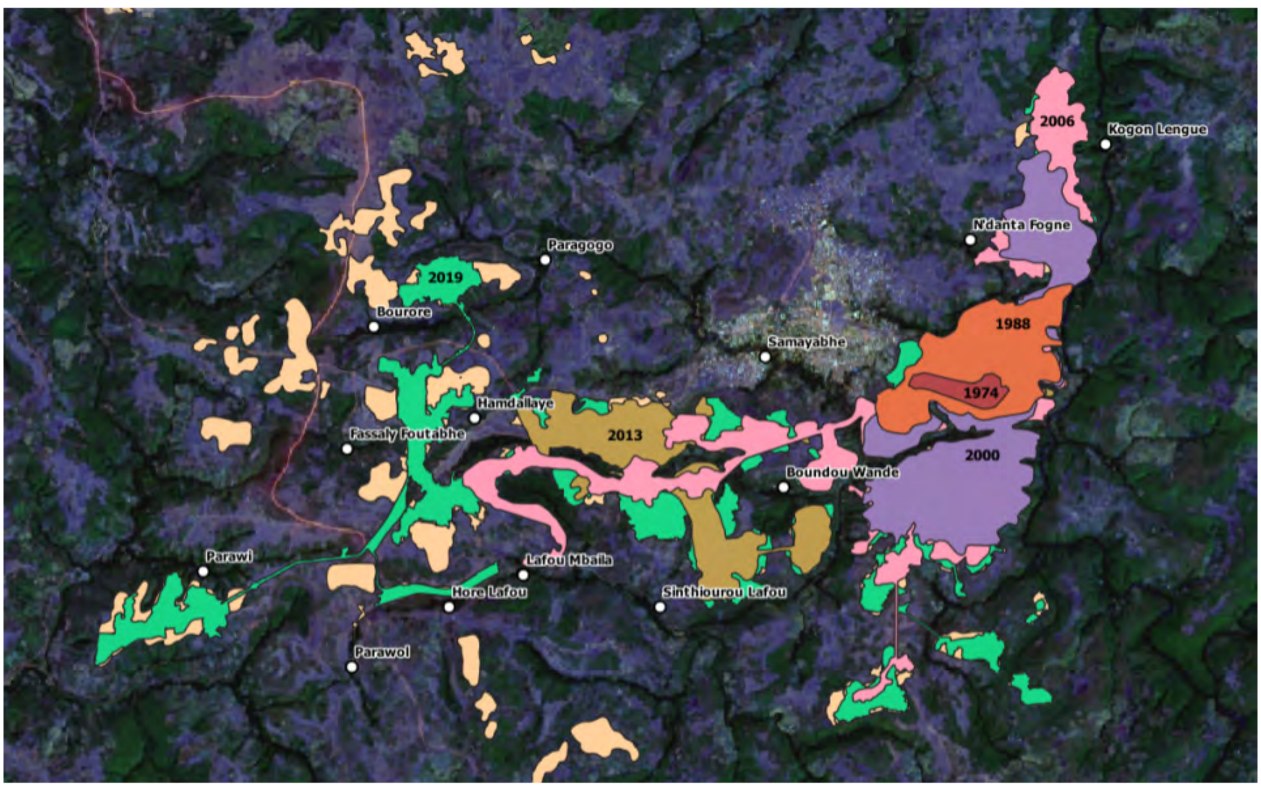


Figure 4. Landsat 8 imagery from December 2019. Overlay shows the extent of the mine expansion in the years labelled, as derived from Landsat data with resolutions 30-60m. The beige polygons show show mining activity before 2017 obtained by HRW. Those outside the Landsat derived overlay are largely bauxite survey areas not visible at 30m resolution.

3.2. Cropland lost

Communities report the loss of ancestral pasture and cropland taken for mining without permission and with inadequate compensation. As reported in HRW18, compensation has reportedly been limited to lost plants and crops with no consideration of crop rotation practices. As a result, little compensation is given for farmed land and none given for fallow land.

Given that the reported damage to the communities dates back to the start of the mining activities, we will focus our analysis on Landsat imagery (available for free from USGS from 1972 to present day), which provides coverage over the whole study period. The resolution of this imagery is 60-80m (Landsat 1-3 1972-1986) to 30m (Landsat 4-8 1986-present); we have used crop identification methods appropriate for moderate resolution.

At these resolutions this pasture land is not distinguishable and fallow land is not reliably identifiable. Given a reported crop rotation cycle of around 7 years (see HRW18) crops will be identified from all available imagery taken in December and January. Using data only from these months maintains a consistent and comparable level of vegetation in the imagery and, as it is the start of the dry season, data is less likely to be affected by cloud cover.

In the following sections, we identify land in the mining region used for agriculture between 1974 and 2015 (the beginning of the CBG Expansion Project). Metrics for identifying cropland from Landsat imagery use comparisons with areas of cropland more easily visible in high resolution imagery from Google Earth Pro. Cropland is then identified for all years for which there is Landsat data but no high resolution imagery available. Overlaying all identified cropland onto current mine region images will provide a more accurate (although not complete) indication of the cropland lost to mine expansion.

3.2.1. Cropland identification

High resolution images from Google Earth are compared with Landsat imagery from the same month to develop metrics for identification of agricultural land from Landsat data, given typical farming practices used in the region. High resolution images showing large areas of the Sangaredi region are available for 2007, 2010, 2011, 2016 and 2019. The high resolution image with a cloud-free Landsat image most closely matching in month and year is reported by Google Earth to be taken by Maxar Technologies on 3/12/2010. The corresponding Landsat 5 image was taken on 28/11/2010.

Areas of agricultural land are identified from the high resolution image by geometric patterns in vegetation such as that shown in the left hand panel of Figure 5. These are found throughout the Sangaredi region, often along a river or tributary. The corresponding Landsat 5 data is shown in false colour (see Section 1.3.4.1) in the right hand panel of Figure 5, where the area of cropland visible in the high resolution image can be seen as pale-red to pink in contrast to the bright red of denser uncultivated vegetation. Appendix 2 shows further examples of cropland in 2010 compared between Landsat and high resolution. The same November 2010 Landsat

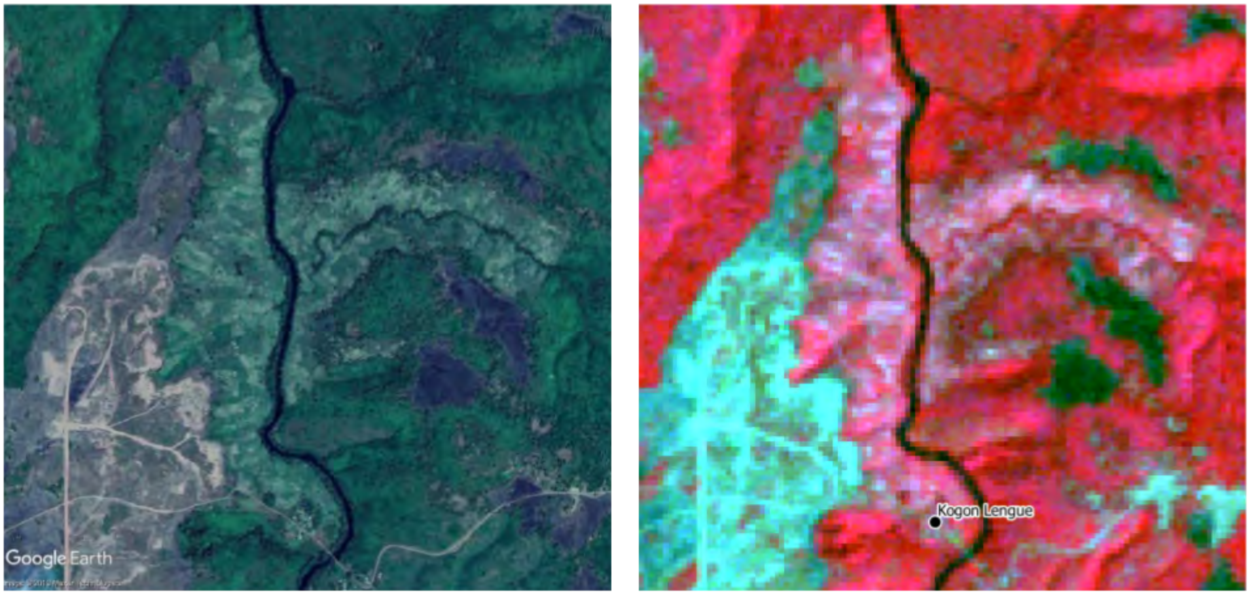


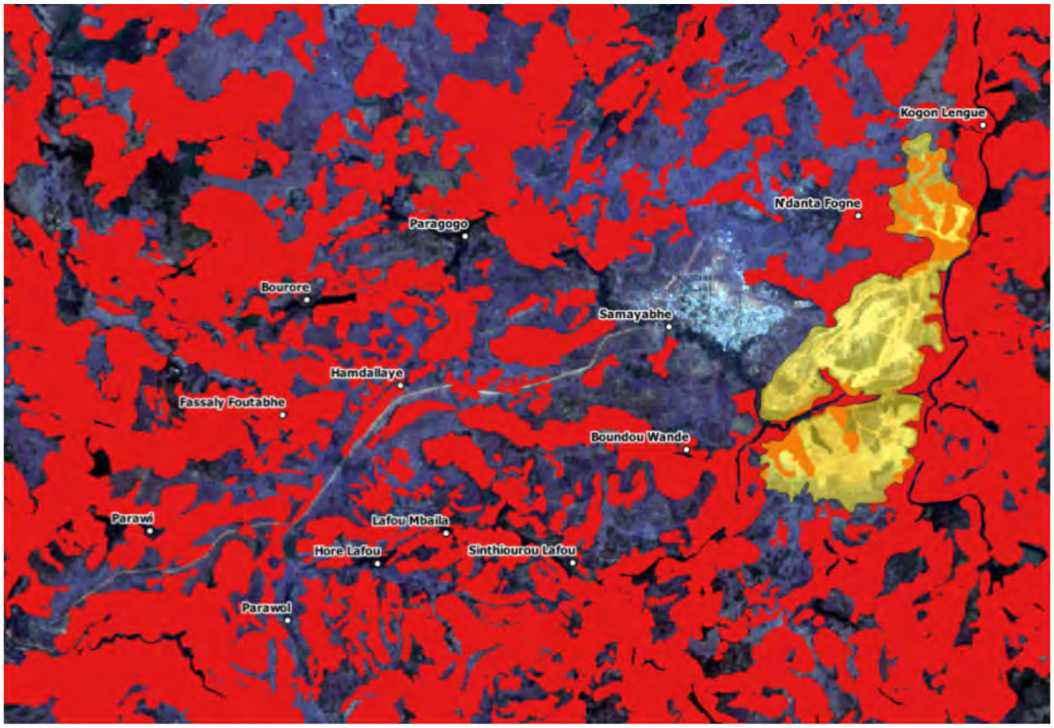
Figure 5. Comparison of cropland in the Sangaredi region between high resolution imagery from Google Earth Pro (dated 03-12-2010), and Landsat imagery presented in false colour (taken 28-11-2010).

imagery is used in Appendix 3, in comparison with January 2010 Landsat imagery, to show crop rotation practices from 2009 to 2010.

Historical land use for areas now occupied by mining sites is evaluated by identifying this signifier of agriculture in pre-expansion Landsat imagery from December and January since 1973. Between 1973 and 2015 cloud-free imagery is available from January 1974, January 1986, December 1987, December 1988, January 2000, December 2001, January 2003, December 2006, January 2010, January 2011, December 2013, and January 2015.

It should be noted that the method used to identify cropland is not exhaustive due to missing or cloud affected images (resulting in missing years in crop rotation cycles), image resolution, and the size of some patches of cultivated land in the region, so not all of the cropland lost to mining activities can be identified.

Polygons showing cropland identified from satellite imagery are overlaid in red onto Landsat images from January 2000, December 2006, December 2013, and December 2019, given in Figure 6 and 7. Also overlaid in Figure 6 and 7 are the mine footprints for the years 2000, 2006, 2013, and 2019, respectively shown in yellow. Where the mining activity has expanded into cropland the overlay shows the areas in orange. During CBG activities in the region between 1973 and 2019 it appears that most of the cropland lost directly to the bauxite mines is close to the villages of Kogon Lengué and N'danta Fognè in the Northeast of the region, and Boundou Wandè and Hamdallaye close to the centre of the region.



