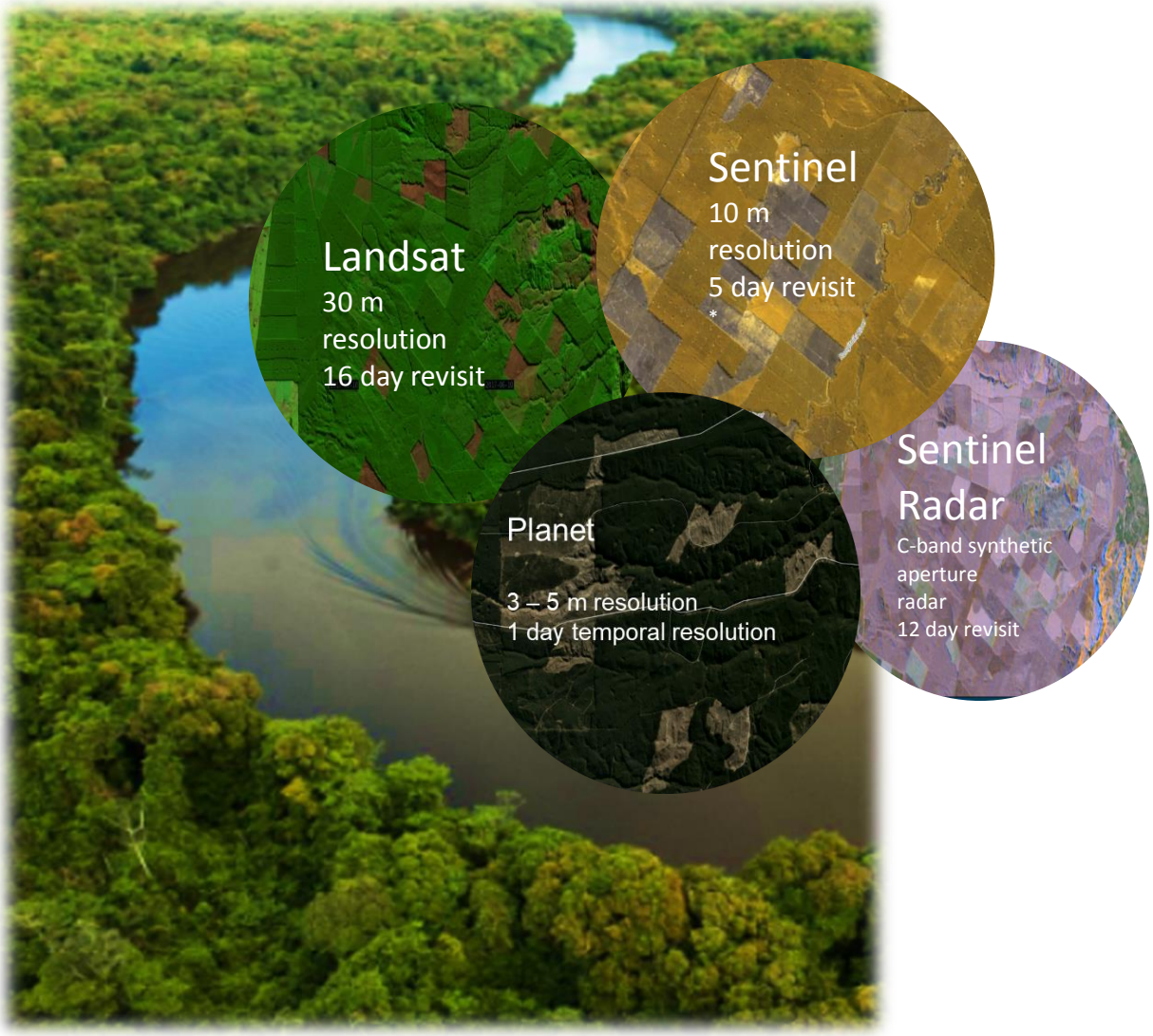
Guyana Forestry Commission

Guyana REDD+ Monitoring Reporting & Verification System (MRVS)

Year 8 Summary Report

1 January 2018 to 31 December 2018

Version 1- 22nd November, 2019



DISCLAIMER

The GFC advises that it has made every possible effort to provide the most accurate and complete information in the executing of this assignment.

PREFACE

Guyana has commenced implementation of Years 6-9 (2015- 2019) of the MRVS with continued support from the Government of Norway. This is a successor to MRVS Phase 1 implementation under the climate and forest partnership between the Government of Guyana and the Government of the Kingdom of Norway that was initiated in 2009.

Activities for implementation in Years 6-9 will support the establishment and long-term sustainability of a world-class MRVS as a key component of Guyana's national REDD+ programme. This system will provide the basis for verifiably measuring changes in Guyana's forest cover and resultant carbon emissions from Guyana's forests as an underpinning for results-based REDD+ compensation in the long-term.

It is important that the MRVS is a continuous learning process that is progressively improved. This is particularly relevant as the MRV matures and the trends and drivers of forest change are better understood.

Critically, the results generated from the MRV System have potential applications to a range of functions relating to policy setting and decision-making within the natural resources sector and in particular to forest management. Guyana's MRV System has, over the past five years, generated a wealth of data that can be utilized in improving management of the multiple uses of forests. Within the MRVS Year 6 to 9, the application of this data for decision-making will be tested at several levels and scales.

Reporting will continue to be based on the REDD+ Interim Indicators set out in the Joint Concept Note[1] (JCN) or other reporting framework agreed between Guyana and Norway. As appropriate the intention is to further streamline the REDD+ performance indicators. It also represents advancement of the implementation of the actions outlined in the MRVS Roadmap Phase 2, which also look to mainstream the system. Advancements are expected to be made to move to full reporting on emissions and removals by end of this phase.

In 2009 Guyana developed a framework for a national MRVS. This framework was developed as a "Roadmap[2]" that outlines progressive steps over a 3-year period that would build towards a full MRVS being implemented. The aim of the MRVS is to establish a comprehensive, national system to monitor, report and verify forest carbon emissions resulting from deforestation and forest degradation in Guyana. The first year of the roadmap commencement was 2010 which required several initial reporting activities to commence. These were designed to assist in shaping the next steps planned for the following years. In 2014, a Phase 2 Roadmap[3] was developed for the MRVS. The overall objective of the Roadmap Phase 2 seeks to consolidate and expand capacities for national REDD+ monitoring and MRV. This will support Guyana in meeting the evolving international reporting requirements from the UNFCCC as well as continuing to fulfil additional reporting requirements. It will also support Guyana in further developing forest monitoring as a tool for REDD+ implementation.

The initial steps allowed for a historical assessment of forest cover to be completed, key database integration to be fulfilled and for interim/intermediate indicators of emissions from deforestation and forest degradation to be reported for subsequent periods. To date, eight national assessments have been conducted, including the one outlined in this Report. The first assessment period covered 01 October 2009 to 30 September 2010 (Year 1) and the second (Year 2) covered the period 01 October 2010 to 31 December 2011. The third assessment (Year 3) covered the calendar year of 2012, the fourth assessment (Year 4) covers the calendar year of 2013, and the fifth assessment (Year 5) covers the calendar year of 2014. The sixth assessment (Year 6) covers a 24-month period spanning 2015 and 2016, Year 7 a 12-month period - the calendar year of 2017.This report details the assessment findings for Year 8, covering the calendar year of 2018.