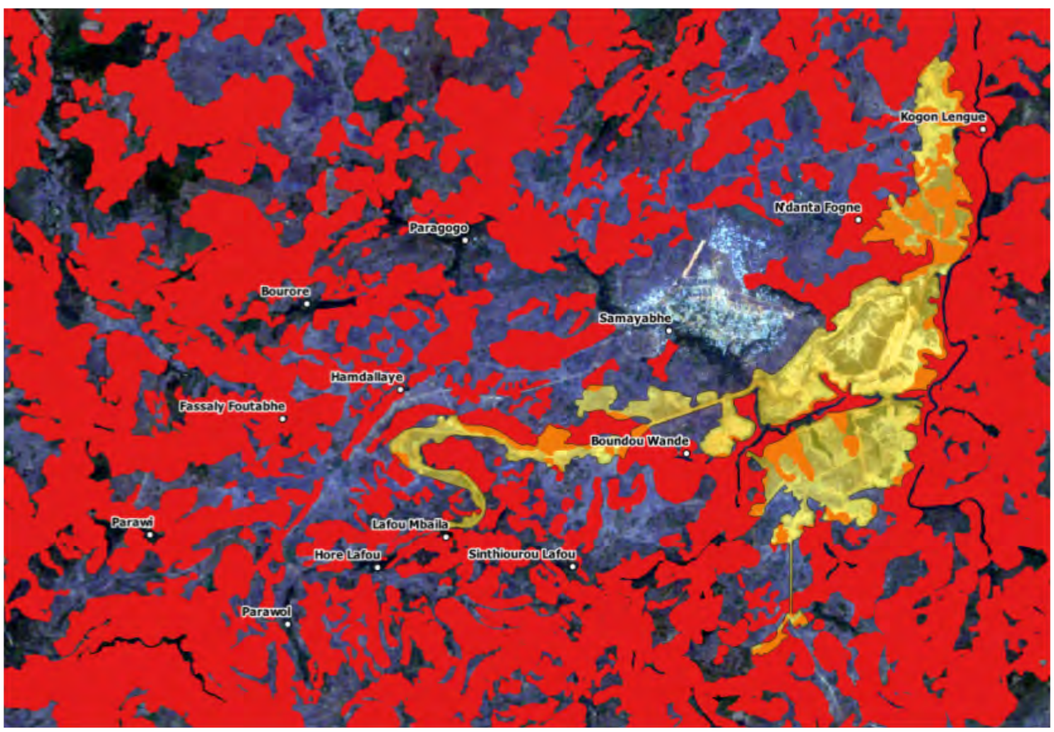
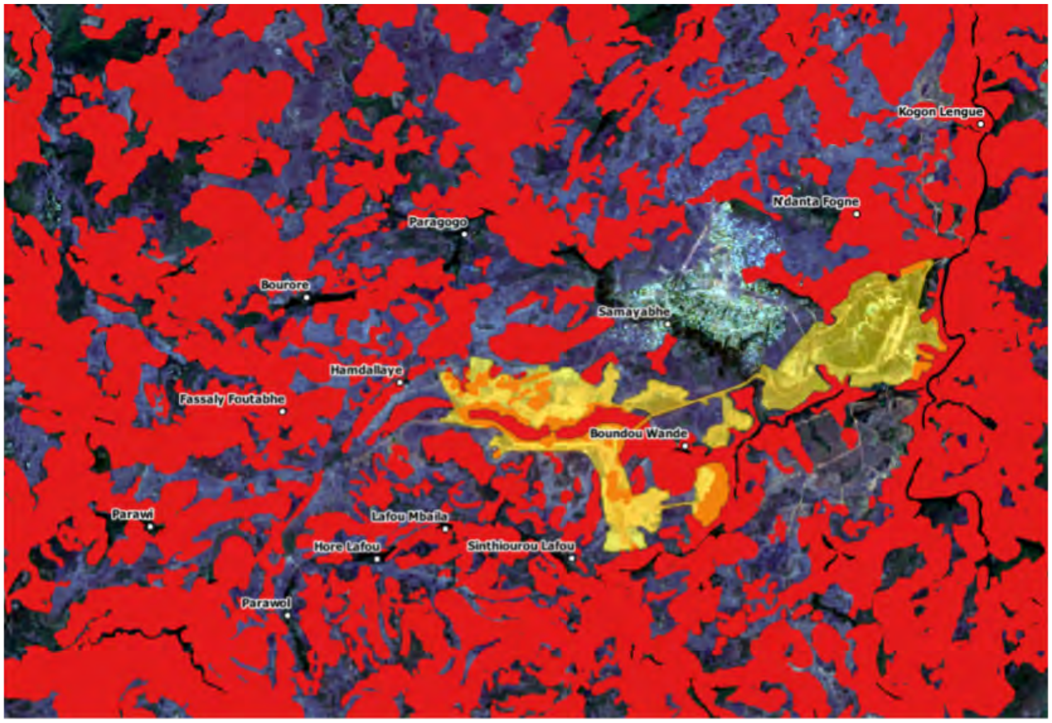


Figure 6. Natural colour Landsat imagery taken in January 2000 (top) and December 2006 (bottom). The yellow overlay shows the mine footprint visible in each image. Red shows all cropland identified from Landsat imagery taken in December-January between 1974 and 2015. Where the mine footprint has expanded into cropland the areas appear orange.



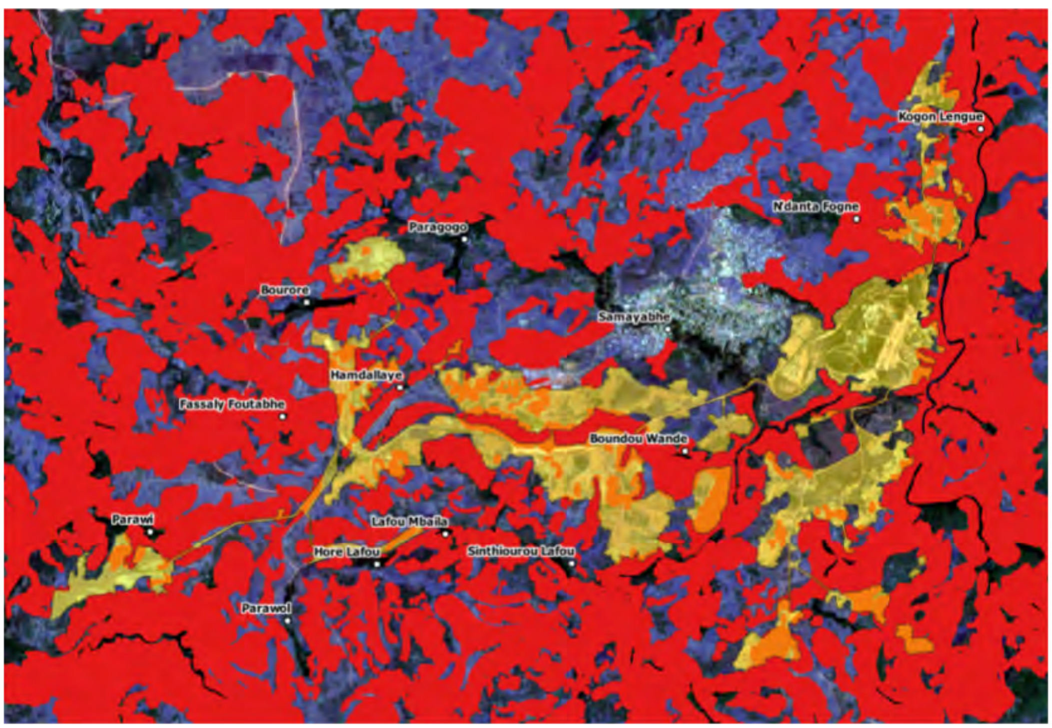


Figure 7. Natural colour Landsat imagery taken in December 2013 (top) and December 2019 (bottom). The yellow overlay shows the mine footprint visible in each image. Red shows all cropland identified from Landsat imagery taken in December-January between 1974 and 2015. Where the mine footprint has expanded into cropland the areas appear orange.

3.2.2. Cropland summary and validation

Cropland identification in Sections 3.2.2 to 3.2.5 shows that much of the cropland close to rivers and tributaries have not been exploited for bauxite mining. This is likely due to the mining methods used requiring largely flat terrain, excluding many of the valleys that host rivers and tributaries. However, as noted previously, this method is not able to identify all of the cultivated and fallow cropland in the region: due to crop rotation practices and missing or cloud cover affected data some crops will be missed. In addition, small crop areas and pastoral land will not be visible at the 30m resolution of Landsat data.

Ground-truth data on the locations of cropland has been collected by IDI independent consultants and on-the-ground contacts, and used in the participatory mapping (see Section 1.3.1). Comparison of cropland in these maps with that identified from EO data allows these community reports to be verified. The participatory maps are divided into four zones representing the social and economic groupings of the local villages (see Figure 8).

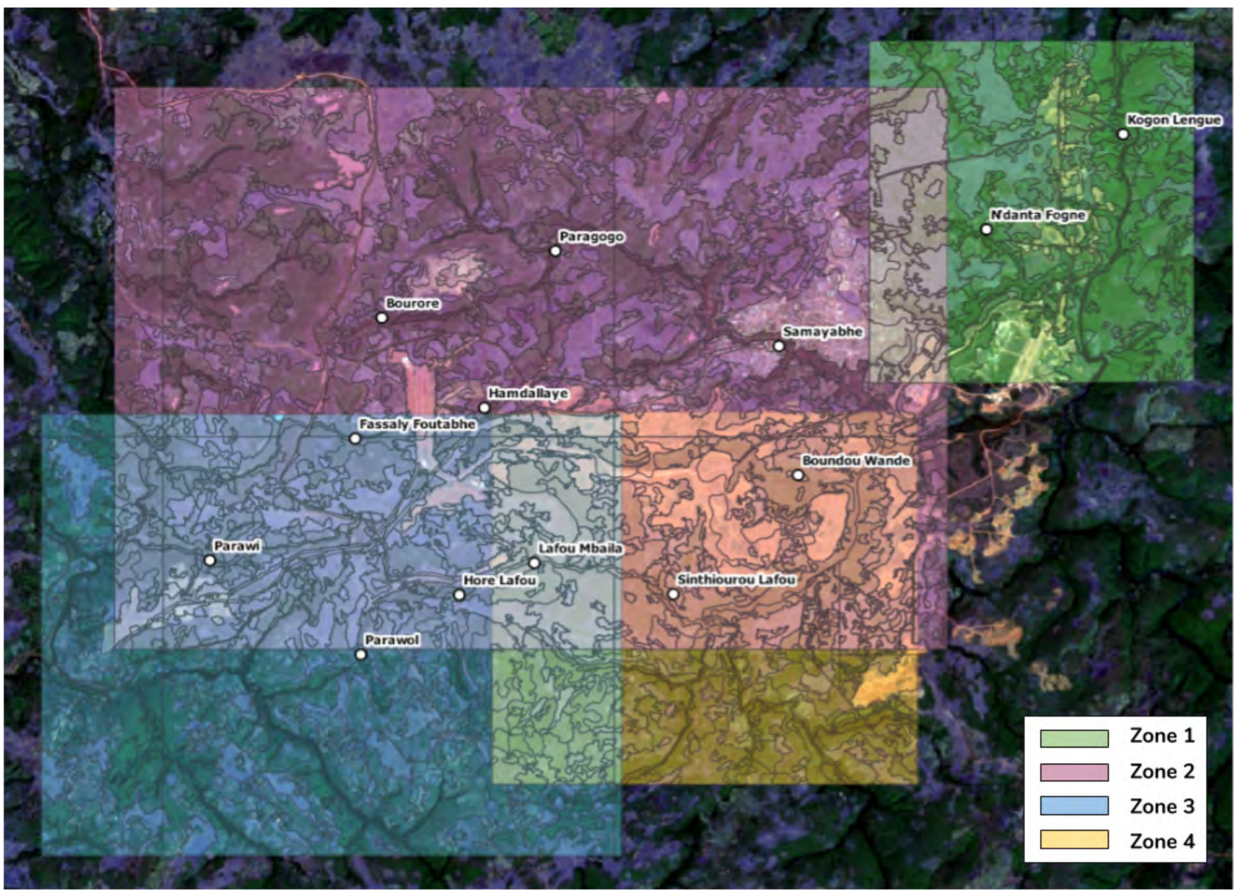


Figure 8. Landsat 8 image of the Sangaredi mining region from 07-12-2019. Overlaid are four zones, representing the social and economic groupings of the local villages, used in the participatory mapping process.

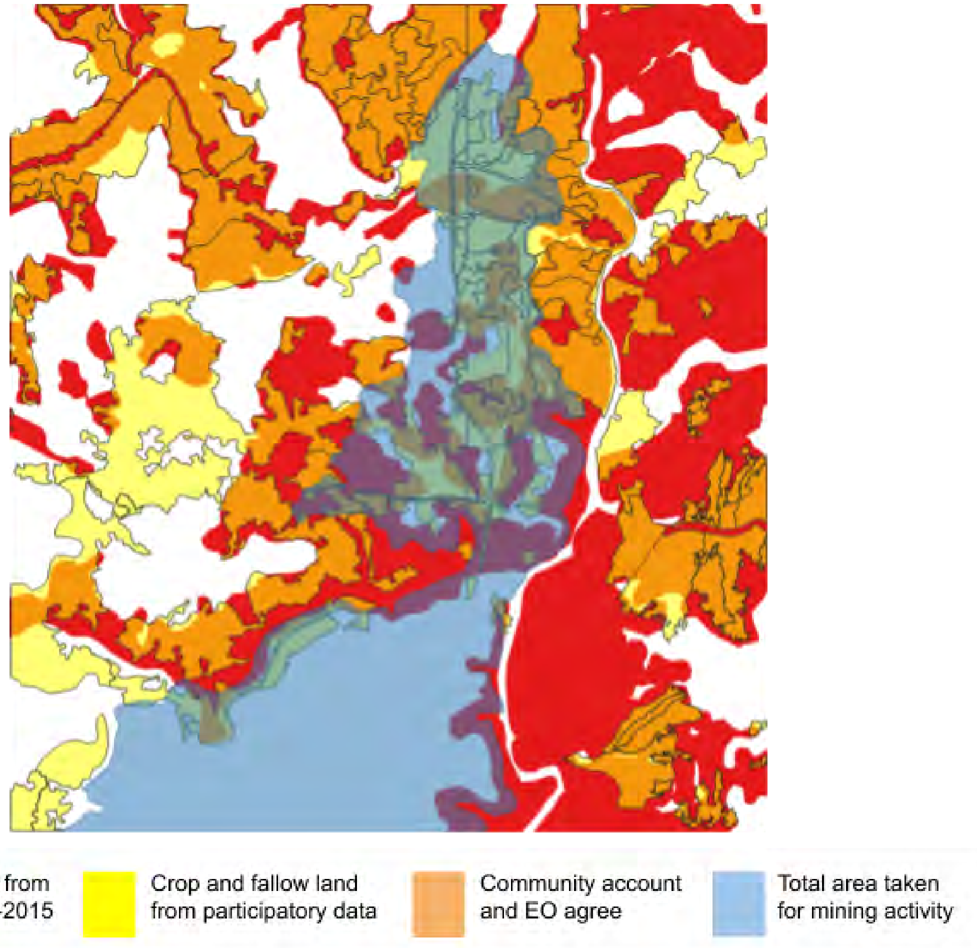


Figure 9. Zone 1 of the Sangaredi mining region. Cropland identified in Landsat images from December-January 1974-2015 is overlaid onto cropland and fallow land reported in the participatory maps. Orange shows agreement between community account and EO data.

Figures 9 to 12 show cropland in zones 1-4: red shows areas of cropland identified in Landsat images from December-January between 1974 and 2015; yellow shows cropland and fallow land reported in the participatory maps. Consequently, orange shows agreement between community account and EO data. Blue shows the total mining activity footprint - the total land area taken for mining activity before December 2019 (see Section 3.1). Agreement between community reported cropland and cropland identified from EO data is generally good given limitations in the methodologies used. In areas where communities report cropland but no cropland is visible in satellite data (shown in yellow) it is likely due to incomplete temporal coverage of the available Landsat imagery. As described in Section 3.2.1 crop rotation cycles in the region will cause areas of cropland to be missed when there is no satellite data available. In addition with a spatial resolution of 30-80m some areas of cropland will not be identifiable from Landsat imagery. Red areas in Figures 9 to 12 show cropland visible in satellite imagery but not reported as cropland in the participatory maps. One explanation for this could be the division of land ownership between local villages: cropland could be missed from the participatory mapping if it is owned by a community outside of the villages involved in the participatory data collection. Similarly, given that the satellite data shows cropland over 45 years, land use could be misremembered or ownership and use could have changed independently of the expansion of mining activity.

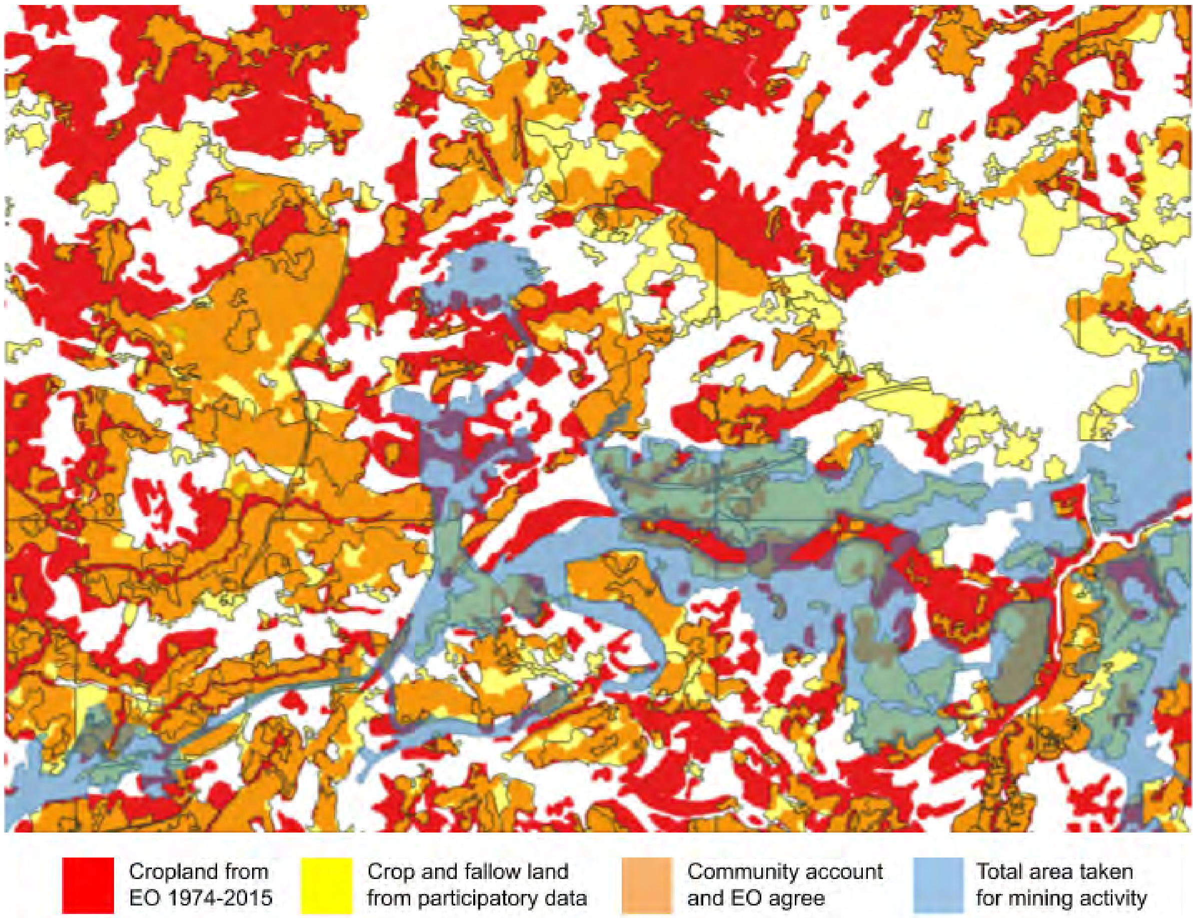


Figure 10. Zone 2 of the Sangaredi mining region. Cropland identified in Landsat images from December-January 1974-2015 is overlaid onto cropland and fallow land reported in the participatory maps. Orange shows agreement between community account and EO data.

3.3. Destroyed and polluted water sources

Communities report some sources of water close to the mining activities have been destroyed or polluted with dust or chemicals from the mining works. In comments obtained by HRW, CBG said that the company "follows international best practices to prevent mining-related damage to water resources", and Halco (Mining) Inc. stated that "CBG is unable to address claims [relating to damage to water sources] of an unsubstantiated nature dating back as far as 1973" (HRW18).

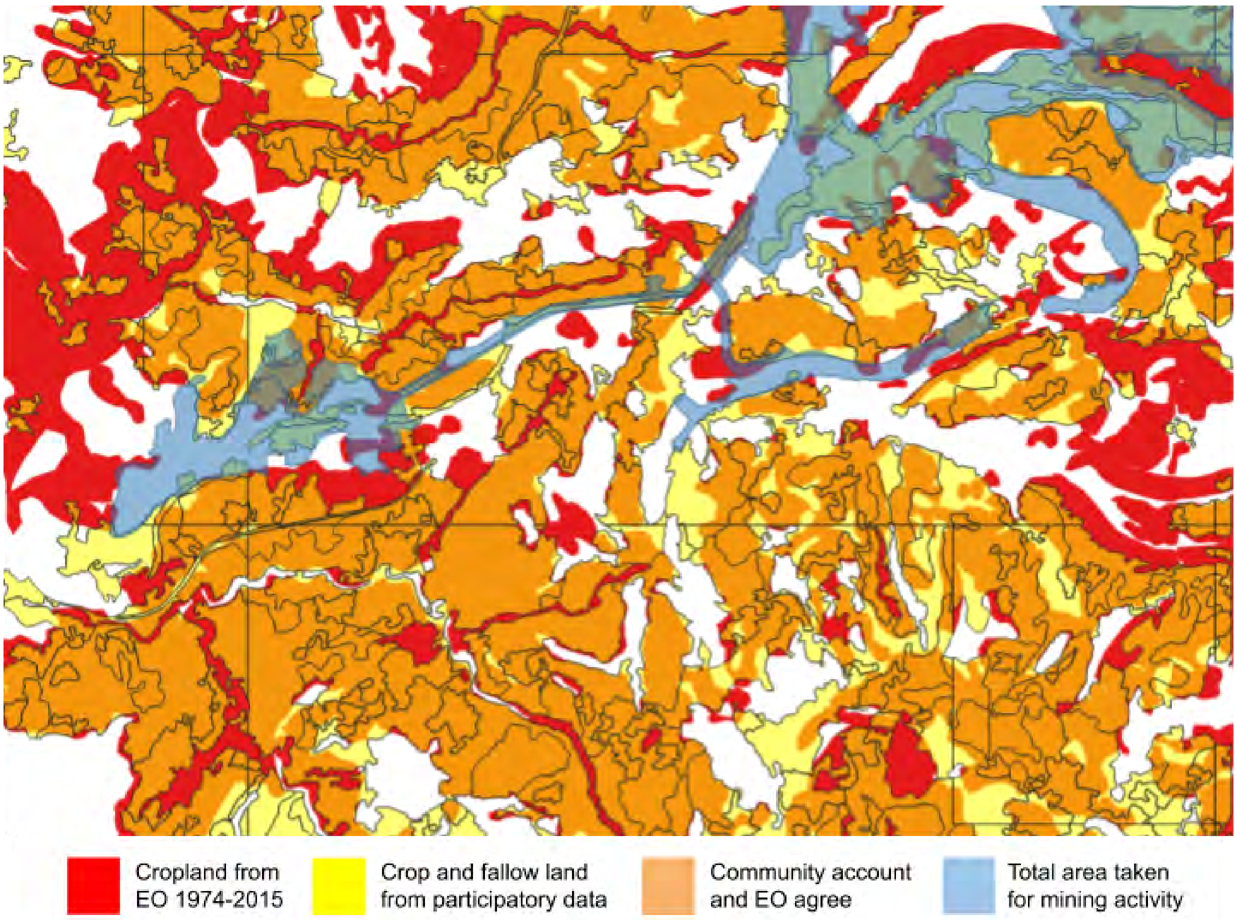


Figure 11. Zone 3 of the Sangaredi mining region. Cropland identified in Landsat images from December-January 1974-2015 is overlaid onto cropland and fallow land reported in the participatory maps. Orange shows agreement between community account and EO data.

Impacts on surface and groundwater was listed as a potential negative effect of the Expansion Project in an annex to the CBG Mine Expansion Project ESIA, “Information Presented During Initial Public Consultation” (see Section 1.3.3) based on suspected reduction of the water retention capacity of the soil.

From data obtained by the IDI team, we have a sample of coordinates of water sources that are reported to have been destroyed or polluted by the mining activity. Many of these are the sources of rivers and tributaries close to the mines and are small and largely obscured by tree cover, preventing direct assessment of the condition of the water source from satellite imagery. Also included are the coordinates for groundwater sources such as wells and boreholes. We have evaluated changes in the Normalised Differential Vegetation Index (NDVI) over time from early stages in the mining development. NDVI relies on the differential absorption between the red and near-infrared wavebands by chlorophyll, producing high values in regions of healthy vegetation (e.g. trees, crops) and low values where it is lacking (e.g. bodies of water, human

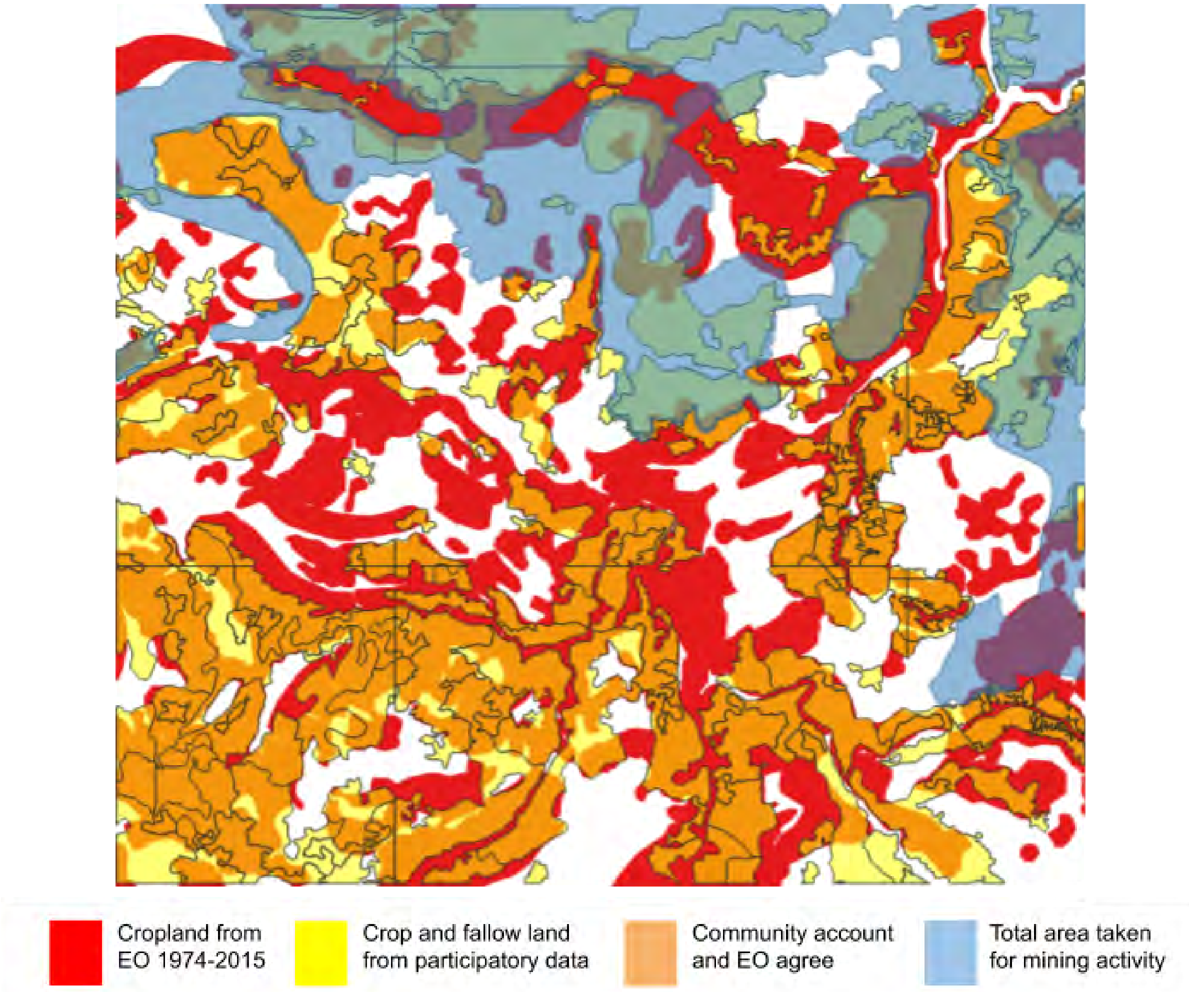


Figure 12. Zone 4 of the Sangaredi mining region. Cropland identified in Landsat images from December-January 1974-2015 is overlaid onto cropland and fallow land reported in the participatory maps. Orange shows agreement between community account and EO data.

infrastructure). In addition to this, vegetation may also change in response to pollutants and/or reduced flow in rivers affected by mining activity[12]. Hence, NDVI variations in the vicinity of these water channels may also be used as a proxy for mine-induced pollution/flow modification.