[1] http://www.lcds.gov.gy/images/stories/Documents/Joint%20Concept%20Note%20%28JCN%29%202012.pdf
[2] http://www.forestry.gov.gy/Downloads/Guyana_MRV_workshop_report_Nov09.pdf
[3] http://www.forestry.gov.gy/wp-content/uploads/2015/09/Guyanas-MRVS-Roadmap-Phase-2-September-2014.pdf

In tandem with the work summarised in this report, an accompanying and closely connected programme of work will continue to be implemented by Guyana Forestry Commission (GFC), with the assistance of Winrock International (WI) to develop a national forest carbon measurement system and related emission factors. This programme will establish national carbon conversion values, expansion factors, wood density and root/shoot ratios as necessary. Additionally, a detailed assessment of key processes affecting forest carbon, including a summary of key results and capacities as well as a long-term monitoring plan for forest carbon, will be further developed. This aspect of the MRVS work, in tandem with continued work as summarized in this report, will enable a range of areas, including forest degradation to be comprehensively monitored, reported and verified at the national scale.

The GFC has attempted to embrace the broader thrust of the MRVS Phase 2 by looking for new and emerging technical solutions across related MRVS areas, as well as to embrace the requirements of implementing a non-REDD+ payment option for the MRVS. This process started Year 6 of the MRVS.

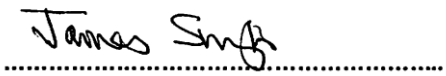
As the MRVS continues to be developed, the reporting in this period, as was the case in previous years will be based on several agreed REDD+ Interim Indicators. The Report therefore aims to fulfil the requirements of several "Interim Indicators for REDD+ Performance in Guyana" for the period 01 January, 2018 to 31 December, 2018, as identified by the JCN Table 2 These intermediate indicators allow for reporting to take place in the interim, while the full MRVS is under development. Concurrently, Guyana's reporting under the MRVS is moving closer to reporting on emissions by drivers of deforestation and forest degradation. This is a new feature of the Year 8 Report. Additionally, this Report describes the satellite imagery and GIS datasets, and processing of these data. It also provides a summary of the 'Interim Measures' that report on Guyana's progress towards implementation of REDD+.

The methods and results of the assessment for the period 01 January 2015 to 31 December 2016 are subject to independent third-party verification. The verification will be conducted annually for Years 6-9 of the MRVS.

Version 1 of the Report will be released for a 6 week period (22nd November 2019 to 3rd January 2020) for feedback. Following the period of public review, Version 2 of the report will be released and include all comments made under the public review process and feedback to each comment, including corresponding revisions to the report to address these comments where these apply. This Version is subject to independent third-party verification. The final version of the Report (Version 3) includes all elements of Version 2, and additionally, integrates the findings of the verification process, and is made public via the GFC website.

A summarised version of the Report has also been developed and released for public information.

These Reports are issued by the Guyana Forestry Commission (GFC). Indufor Asia Pacific has provided support and advice as directed by the GFC.



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SUMMARY

In 2017 the Monitoring Reporting and Verification System (MRVS) moved into its second phase in line with tasks set out in the MRVS Road Map. This document outlines the stepwise progression and development of the MRVS for the next four years 2017 to 2020.

The framework for Year 8 is progressively moving away from Interim Indicators towards the reporting of total forest carbon emissions and removals, with a focus on reporting emissions. Originally it was intended that the reference measure as well as the interim performance indicators would only apply while aspects of the MRVS were under development and eventually phased out and replaced by a full forest carbon accounting system as methodologies are further developed. Year 8 places Guyana at this stage.

For reference the ongoing comparison of performance for the area-based interim indicators is against the values reported in the 2009 "Benchmark Map[4]". From that point onwards, the reporting periods are numbed sequentially with year 1 covering 2009 to 2010. This report presents the findings of the eight national assessment which spans a twelve-month period, 1 January 2018 to 31 December 2018.

The purpose of the MRVS is to track at a national-level forest change of deforestation and degradation, by change driver. Deforestation is monitored using a national coverage of satellite imagery. A revised method for accounting for Shifting Cultivation has been developed over 2018 and 2019 and this is reflected in the Year 8 forest cover and emissions reporting. Reporting on timber harvesting and illegal logging has been mainstreamed under full emissions accounting using existing methods. Degradation estimates for mining and infrastructure are computed using new methods developed over the years 2018 and 2019, as a part of moving towards a more comprehensive yet sustainable (in terms of financing and technical implementation) MRVS implementation post-2020. This aspect of sustainability refers to determining estimates for mining and infrastructure degradation that do not necessitate costly high-resolution imagery or aerial surveys to derive these estimates. These improvements provide a robust measure of both deforestation and degradation that aligns with Guyana's desire to pursue a low or no-cost REDD+ implementation option – this is an integral part of the Phase 2 objective whilst moving toward full emissions accounting.