Measurements of the NDVI are made at the coordinates of impacted water sources reported in the participatory materials. In addition, we measure the NDVI at the coordinates of water sources reported to be intact, providing potential insight into yearly variation in weather, climate conditions, and any effects of climate change in the region, reported by mining companies to be one of the factors contributing to water access problems in the Boké region (HRW18). Water sources in urban areas (e.g. close to Samayabhe) are removed from these samples as they have little to no vegetation nearby. Similarly, we note that vegetation close to water sources within villages could be cultivated or cared for by the community, so NDVI measurements will not indicate the condition of the water source. Measurements are made from Landsat NDVI images (made from bands 3 and 4 of Landsat 4-7 images and bands 4 and 5 of Landsat 8 images). The images used are those taken at the end of the dry season, between mid-March and mid-April to capture seasonal water stress of vegetation. Time series plots are made of the NDVI measurements from water sources in each zone defined in the participatory mapping (see Section 3.2.2).

3.3.1. NDVI trendlines

The NDVI measurements and trendlines are assessed based on the location of the water source, and the mining developments and activity in the nearby environment. Comparison of the NDVI time series for water sources reported to be intact with those for water sources reported to be destroyed or polluted shows very little consistent or significant difference in measurements between the two samples. Across the region the NDVI measurements for some intact water sources appear to be more stable over the study period than those for impacted water sources, producing time series plots with lower scatter. However, where this is the case the intact water sources often lie within villages or nearby (i.e. within ~300m), so this may be an effect of community activity such as vegetation management.

For almost all water source coordinates, the 1993 NDVI measurements are low relative to other measurements. This is the only Landsat 4 observation used for NDVI measurement and the low value could be due to a calibration issue with the image or other instrumental differences. Alternatively, it could indicate a region-wide climate effect. Similarly, a sharp drop in NDVI in 2007 is visible for some of the water sources throughout the region, particularly in Zone 1.

Over the whole region the majority of the NDVI trendlines found at the coordinates of water sources reported in the participatory materials, both intact and impacted, show very little correlation with the surrounding mining activity. The most significant and widespread trend visible over the region is an increase in NDVI from 1986 to 2019. This increase could be due to changes in climate in the region since 1986 resulting in healthier vegetation, or differences between the Landsat satellites (although no clear correlation is seen). Local changes in NDVI at each water source could be masked by the 30m resolution of the Landsat satellites, or vegetation health could be a poor proxy for water source condition in this region (i.e. due to native vegetation root depth or sensitivity to water stress).

Correlation with nearby mining activity is seen in NDVI measurements for some water sources that lie either within or close to mining areas or infrastructure (e.g. roads or rail lines). For these water sources it is possible that the low NDVI values are due to damage of the water source from nearby activity, causing disruption of water availability, and/or clearing of the surrounding vegetation for construction. This is found for 10-15% of water sources reported to be destroyed or polluted, the strongest examples which are shown in Figure 13.

The top right of Figure 13 shows the NDVI time series for a water source close to a mining area that is active from the mid-90s until between 2003 and 2006. Mining is then restarted in the area after 2016. The NDVI measurements at this water source appear to coincide with this activity. The approximate periods of mine activity (determined from Landsat imagery) are marked on the time series plot with red dashed lines (top right of Figure 13).

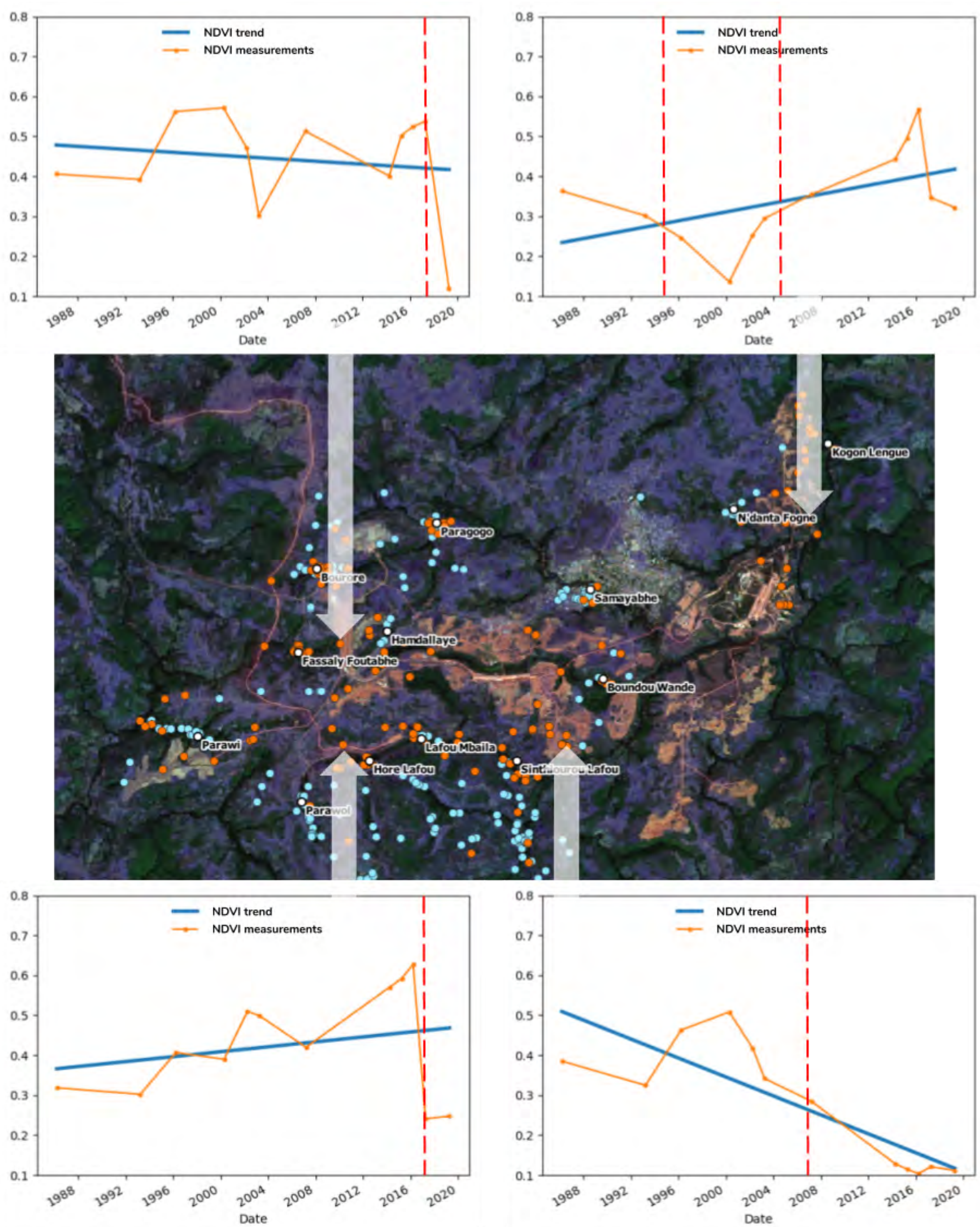


Figure 13. Landsat image of the Sangaredi mining region from December 2019. Water sources reported as intact are shown in blue, water sources reported as destroyed or polluted are shown in orange. Example NDVI time series plots are shown for the water sources indicated by the arrows. On the graphs, orange shows the NDVI measurements, dark blue shows the measurement trendline, and the red dashed lines show mining activity.

A group of water sources within a mine area south of Boundou Wandè show significant changes in trend over the study period (Fig. 13 lower left and lower right): NDVI measurements begin to decrease in the early 2000s (see bottom right of Figure 13). The area is strip-mined from mid-2013, but bauxite survey activities are visible in high resolution imagery from 2007, seen as grid-lines of bare earth. Although we have no later high resolution imagery, we speculate that the change in trend coincides with the start of bauxite surveying.

Further examples are shown in Figure 13 where the NDVI measurements appear to respond to mining activity or infrastructure developments, marked as dotted lines on the NDVI time series. The dotted line in the bottom left of Figure 13 shows the development of rail infrastructure at the water source in 2017, corresponding to a drop in NDVI that does not recover from 2017 to 2019. The top left of Figure 13 shows the construction of the stockpiling facility in 2017 which also appears to cause a sudden drop in NDVI.

3.4. Mobility and water access reduced

Communities have reported that water access and mobility between villages and key local infrastructure (including mosques and schools) has been reduced. In addition to some water sources being destroyed or polluted villagers must now walk great distances around mining works and infrastructure to collect water. Tracks between villages that are destroyed or blocked by mining activity reduce mobility between villages resulting in increased isolation and associated social and community impacts.

The participatory mapping includes the positions of some tracks previously used by communities. The pre-mine expansion tracks identified and mapped in the participatory maps are likely incomplete. The locations of tracks that are within the mining works would be difficult and dangerous to access, making it impossible to map the track location on foot (see Section 1.4 for the participatory mapping methodology). In Section 3.4.1, the available Landsat and high resolution imagery is inspected to identify tracks across the landscape and between villages that have been missed by the participatory mapping. Where the mine footprint has destroyed tracks, mobility between villages and resources has been reduced. Where tracks have not been identified, isolation and impact to resource accessibility will be discussed on a village-by-village basis by assessing the geographical positions of the 13 villages involved in the IFC complaint relative to the mining activity (see Section 3.4.2).

3.4.1. Tracks and paths from EO

The method used does not provide an exhaustive survey of the past and present tracks in the region. This is due in part to the availability of high resolution imagery only beginning in 2007 after much of the mine expansion had occurred. In addition, most of the tracks across the region are narrow and intermittent resulting in them being below the resolution of the Landsat imagery. Therefore, identification focuses on more established tracks that have been active for a number of years (i.e. visible in more than one image), before and after mine developments nearby. The most established tracks can be seen in Landsat imagery, allowing the most valuable routes for community mobility to be identified. High resolution imagery is available via Google Earth Pro for 2007, 2010, 2016, and 2019. An additional high resolution image from Bing maps is accessed via the OpenLayers Plugin for QGIS[2].

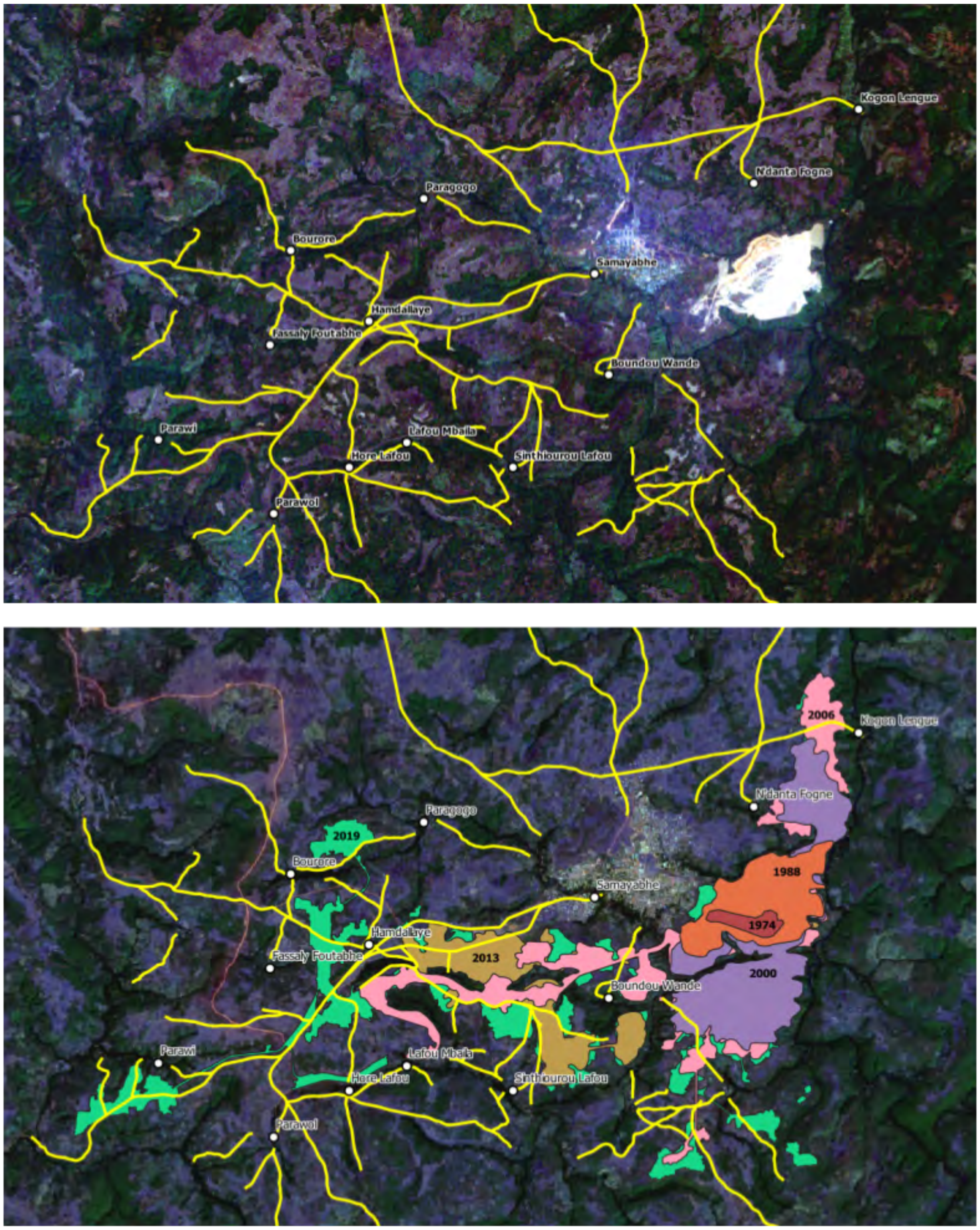


Figure 14. Natural colour Landsat imagery taken in December 1988 (top) and December 2019 (bottom). Tracks identified from Landsat, Sentinel 2, and high resolution imagery before expansion of the mining activity into the area are overlaid in yellow. The positions of the 13 villages involved in the IFC complaint are marked.

[2] Although no date is provided for the image from Bing Maps, comparison with those accessed via Google Earth Pro suggests that this was taken in 2010.