Deforestation for the period between 1 January 2018 and 31 December 2018 is estimated at 9 227 ha. This equates to an annualised deforestation rate of 0.051% which is slightly higher than the change reported in the previous year (0.049%). The 2017 rate was the lowest of all annual periods from 2010 to present. As with previous assessments the GFC's deforestation area has been verified by the Durham University (DU) team using a statistically representative independent sample. The area of deforestation reported by DU closely aligns with the values reported by the GFC.

The main deforestation driver for the current forest year reported is mining (sites), which accounts for 75% of the deforestation in this period. The majority (78%) of the deforestation is observed in the State Forest Area. The temporal analysis of forest changes post-1990 indicates that most of the change is clustered around existing road infrastructure and navigable rivers. In Year 8 (2018) the change has continued primarily near the footprint of historical change. The findings of this assessment assist to design REDD+ activities that aim to maintain forest cover while enabling continued sustainable development and improved livelihoods for Guyanese.

[4] Originally the benchmark map was set at February 2009, but due to the lack of cloud-free data the period was extended to September 2009.

1. INTRODUCTION

1.1 Initiation of REDD+ activities in Guyana

On 8 June 2009, Guyana launched its Low Carbon Development Strategy (LCDS). The Strategy outlined Guyana's vision for promoting economic development, while at the same time contributing to combating climate change. The LCDS has two goals:

i. Transform Guyana's economy to deliver greater economic and social development for the people of Guyana by following a low carbon development path; and

ii. Provide a model for the world of how climate change can be addressed through low carbon development in developing countries if the international community takes the necessary collective actions, especially relating to REDD+.

As at September 2009 Guyana had approximately 18.5 million ha. Historically, relatively low deforestation rates have been reported for Guyana.

Approximately 87% of Guyana land area is covered by forests, with a low deforestation rate, 0.02% and 0.079% per annum. Deforestation rates typically expand along with economic development, thus prompting the formation of the United Nations Collaborative Programme on Reducing Emissions from Deforestation and Forest Degradation in Developing Countries (UN-REDD programme), the Forest Carbon Partnership Facility (FCPF) and the REDD+ Partnership, among others.

The activities undertaken, are part of the three-phase Road Map developed for Guyana's MRVS. The objective of the initial MRVS Road Map was to undertake comprehensive, consistent, transparent and verifiable assessment of forest area change for the historical period of (about) 1990 to 2009 using several period steps of archived Landsat-type satellite data that meet the criteria of the IPCC Good Practice Guidelines for LULUCF.

A Second Phase MRVS Roadmap was developed following a stakeholder consultation process, the year 5 report was the commencement of the first cycle of the Phase 2 Roadmap covering knowledge and capacity sharing aspects.

1.2 MRVS Development & Progress

Several areas have been progressively improved since the inception of the MRV. For the current MRV phase 2017-2020 workplan the following areas are relevant.

Interoperability of various data streams within Guyana's MRVS
From its inception in 2009, Guyana's MRVs was designed to include data from multiple sources which can be combined in a consistent manner. The stepwise approach allowing time to bridge gaps in capacity allowing the integration of image processing and time series analysis routines. Today, the potential of the data generated through annual mapping of forest change extends well beyond the intended MRV function to include a range of functions relating to policies, decision- making, integration of compliance functions, and more effective management within the natural resources sector.

Recent and evolving developments in the remote sensing environment has opened up many possibilities over the last 4 years, including with a broader range of high-resolution optical satellites, higher revisit rates, and online platforms that support a faster and more efficient use of that data, all possible now at a country level.

As Guyana embarked on the second phase of its MRV System (2015 to 2019), lower cost satellite options were explored in common with many other countries. For deforestation mapping a

combination of ESA Sentinel 2 and Landsat imagery provides a sound alternative to RapidEye, with high enough resolution and sufficient temporal coverage to generate an annual snapshot of forest change. This is the intended approach for the MRVs for 2019-2020. Sentinel's five-day revisit rate will be leveraged to develop a more real time, continuous monitoring system hosted within the MRVs.

A measure of the MRVs robustness, and consistency can be attained by comparing results of national estimates against those calculated from an independent sample-based assessment. Accuracy assessment reports on the accuracy of the forest change area and attaches confidence limits (i.e. +/- x ha). Guyana is fortunate in that the comparison has been a feature of each reporting period since 2010. The results show a close correspondence across all periods when compared to the area of deforestation generated from the wall to wall national map.

To embrace this dynamic, the MRVS has been built to be data agnostic and this has provided a versatile platform that grows, develops and allows improvements as these became necessary for Guyana. Currently, the MRVs which has been created from the interoperability of various satellite data streams has significantly strengthened decision-making processes. Decisions are more informed, responsive, and well-planned leading to better management of extractive activities, protected areas, and planning for development within forests.

Forest Change Monitoring

As with previous assessments GFC has incorporated publicly available satellite imagery - Sentinel a constellation commissioned by the European Space Agency (ESA). The two Sentinel satellites 2A and 2B alone, enable repeat imaging of the same spatial location every five days at a spatial resolution of 10 m. Combined with the Landsat constellation (L7 and L8) this increases to 6-7 observations per month.

GFC has moved towards the use of open source software and has secured an agreement that allows the use of Google Earth Engine to assist with the processing of remotely sensed data. The forest change detection processes focus on the use of freely available satellite imagery, or in the case of degradation aims to provide robust and efficient estimates via a sampling approach.

Reporting on Forest Carbon Emissions

In tandem the to the forest change monitoring the work on determining forest carbon emission has undergone stepwise improvements over the last 10 years. Winrock International has worked closely with the Guyana Forestry Commission to develop the Forest Carbon Monitoring System and carbon stock values for Guyana's forest, develop emission factors for deforestation and degradation drivers, produce a Forest Reference Emission Level, and estimate annual emissions.

Guyana's REDD+ Monitoring, Reporting, and Verification System (MRVS) enables the country to determine greenhouse gas emissions and removals resulting from deforestation and forest degradation measured against business-as-usual (BAU) emissions. The Forest Carbon Monitoring System (FCMS) is a critical element of the MRVS as it provides the detailed methods needed to establish statistically robust Emission Factors (EFs). EFs are combined with activity data (AD) to estimate carbon emissions due to changes in Guyana's forest cover.

The MRVS and FCMS were initially developed between 2010 and 2011 and have been updated on an annual basis. The original emission factors covered only part of the country (the area at highest threat of forest conversion) and included only limited activities (deforestation and degradation from logging). Additional fieldwork was subsequently conducted allowing for stepwise improvements, with emission factors for deforestation developed for the entire country. The most recent emission factors were developed in 2016[5], and included complete EFs for deforestation, and for degradation from logging, mining and infrastructure degradation. For each, comprehensive uncertainty estimates were derived from a Monte Carlo analysis to ensure inclusion of other error sources.

With the completion of the EF development, Guyana is now ready to move beyond reporting on REDD+

[5] Goslee, K. and S. Brown. 2016. Forest Carbon Monitoring System: Emission Factors and their Uncertainties, Version 3. Submitted by Winrock International to the Guyana Forestry Commission.

Interim Measures which have in previous assessment focused on activity data, and to full Emissions Reporting.

Build capability of local communities and stakeholders to monitor forests

Over the reporting period, twenty-three (23) indigenous communities across Guyana received Community Monitoring Reporting and Verification (CMRV) training. The sessions sought to enhance CMRV capabilities based on the general needs of the communities.