The tracks identified are overlaid onto two images in Figure 14: the top panel shows a Landsat image from December 1988, and the bottom panel shows a Landsat image from December 2019. The mining activity footprints from 1973 to 2019 defined in Section 3.1 are also shown.

3.4.2. Impact on tracks and mobility

The total mining activity footprint is used to show areas where tracks and paths have been directly disrupted by mining activity (Figure 15). The positions of impacted and intact water sources in the region, obtained through participatory mapping and detailed in Section 3.3, are used in the following discussions to show where mining activity has impacted access to water.

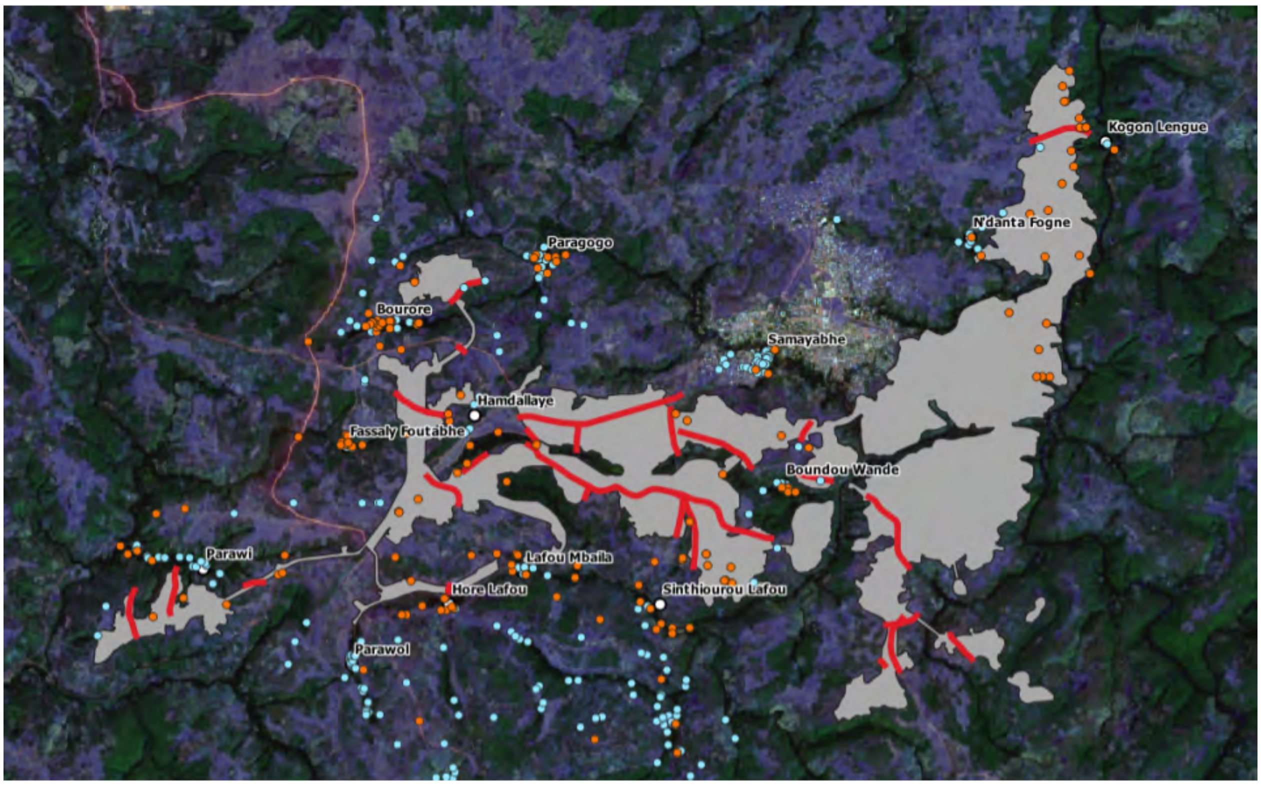


Figure 15. Landsat 8 imagery from December 2019. Overlay shows the total extent of the mine expansion from 1973 to 2019, as derived from Landsat data with resolutions 30-60m. Tracks identified in Section 3.4.1 are shown in red where they are disrupted by the mining activity. Water sources reported as intact are shown in blue, water sources reported as destroyed or polluted are shown in orange.

3.4.2.1. Hamdallaye

As described in Section 3.5.1, the community of Hamdallaye is expected to be imminently relocated following the Resettlement Action Plan (RAP) proposed in October 2015[6]. As of December 2019 the village of Hamdallaye is almost completely surrounded by mining activity and mine infrastructure (see e.g. Figures 3, 4, 15). Construction works at the resettlement site are ongoing and IDI contacts report that the community has not yet been relocated.

Multiple tracks existed between Hamdallaye and surrounding villages prior to the mine expansion. The most established of these was the road from Hamdallaye to the larger town Boulleré to the north-west (Figure 14). This road also enabled travel between Hamdallaye and Fassaly Foutabhè and Bourorè. This road was destroyed in 2017 for construction of the stockpiling facility between Hamdallaye and Fassaly Foutabhè. Around the same time, a new road was developed that is 1.5km longer running north of the stockpiling facility. Tracks visible in imagery from before 2006 run from Hamdallaye east and north-east, towards Samayabhè, Sangaredi, and Boundou Wandè, and south and south-east, towards Sinthiourou Lafou, Lafou Mbaïla and Horè Lafou. These were destroyed between 2006 and 2016 (see Figures 14 and 15) and mining activity is ongoing in these areas. Mobility between Hamdallaye and other villages in the region is likely to be very difficult, limiting access to resources and resulting in isolation of the community. Within the perimeter of the mining activity are 11 reported water sources, four of which are classed as intact in the participatory data (see Figure 15), however it is unknown if this is adequate for the population size.

3.4.2.2. Fassaly Foutabhè

Although not facing relocation, the community of Fassaly Foutabhè have also lost land to the construction of the stockpiling facility. Landsat images from December 2019 show Fassaly Foutabhè surrounded by mining activity and infrastructure including the stockpiling facility, mines, new roads and rail infrastructure (see e.g. Figures 3, 4, 15). A new road joins Fassaly Foutabhè to the Boulleré road (although the safety of this road for pedestrians is unknown), but the road to Hamdallaye and villages further to the east was destroyed by construction of the stockpiling facility (see Section 3.4.2.1). Another road in the direction of Lafou Mbaïla has also been destroyed. Mobility between Fassaly Foutabhè and villages to the north-east, east, and south-east appears restricted due to the mining activity (see Figures 14 and 15). Two intact water sources are reported close to the village with other sources around 1.5km away. Eight water sources close to the village are reported destroyed or polluted.

3.4.2.3. Boundou Wandè

With the destruction of tracks between Boundou Wandè and the villages to the north and the expansion of extensive mining activity close to the village, Boundou Wandè appears largely isolated (see Figures 14 and 15). Within 0.5km of the centre of the village there are 11 water sources reported, four of which are classified as destroyed or polluted (orange points in Figure 15). We note that all but one of the intact water sources (blue points in Figure 15) are observed to be seasonal or dry to two months of the year.

3.4.2.4. Kogon Lengué

Mining activity was expanded close to Kogon Lengué between the late 90s and around 2007 (see Figures 3 and 4). The road connecting Kogon Lengué with the nearest village, N'danta Fognè, and the villages to the west and north was destroyed during this development, severely affecting mobility (Figure 15). These mines appear to fall out of use and rehabilitation efforts are visible in the area from around 2011 to 2016. From late 2016 the area is re-exploited for mining. New roads appear to have been constructed during these periods but their accessibility to the community is not known. The majority of water sources reported in the area are classified as destroyed or polluted (see Figure 15). One intact water source is reported within the village and another about 1.5km away, although access to this water source by the newly constructed roads is not known.

3.4.2.5. N'danta Fognè

N'danta Fognè is reported to have been relocated in 1986 due to CBG developments disrupting the community water supply. Although the original location of N'danta Fognè is unclear, Landsat imagery shows mining activity before 1986 was in an area east of Sangaredi (see Figures 3 and 4). The mining activity was expanded north close to the new location N'danta Fognè from the late 90s. As described in Section 3.4.2.4, access to neighbouring village Kogon Lengué is restricted by destruction of the road by the mine expansion, and mobility to the north and east of N'danta Fognè appears to be maintained (see Figure 15). Six intact water sources are reported within 0.5km of N'danta Fognè, two of which are within the village. This may be sufficient to supply a village of this size but a number of settlements are visible close to N'danta Fognè which may cause increased pressure on the water sources available.

3.4.2.6. Bourorè

As discussed in Section 3.3.1, mining activity expands close to Bourorè from 2016. This destroys the road between Boulleré and Hamdallaye that also serves Bourorè (see sections 3.4.2.1 and 3.4.2.2), and the road between Bourorè and Paragögö, also restricting travel between Paragögö and Boulleré (see Figures 14 and 15). A number of water sources close to Bourorè are reported to be destroyed including eight within the town. Seven intact water sources are reported between 0.2km and 1km away from the village centre.

3.4.2.7. Samayabhè

Samayabhè is a large village close to Sangaredi and has experienced close-by mining activity from 2006, with nearby roadways developed before 1973, (see Figures 3 and 4). Disruption and redirection of these roadways is visible in Landsat imagery since 2006 (see Figure 14), during development and expansion of the mines to the west of Samayabhè. Tracks facilitating mobility south of Samayabhè were also destroyed during mine developments after 2006, disrupting travel between Samayabhè and Boundou Wandè and villages further to the south. A large number of intact water sources are reported within Samayabhè and few reported to be destroyed or polluted.

3.4.2.8. Paragögö

As described in Section 3.4.2.6., travel between Paragögö and it's closest neighboring village Bourore was disrupted in 2019 due to destruction of the road for mine development (see Figure 14). The majority of the water sources in and close to Paragögö are reported to be intact.

3.4.2.9. Parawi

The rail and road ways that were constructed before 1973 to serve the Sangaredi bauxite mine pass Parawi to the south. The first impact reported by the community of Parawi is related to this development. Between 1973 and 2016 very little additional impact from the mining activity is visible, apart from bauxite survey activities (see Figure 4). The pattern of grid-lines of bare earth, characteristic of bauxite survey in the region, is visible in an area to the north of the village in Sentinel 2 and high resolution imagery from 2015. High resolution imagery from 2004 shows some signs of this in an area to the south of the village. This southern area is surveyed extensively in 2016 and 2017 and strip-mined in 2018 and 2019 (see Figure 4). This destroyed the tracks that connected Parawi, and other settlements along the Parawi valley, with the road (Figure 15). 10 water sources are reported within 0.5km of Parawi in the participatory data, lying along the valley. Note: the position of Parawi used here is not consistent with that in the participatory data, see Section 2.2.

3.4.2.10. Parawol

Impact on Parawol from the Sangaredi mine developments began before 1973 with construction of the train line from Sangaredi to the port in Kasmar, passing close to the village. Further developments to the rail infrastructure occurred in 2016 around 1.5km away (see e.g. Figure 4). Nearby activity to the NE of the village is visible in high resolution imagery, which shows bauxite surveying occurring prior to 2007. Tracks identified from Parawol appear largely intact and travel to the nearest villages is likely to be mostly unaffected by mining in the region since 1973 (see Figure 14). The participatory materials include 15 water sources within 0.5km of Parawol, 12 within the village. One of these is reported to be destroyed or polluted.

3.4.2.11. Horè Lafou

Horè Lafou lies along the rail line between Sangaredi and the port in Kasmar, constructed before mining activity began in the region in 1973. Similar to the impact experienced by neighbouring Parawol village, areas close-by are surveyed for bauxite some time before 2007. No other mining activity is visible within 2km until 2016 when infrastructure for the rail line is constructed within 0.5km to the north (see e.g. Figure 4). This has destroyed a track north from Horè Lafou. If it is not possible or not safe to cross the rail infrastructure the community must now travel an additional 1.5km either east or west to go around, restricting mobility (Figure 15). Only one of the nearby water sources is reported to be intact. This is likely insufficient to support the village so the community will rely on water sources a kilometre away or those in Parawol and Lafou Mbaïla (distances of around 1.5km to 2.5km, see Figure 15).

3.4.2.12. Lafou Mbaïla

The impact to Lafou Mbaïla is similar to that experienced by Parawol and Horè Lafou. Lafou Mbaïla also lies close to the rail line developed before 1973. Some bauxite survey activities are visible to the north from 2010 and further development of the rail infrastructure occurred 0.5km to the west in 2016 (see Figure 4). Mobility between Lafou Mbaïla and the closest neighbouring villages appears unaffected and access to areas north of the rail line appears intact for around 2km up to the extensive mining activity to the north (see Figure 15). 12 water sources are reported within 0.5km of the village, with 6 out of 7 intact sources close to the centre. Demand on these water sources may be increased due to the limited water resources reported for the community of neighbouring Horè Lafou.

3.4.2.13. Sinthiourou Lafou

Sinthiourou Lafou is situated along the rail line between Sangaredi and Kasmar, constructed before 1973, to the east of Lafou Mbaïla and Horè Lafou. Strip-mining had been expanded to within 1km of the settlement by the end of 2013 (see Figure 4). Expansion of mining activity between 2006 and 2015 destroyed many of the tracks in the area to the north of Sinthiourou Lafou, including tracks serving the village (Figure 15). Mobility between Sinthiourou Lafou and villages to the west (e.g. Lafou Mbaïla and Horè Lafou) appears unchanged by the mining activity but areas towards the north and north-east are likely to be inaccessible. Many of the water sources within 1km of the village are reported to be impacted or destroyed. All of the nearest water sources are across the rail line from Sinthiourou Lafou and only two are within 0.5km (see Figure 15).