The key objective of CMRV is the empowering local people to participate in REDD+. CMRV is a means of augmenting the traditional expert-led process of Monitoring, Reporting, and Verification (MRV). The involvement of locals from indigenous communities in the MRV of carbon stocks and other forest-related attributes has many national and community-level benefits. Nationally, it is a cost-effective method and allows REDD+ activities to benefit from the diverse skills and experience of local communities. Communities were selected to represent the administrative regions of Guyana as well as the main drivers of deforestation and forest degradation.

List of communities trained in CMRV for 2018

Village Name	Administrative Region
Tapakuma/St. Denny's, Bethany, Mainstay, Mashabo, Capoey	2
Santa Aratak	3
St. Cuthberts	4
Moraikobie	5
Batavia, Karrau	7
Kumu, St. Ignatius, Moco Moco, Shulinab, Toka, Katoka, Rupertee, Woweta, Annai, Central, Surama, Kwatamang	9
Riverview, Muritaro	10

Over the long-term the GFC aims to create a feedback mechanism that will support the data feeding into the MRVS and further qualification of the results generated. This would essentially involve the verification and validation of the data generated by the GFC via a CMRV system. While in return adding integrity to the GFC's mapping process. This approach is similar to the manner in which the GFC has developed and improved the MRVS and associated reporting and monitoring processes. At the community-level it is envisaged that the CMRV would improve strategic planning by providing an improved understanding of land use trends and resource use.

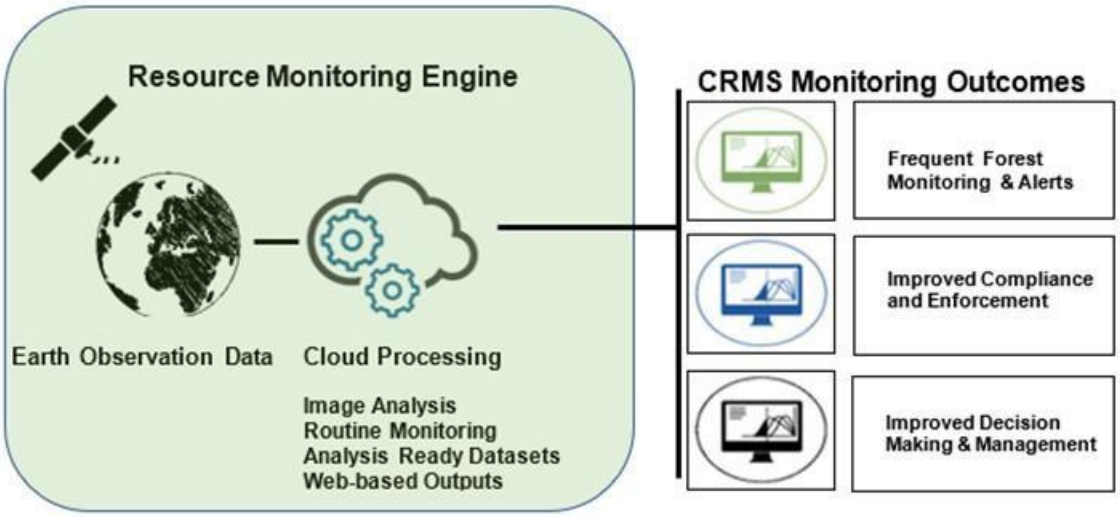
Continuous Resources Monitoring System

The GFC continues to move the MRVS towards more near real-time monitoring. This has been identified as one of the major improvements to the System that would enable wider applications of the MRVS data. The GFC is exploring the use of Sentinel imagery as an option for a Continuous Resources Monitoring System (CRMS). The CRMS concept leverages increased data and cloud processing capacity, utilising a powerful cloud processing engine for computation. Data is also entirely hosted on the cloud.

The CRMS will seek to build on Guyana's MRVS design to provide analysis-ready data that allows alerts, proactive management of natural resources that leads to improved decisions and policies. The layers produced can be integrated into common GIS packages, or via web-enabled dashboards.