3.5. Land rehabilitation

Some areas of the mine footprint appear to have been rehabilitated after exploitation for bauxite strip-mining. This is consistent with claims made by CBG regarding land rehabilitation plans (see e.g. HRW18), and with reports from local communities found in HRW18 and the participatory mapping data. Full rehabilitation would require the top soil to be replaced and vegetation native to the area replanted. The rehabilitation methods used by CBG are not known

Figure 16. Examples of suspected rehabilitation efforts by CBG in areas previously mined. Mining in these regions is visible between 1973 and 2003 and appears to have ended between 2003 and 2006. Rehabilitation appears to have been performed from around 2006 to 2016.

and some areas could be rehabilitated using methods that cannot be confirmed from satellite imagery alone. Similarly, areas of vegetation that have not thrived due to environmental conditions and/or plant species may mask rehabilitation efforts. Rehabilitation is clear from satellite imagery when the method used results in a grid pattern in new vegetation. These areas are identified from high resolution imagery in the regions first mined between 1973 and 2003. Examples of these areas visible in high resolution images are shown in Figure 16.

Figure 17 shows the approximate areas of bauxite mines that appear to have been rehabilitated some time between 2006 and 2016: these are overlaid onto Sentinel 2 images taken in December 2016 (left hand panel), and December 2019 (right hand panel). The area of suspected rehabilitated land is estimated to be approximately 10-12% of the total mining activity footprint area (see Section 3.1).

Reports from members of the community of Kogon Lengué, found in HRW18, claim that these rehabilitated areas, often planted with cashew trees, are not returned to the community or previous owners. Interviews in HRW18 conducted with CBG personnel report that these areas have not been returned to the villagers to allow CBG to return to re-exploit the area. The right hand panel of Figure 17 shows the approximate area of the rehabilitated areas identified from satellite imagery overlaid onto a Sentinel 2 image from December 2019, showing the return of mining activity to areas that have been rehabilitated.

Figure 17. The approximate areas of bauxite mines that appear to have been rehabilitated some time between 2003 and 2016 are shown in blue overlaid onto Sentinel 2 images taken on 13-12-2016 (left) and 03-13-2019 (right).

3.5.1. New Hamdallaye

As mentioned earlier, the community of Hamdallaye will soon be relocated to a previously mined site. Part of the work performed by EEM in preparation for the Expansion Project (see Sections 1.3.3 and 3.5.1) was a Resettlement Action Plan (RAP)[6] for the communities of Hamdallaye and Fassaly Foutahbè, dated October 2015. This document includes a proposed site for resettlement within the mining activity footprint and actions for site preparation. A second document, produced by CBG in January 2018[13], presents updates on the status of the resettlement plan and preparation of the site. Figure 18 is a diagram, taken from this resettlement document, showing the planned site. The diagram shows the northern area marked for housing development and the southern area to be prepared for agriculture. The resettlement site is estimated to be around 1.2sqkm and the area marked for agriculture around 40-50sqkm. A status update in the text reports that mining on the site ended in May 2016 and, as of January 2018, the northern area had been leveled for housing construction and that "Topsoil stockpiled prior to mining activities will be spread back onto dedicated areas planned for agriculture and livelihood restoration programs south of the built areas". This seems to state that less than half of the resettlement site is planned for full rehabilitation.

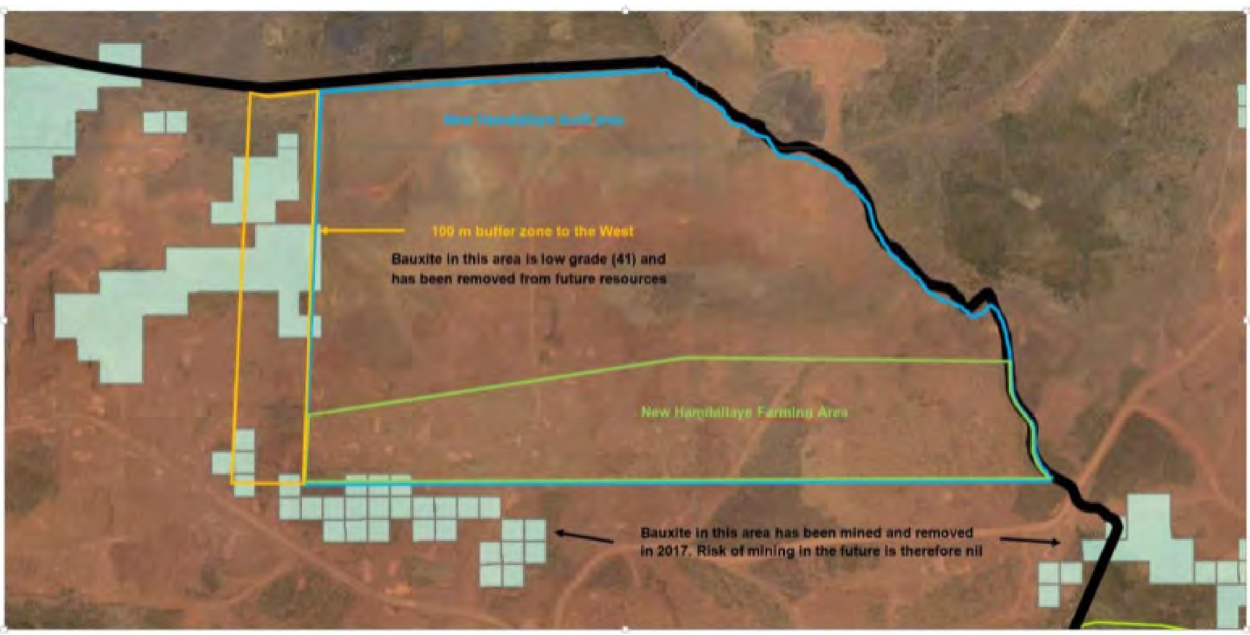


Figure 18. The approximate area marked in CBG materials as New Hamdallaye, the resettlement site for the communities of Hamdallaye and Fassaly Foutabhè, shown in red on Google Earth Pro images dated 24-01-2016 (left) and 30-10-2019 (right).

Sentinel 2 imagery and high resolution imagery is used to survey the New Hamdallaye resettlement site between 2015 and present day to assess any visible rehabilitation activities or construction. Figure 19 shows the resettlement site in Sentinel 2 imagery taken on 29-11-2015 (top left), 13-12-2016 (top right), 03-12-2018 (bottom left), and 03-12-2019 (bottom right).

The approximate boundary of the site is overlaid in red, drawn by hand following that defined in CBG materials (shown in Figure 18). Roads and buildings are visible in the images taken in 2018 and 2019, construction of which appears to have begun in February 2018, based on further Sentinel 2 data viewed using EO Browser. Survey of Sentinel 2 imagery via EO Browser also indicates that leveling of the northern section of the site occurred during November 2016. Comparison of the colour of the bare earth between mined and leveled ground in the 13-12-2016 image (top right of Figure 19) suggests that top-soil may have been returned to the northernmost mine in the resettlement site. In the images from 2018 and 2019 (bottom panels of Figure 19) some areas of vegetation appear to have developed close to the centre of the site but no rehabilitation of the southern areas is visible. The resettlement plan update document from CBG, dated January 2018, refers to future rehabilitation planned for the southern area: very little difference is visible in the southern area of the site in Sentinel 2 imagery from 2018 and 2019 (bottom panels of Figure 19) confirming that this has not yet been done.

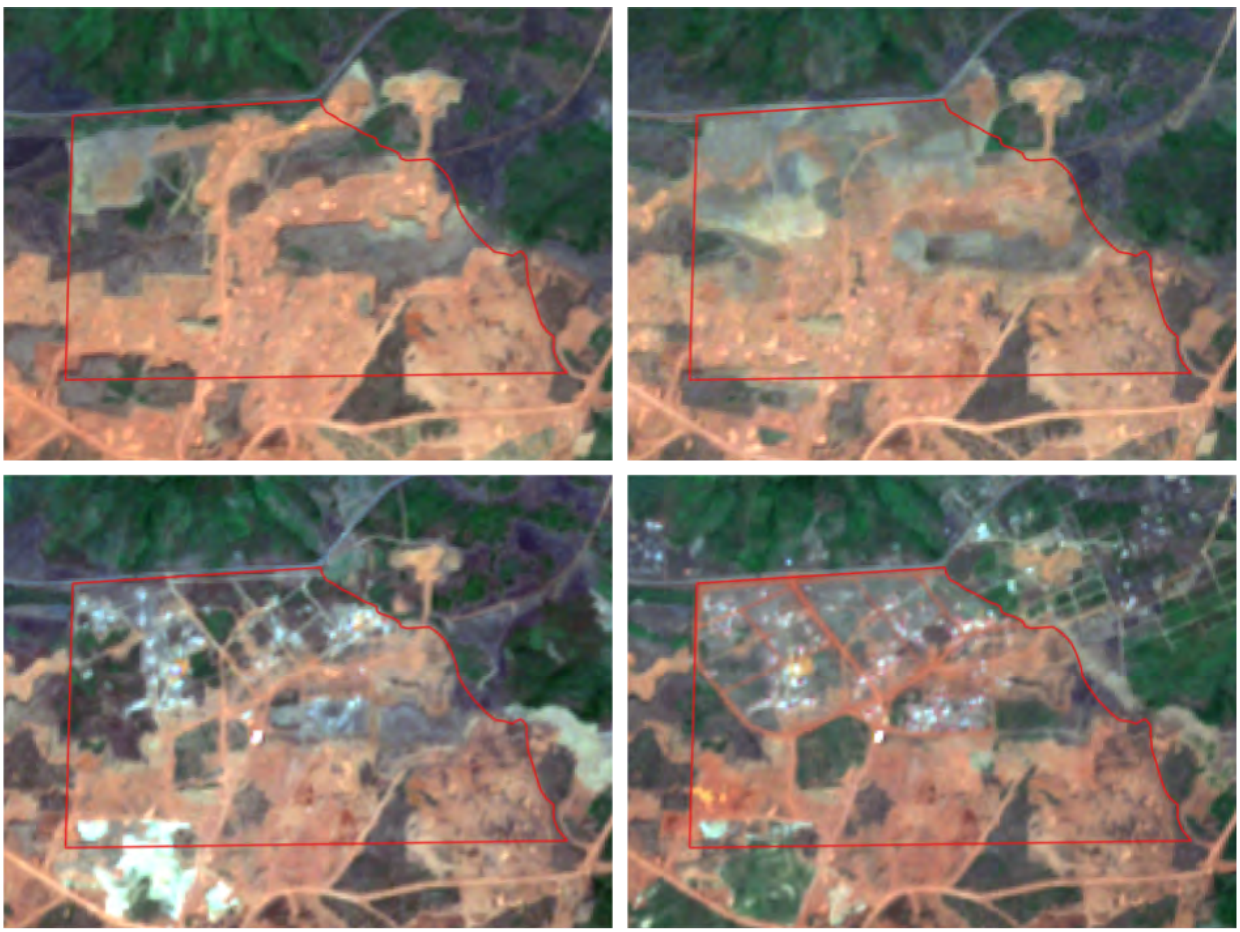


Figure 19. Sentinel 2 imagery of the resettlement site referred to as New Hamdallaye. Images shown were taken on 29-11-2015 (top left), 13-12-2016 (top right), 03-12-2018 (bottom left), and 03-12-2019 (bottom right).

This is supported by comparing high resolution imagery (from Google Earth Pro) between 2016 and 2019. These high resolution images are shown in Figure 20, with the approximate site boundary drawn by hand and overlaid in red. High resolution imagery confirms that mining has ceased since 2016, however it is not clear if top-soil has been returned to the southern areas of the site, as little vegetation has grown since. The most recent high resolution image, taken on 30-11-2019[3] (right of Figure 20), shows housing still under construction and it is not known to Omanos when the resettlement is due to occur.

Not visible in either Sentinel 2 imagery or high resolution imagery are water resources available at the site. Pools of surface water are visible in imagery from 2019 but this is likely from the recently-ended wet season. The resettlement plan update document from CBG claims that two bore holes were drilled in November 2017 and the water found to be good drinking-water quality in quantities sufficient to support the future inhabitants of the site. The resettlement plan update document also claims that ground and surface water at the site will be monitored monthly for the duration of the mining activities.

Figure 20. The approximate area marked in CBG materials as New Hamdallaye, the resettlement site for the communities of Hamdallaye and Fassaly Foutabhè, shown in red on Google Earth Pro images dated 24-01-2016 (left) and 30-10-2019 (right).

[3] The high resolution imagery from Google Earth Pro is a mosaic of images from different dates and instruments. The image shown in the right panel of Figure 20 shows imagery dated 30-11-2019 but the top left hand corner shows imagery dated 24-01-2016.

4. Summary

We have conducted an analysis of satellite imagery of the Sangaredi mining region in Boke, Guinea to provide an objective assessment of the impacts of bauxite mining on the local communities living close to the mining activity. This analysis was requested and performed in partnership with IDI and their consultants, who are supporting 13 of these communities in mediation procedures following submission of a complaint to the CAO against the IFC for financial support of CBG mining activities. The complaint details social and environmental harms including loss of lands, livelihoods, and resources. The satellite data analysis aims to show the change in land use since CBG began operations in 1973, the footprint of the impacted region over time, and provide independent verification of claims made by the local communities. This will be used in the mediation process alongside participatory data collected by IDI consultants, on-the-ground contacts, and community representatives.

Landsat imagery from 1974 to 2019 is used to define mining activity footprints over the period of CBG operations. Footprints are defined from seven images during mining development to represent the progression of activity and its impact on the region. This is used to show valuable cropland lost due to the mining activity. Cropland is identified from all available cloud-free Landsat images taken in December-January by comparing areas of cropland visible in high resolution images with Landsat images from the same month. December-January data is used as this is the start of the dry season, increasing the number of cloud-free images that are available whilst vegetation is still healthy enough to be easily distinguishable from cropland. We have used all available cloud-free images of the cropland to provide as complete a description as possible, necessary because of the crop-cycling practices used by the communities. The cropland identified from satellite imagery is compared to the areas labelled as cropland during the participatory mapping process, based on community accounts. Good agreement is found between these in most areas of the study region (see Figures 9 to 12). In some areas cropland has been identified in satellite imagery where the land is not classed as either crops or fallow land in the participatory data. We expect that this may be due, in part, to the length of the study period: cropland is identified from 1974 and perfect community recollection is unlikely over 45+ years. In addition, not all of the villages in the region are involved in the complaints process, and not all of the communities with land in the region will have contributed to the participatory data collection process.

The complaint to the IFC includes reports from the local communities of water sources being destroyed or polluted by CBG mining activities. Included in the participatory process are the coordinates of these water sources along with water sources that are classed as intact. These surface and groundwater sources are small and largely obscured by trees, making direct assessment via EO data difficult. We have made measurements of the NDVI of vegetation at the coordinates of these water sources as an indicator of vegetation health and therefore a proxy for the condition of the water source. Landsat imagery from 1986 to 2019, with 30m resolution, taken during the end of the dry season (mid-March to mid-April) is used to produce

NDVI time series which are evaluated based on water source location and nearby environment. Over the region, for both impacted and intact water sources, little correlation is seen between NDVI trendlines and the mining developments. Some correlation is seen when mining activity directly disrupts the vegetation at a water source coordinate, but clearing of vegetation for construction hides any decrease in vegetation health due to water availability. A widespread but weak trend in NDVI with time is also evident for many water sources throughout the region. We speculate that this could be a regional climate effect between 1986 and 2019, or due to satellite specific wavelength sensitivities (however, no correlation is visible between Landsat satellites). These inconclusive results could be due to local NDVI changes not being visible at 30m resolution or due to the health of native vegetation providing a poor proxy for changes in water condition and availability.

The communities of the villages involved in the IFC complaint have reported that mining developments have disrupted water access and mobility between villages and local infrastructure. Tracks and paths have been destroyed meaning villagers must walk great distances around mining works. Landsat, Sentinel 2 and high resolution imagery has been evaluated for tracks across the landscape that existed before mining activity expanded into the area. Due to the availability of high resolution imagery before 2006, and the appearance of narrow pedestrian tracks (with seasonal contrast against the landscape), this provides an incomplete survey of the tracks used by the local communities. The analysis has focused on the impact of mining activity on established tracks that are visible in more than one satellite image (i.e. used for a number of years). The tracks destroyed by the mining activity and the coordinates for intact water sources close to the villages have been assessed relative to the locations of villages involved in the complaints process. We expect that all of the 13 villages have had their mobility affected by the mining activity to some degree, with some likely becoming almost completely isolated (such as Hamdallaye and Boundou Wandè). The mining activity has destroyed long sections of established tracks and roads and blocked large areas of the land between the villages. Most of the villages are found to have access to more than one intact water source within the village which may be sufficient depending on the capacity of the water sources. However, some villages have reported only one intact water source. In particular, Kogon Lengué has one intact water source within the village with all other water sources within 1.5km classified as impacted. If this is not sufficient to supply the whole village the inhabitants would have to cross CBG mines and rehabilitated land. Similarly, the community of Horè Lafou would need to travel over 1km to the nearest village, Lafou Mbaïla, if their single intact water source is insufficient. Boundou Wande reports six intact water sources within the village but note that all but one of these are seasonal or dry for two months of the year. In addition, villages neighbouring those with limited water resources are likely to experience increased demand for their own supplies.

We have investigated claims made by CBG, and reports from the local communities, of rehabilitation of disused mines by CBG. Using high resolution imagery we have identified all areas that appear to have had some form of rehabilitation after 2006. The total rehabilitated area is found to be around 10-12% of the total mining footprint. However, imagery from 2016 shows large sections of these areas have been re-exploited for mining. Further rehabilitation is expected to be taking place at the resettlement site for the community of Hamdallaye village, along with construction of housing. Materials from CBG detail plans for the resettlement site including plans to replace the topsoil in the area set aside for agriculture, which is less than half of the resettlement site. It is unknown if other areas of the site will be rehabilitated e.g. to allow for gardens in the build area. Sentinel 2 imagery is used to monitor progress at the resettlement site from the end of mining works (reported to be May 2016 by CBG) to December 2019. Developments at the resettlement site appear consistent with the plans produced by CBG, although, as of December 2019, little to no rehabilitation is visible in the area set aside for agriculture. Relocation is reported to be “imminent” but it is not known when this is expected to occur.

5. References

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6. Appendices

6.1. Appendix 1: Key actors and stakeholders

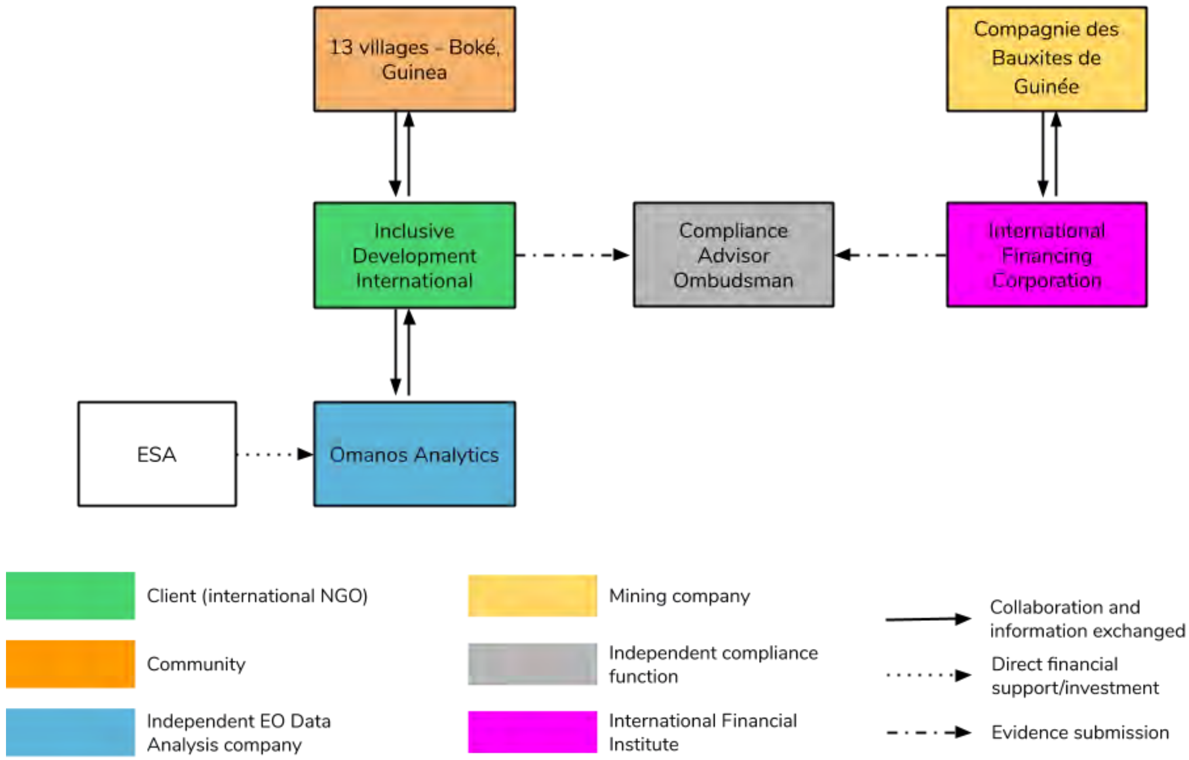

Figure A1.1. Actor map Illustrating the key actors and stakeholders involved in the mediation and dispute resolution procedure.

6.1.1. IDI and partners

6.1.1.1. Key contacts

Omanos has two primary contacts with IDI: a human rights lawyer and the co-founder and legal director of IDI. She has been a key contact on past work between Omanos Analytics and IDI. Our second primary contact works closely with the community representatives and on-the-ground contacts in Boké. They are leading collection of evidence in preparation for the mediation process, and have requested satellite data analysis of the region to show the impact of CBG operations.

6.1.1.2. Consultants

A UK-based GIS consultant is working closely with IDI and consultants to construct participatory maps from community data and collate all existing information on the Sangaredi mining region, including existing reports, CBG materials and GIS information obtained by Human Rights Watch in 2017.

A GIS and remote sensing consultant based in Guinea has worked with community representatives to provide supporting information. A brief description of the methodology employed to obtain the data needed for the participatory maps is provided by the independent consultants and given in Section 1.3.1.

6.1.2. Human Rights Watch

Human Rights Watch (HRW) has investigated the bauxite mining practices of large mining companies in the Boké region in Guinea to assess the impacts reported by the local communities close to the mining activities. Further details of this work, which includes GIS data and interviews with villagers, government officials, environmental scientists and mining company representatives. This work is presented in the report "What do we get out of it?", dated October 2018[5].

6.1.3. Community representatives

Members of the 13 local communities involved in the complaint to the IFC are assisting IDI and consultants with their investigations of the impact the mining activity has had on their lives and local environment, including by facilitating participatory data collection.

6.1.4. Compagnie des Bauxites de Guinée (CBG)

CBG, jointly owned by the Government of Guinea (49%) and by Halco Mining Inc. (51%), was formed in 1963 and began mining operations in the Sangaredi region in 1973. The current expansion project was started in 2016 and is supported by an IFC loan. In accordance with the terms of this loan CBG introduced new environmental and social policies to meet IFC Performance Standards. Many of the complaints submitted claim that CBG are in violation of these Performance Standards. Further details are included in Section 1.

6.1.5. International Finance Corporation (IFC)

The World Bank's private-sector arm, the International Finance Corporation (IFC, World Bank Group) provides funding for large-scale development to encourage private-sector development in developing countries. Financial support of development projects is granted under the condition that activities comply with the IFC Performance Standards which establish requirements for environmental and social sustainability. The IFC is providing a loan up to $200 million to CBG for expansion of the Sangaredi bauxite mine, processing facilities and infrastructure (IFC, CBG Expansion, Summary of Investment Information).

6.1.6. Office of the Compliance Advisor Ombudsman (CAO)

The CAO is the independent accountability mechanism for projects supported by the IFC. The CAO provides a mechanism to address complaints related to IFC-funded projects and assist compliance with social and environmental obligations. The IFC complaint letter, submitted to the CAO, was ruled eligible for assessment, beginning a dispute resolution process.

6.2. Appendix 2: Village coordinates

Village name	IDI coordinates	CBG coordinates	Comments
Hamdallaye	11.08274 -13.8834	11.08555 -13.8818	Moderate difference in position, both visibly within the village.
Fassaly Foutabhè	11.07923 -13.9079	11.07925 -13.908	Very little difference between IDI and CBG coordinates.
Boundou Wandè	11.07163 -13.8189	11.0713 -13.8182	Small position difference between CBG and IDI sources.
Kogon Lengué	11.14142 -13.7519	11.14178 -13.7519	Very little difference between IDI and CBG coordinates.
N'danta Fognè Ndanta Fongne	11.12172 -13.779	11.12215 -13.7797	Small position difference between CBG and IDI sources.
Bourorè	11.10533 -13.9035	11.1044 -13.9025	Moderate difference in position, both visibly within the village.
Samayabhè Samayaghe Samayabe	11.09813 -13.822		No coordinate found in CBG materials. IDI coordinate used.
Paragögö	11.11753 -13.8659	11.11807 -13.8673	Moderate difference in position, both visibly within the village.
Parawi	11.04488 -13.9446	11.05405 -13.9377	Large difference between coordinates. CBG coordinate used as close to a village.
Parawol	11.03551 -13.9072	11.03437 -13.907	Small position difference between CBG and IDI sources.
Sinthiourou Lafou Sintiourou Lafou	11.04674 -13.8436		No coordinate found in CBG materials. IDI coordinate used.
Lafou Mbaïla	11.05433 -13.8735	11.05331 -13.8718	Moderate difference in position either side of a river. CBG coordinate at largest group of buildings.
Horè Lafou	11.04749 -13.8875	11.04675 -13.887	Small position difference between CBG and IDI sources.

6.3. Appendix 3: Land concessions

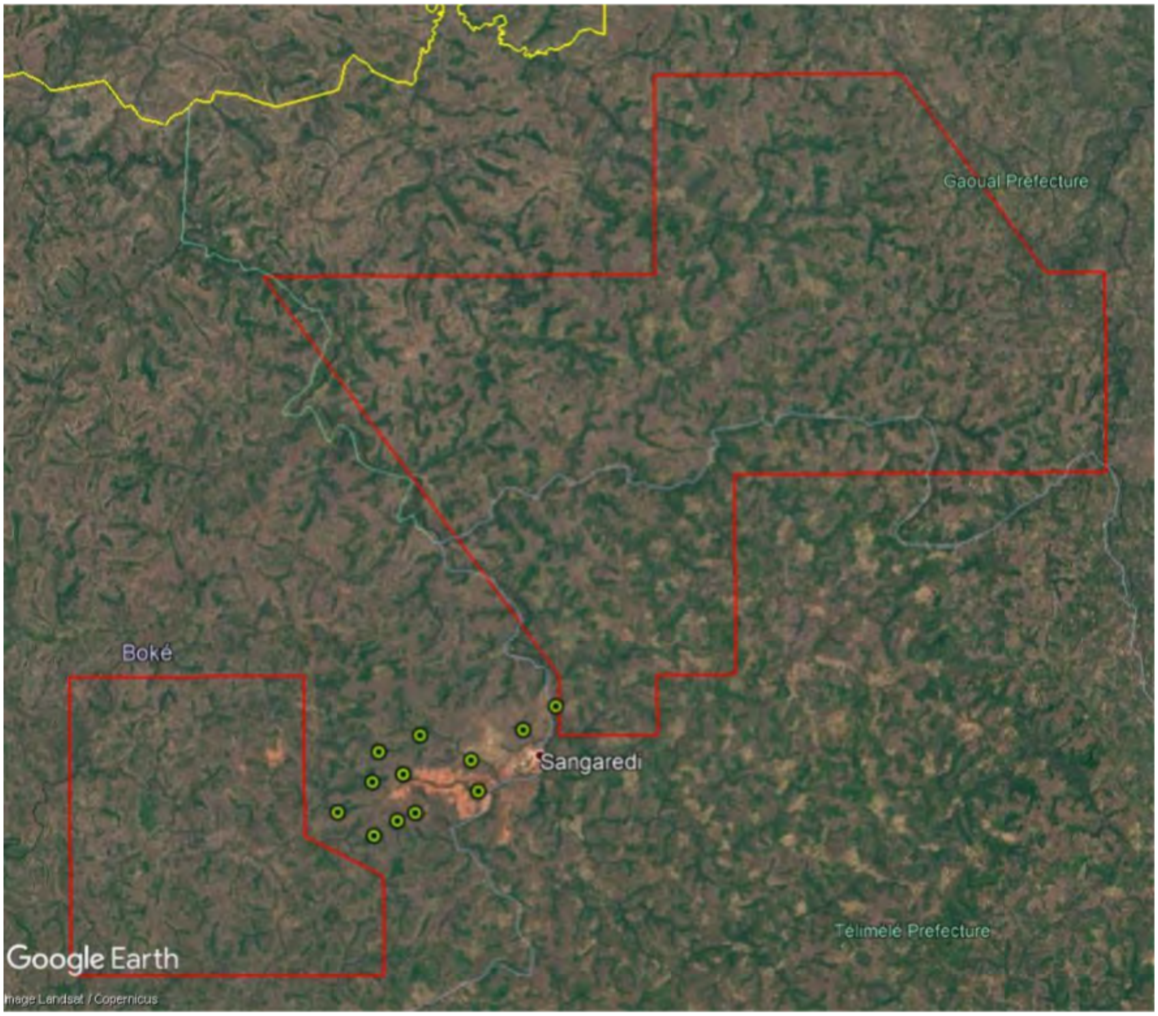

Figure A3.1. Landsat image accessed via Google Earth Pro showing The Sangaredi mining region in the primary CBG land concession. The red outlines show the boundaries of further concessions granted to CBG in 2006.