An important aspect is that the design will be flexible, and development recognises existing functionality of the current GIS-focused MRV. The design concept presented in the figure below, shows the link between satellite imagery, which is held and processed in the cloud and the final output layers which are either held by GFC within the MRV, or hosted on a web-based GIS platform.

Figure 1-1: Design Concept: Continuous Resource Monitoring System



The Sentinel mission provides global coverage of the Earth's land surface every five days making the data a valuable resource for monitoring forest change.

GFC has negotiated with Google Earth Engine to allow for free processing for GFC. GFC has further negotiated access to ESRI's full mapping suite which includes Web-enabled dashboards.

2. Distribution of Tenure & by IPCC Land Classes

Table 2-1 shows the area by the adopted IPCC classes, as at the start of Year 8 (2018). Non-forest classes can shift from one (non-forest) class to another non-forest class.

Table 2-1: Tenure by Adopted IPCC Land Cover Classes

2018 Land Classes	Forest	Non-Forest					
		Grassland	Cropland	Settlements	Wetlands	Other Land	Total
	(Area '000 ha)						
State Forest Area	12 156	195	106	9	123	6	12 595
Titled Amerindian lands	2 485	981	409	46	121	32	4 074
State Lands	2 338	654	282	7	16	8	3 305
Protected Areas*	1 091	24	3	0	20	1	1 139
Total Area	18 070	1 854	800	63	280	47	21 114

3. MONITORING & SPATIAL DATASETS

The process developed aims to enable areas of change (>1 ha) to be tracked spatially through time, by driver (i.e. mining, infrastructure and forestry). The approach adopted seeks to provide a spatial record of temporal land use change across forested land (commensurate to an Approach 3). Mapping is undertaken by a dedicated team located at GFC and all spatial data is stored on the local server at GFC and builds on the archived and manipulated data output from the previous analyses. The server is managed by the IT department at GFC and is routinely backed up and stored off-site.

3.1 Agency Datasets

Several Government agencies that are involved in the management and allocation of land resources in Guyana hold spatial datasets. Since 2010 GFC has coordinated the storage of these datasets for the MRVS. These agencies fall under the responsibility of the Ministry of Natural Resources (MNR). The Ministry has responsibilities for forestry, mining, and land use planning and coordination.

In 2016, activities of environmental compliance and management, protected areas development and management, national parks management and wildlife conservation and protection were reassigned from the Ministry of Natural Resources to a newly established Department of Environment. The Department of Environment falls under the oversight of the Ministry of the Presidency.

Table 3-1: Agency Datasets Provided

	Agency	Role	Data Held
Ministry of Natural Resources	Guyana Forestry Commission (GFC)	Management of forest resources	Resource management related datasets
	Guyana Geology and Mines Commission (GGMC)	Management of mining and mineral resources	Mining concessions, active mining areas
Ministry of the Presidency	Protected Areas Commission	Management of Protected Areas System in Guyana	Spatial representations of all protected areas
	Guyana Lands and Surveys Commission (GL&SC)	Management of land titling and surveying of land	Land tenure, settlement extents and country boundary

Interim datasets have been provided by GFC, GGMC, GL&SC and the PAC. Information is progressively updated as necessary.

3.2 Monitoring Datasets - Satellite Imagery

In keeping with international best practice, the method applied in this assessment utilises a wall-to-wall approach that enables complete, consistent, and transparent monitoring of land use and land use changes over time.

The approach employed allows for land cover change greater than one hectare in size to be tracked through time and attributed by its driver (i.e. mining, shifting agriculture etc.).

The datasets used for the change analysis have evolved over time. Initially the historical change analysis from 1990 to 2009 was conducted using Landsat imagery. From 2010 a combination of DMC and Landsat was used and from 2011 onwards these datasets were primarily superseded with high-resolution images from RapidEye. For 2015 and 2016 (Year 6), a combination of Landsat and Sentinel data have been used.