6.4. Appendix 4: Crop identification in Landsat - further examples

This appendix gives further examples of comparison of cropland identified in high resolution imagery with Landsat imagery taken close in time, following the example given in Section 3.2.1. Areas of cropland are shown in a high resolution image from Google Earth Pro, dated 03-12-2010, in the top panel of Figures A4.1 to A4.3. The same area is shown in a Landsat image, taken on 28-11-2010, in the bottom panel. As in Section 3.2.1, the Landsat data is displayed in false colour to highlight vegetation and mining activity. The agricultural land in the false colour Landsat image is visible as a pale-red to pink, often close to waterways.

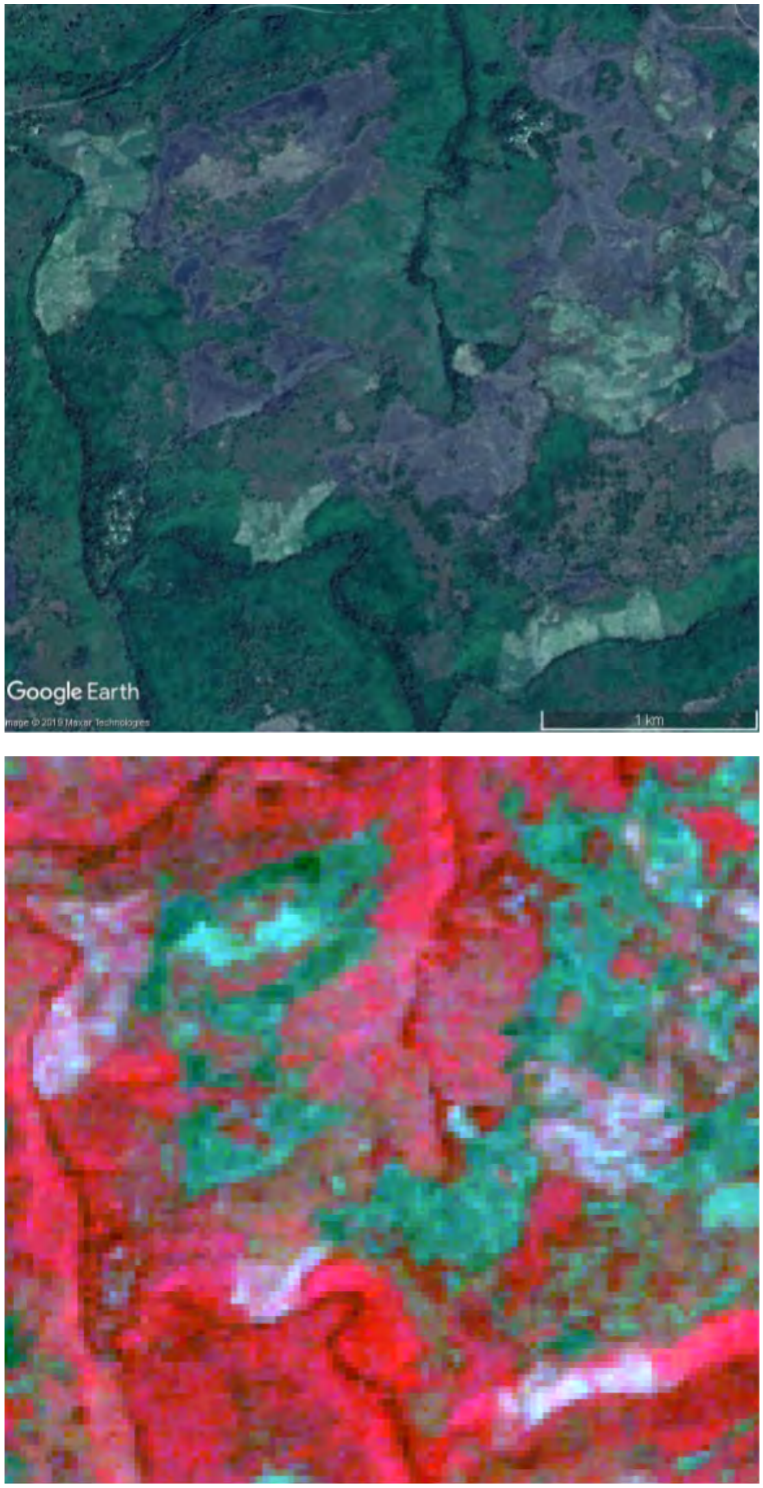

Figure A4.1. Example of cropland shown at high resolution (top panel) and 30m resolution in Landsat 5 image (bottom panel). These are dated 03-12-2010 and 28-11-2010, respectively.

Figure A4.2. Example of cropland shown at high resolution (top panel) and 30m resolution in Landsat 5 image (bottom panel). These are dated 03-12-2010 and 28-11-2010, respectively.

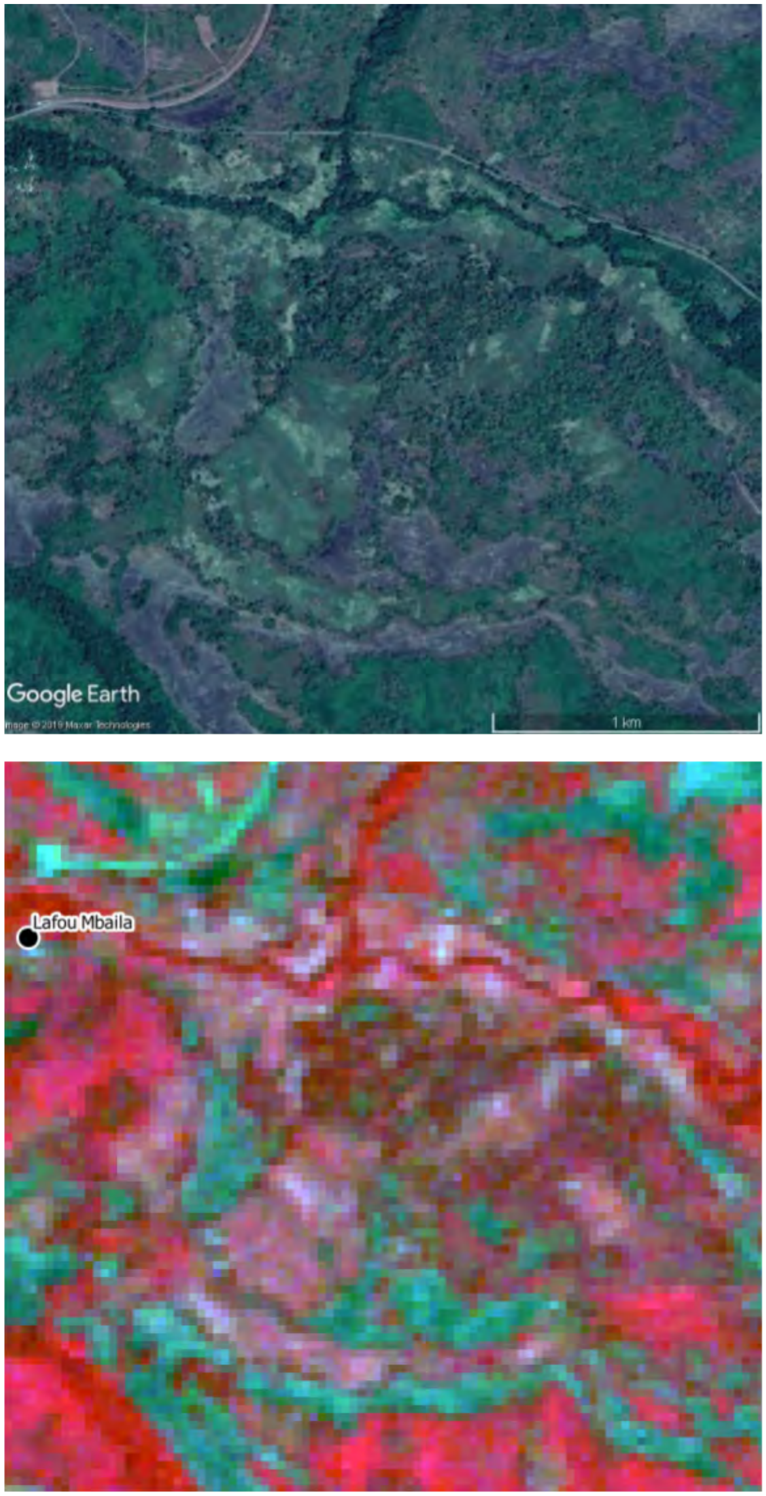

Figure A4.3. Example of cropland shown at high resolution (top panel) and 30m resolution in Landsat 5 image (bottom panel). These are dated 03-12-2010 and 28-11-2010, respectively.

6.5. Appendix 5: Crop rotation

Figure A5.1 shows imagery from January 2010 (top panel) and December 2010 (bottom panel). These represent two separate crop seasons, one planted in 2009 and the following planted in 2010. Crop rotation practices are visible by comparing the cropland between the two images, 2009 crops are marked by yellow rectangles and 2010 crops are marked by green rectangles.

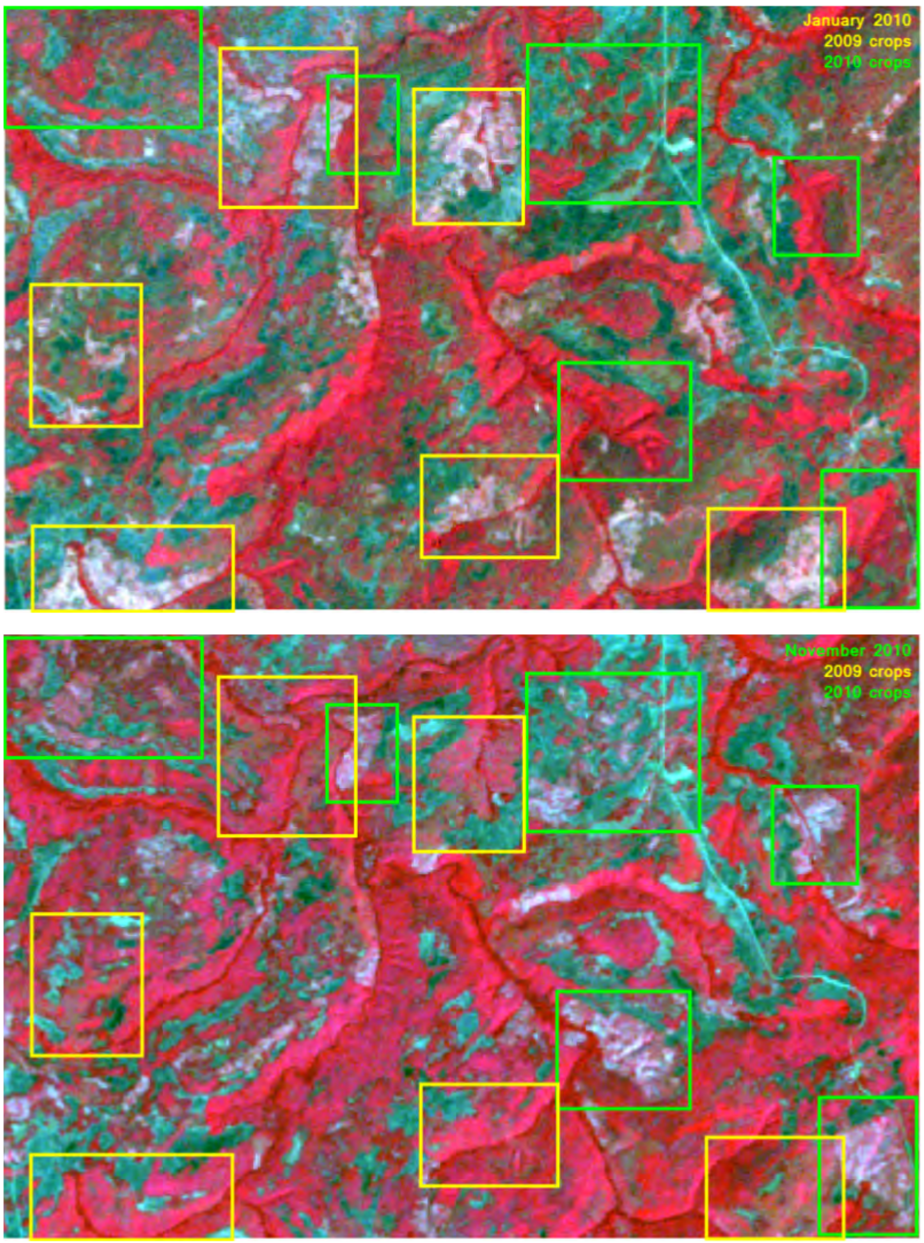

Figure A5.1. Crop rotation between 2009 and 2010. Farmed land visible in January 2010 Landsat imagery (top panel) is marked with yellow rectangles whereas farmed land visible in December 2010 Landsat imagery (bottom panel) is marked with green rectangles.