Table 3-2: Sentinel Coverage 2018

Image Acquisition Month	Number of Satellite Tiles
August	36
September	43
October	23
November	17
December	8
Total	127

Moving forward, data from the Sentinel (2A/2B) multi-spectral imager (MSI) will be the primary dataset for monitoring deforestation, supplemented by Landsat and fire monitoring datasets. Over the 2018 census period, 127 tiles were acquired spanning from August to December.

Degradation is not mapped directly but estimated from a sample of high-resolution aerial imagery (GeoVantage, 4 band multispectral data) and PlanetScope multispectral satellite images.

Overall, the transition to the Sentinel MSI sensor with 10 m pixel size in the visible and near infrared has not had a detrimental impact on the accuracy of the forest monitoring.

3.3 Accuracy Assessment

Historically, the intention of the Accuracy Assessment (AA) has been to provide an assessment of the quality of the GFC's mapping of land cover land use change across Guyana. In 2017 the function of the accuracy assessment changed so use the sample-based approach to provide a statistical estimate of both gross deforestation and degradation. The progressive change of approach meant that GFC no longer needed to map the extent of forest degradation surrounding mining sites – a time-consuming and from Sentinel 2 imagery a difficult process.

From 2013 to 2015 and 2017 to 2018, high-resolution imagery has been captured using a Cessna mounted aerial multispectral imaging system. The camera system (Aeroptic, aka GeoVantage) is a flexible unit that can be installed quickly and easily on to various models of light aircraft. The resolution of the images captured over pre-defined samples ranges from about 25 to 60 cm (varied by the altitude of the aircraft at the time of capture), a resolution capable of identifying forest degradation with some certainty.

The strategy employed uses the imaging system to capture high-quality image data at sites pre-determined by a two-stage stratified-random sample design that provides good coverage of the strata with high and medium risk of change. Full sample coverage is achieved by including satellite images over areas the stratum with low risk of forest change and over any area where it is not possible to safely operate a small aircraft.

In keeping with previous years, the same sample locations were analysed. The locations of these samples were provided to the aerial survey contractor by the independent accuracy assessment team from Durham University, UK.

In Year 8 (2016-2017), the accuracy assessment involved the collection of 322 sample units randomly selected from three forest strata organised by risk of deforestation. The High Risk and Medium Risk strata was assessed predominantly using Planet (2016) and GeoVantage/Planet (2017) imagery. The Low Risk stratum (where no previous activity has been recorded) was assessed using repeat coverage Sentinel/Landsat imagery. The same approach was used for 2018 except the initial interpretation was carried out by the GFC Mapping Team and checked by the independent accuracy assessment team.

4. NATIONAL MAPPING OF DEFORESTATION & DEGRADATION

Guyana's GIS-based monitoring system is designed to map change events in the year of their occurrence and then monitor any changes that occur over that area each year. Where an area (polygon) remains constant, the land use class and change driver are updated to remain consistent with the previous analysis. Where there is a change in the land cover of an area, this is recorded using the appropriate driver. Deforestation is mapped manually using a combination of repeat coverage Landsat and Sentinel 2 images. National estimates of degradation are estimated by repeat interpretation of a series of linear randomly located samples.

The following drivers of land use change are relevant. Drivers can lead to either deforestation or forest degradation.

4.1 Deforestation

Formally, the definition of deforestation is summarised as the long-term or permanent conversion of land from forest use to other non-forest uses (GOFC-GOLD, 2010). An important consideration is that a forested area is only deemed deforested once the cover falls and remains below the elected crown cover threshold (30% for Guyana). In Guyana's context forest areas under sustainable forest management (SFM) that adhere to the forest code of practice are not considered deforested if they regain the elected crown cover threshold. The anthropogenic change drivers that lead to deforestation include:

- Forestry (clearance activities such as roads and log landings)
- Mining (ground excavation associated with small, medium and large-scale mining)
- Infrastructure such as roads (included are forestry and mining roads)
- Agricultural conversion
- Fire (all considered anthropogenic and depending on intensity and frequency can lead to deforestation).
- Settlements change such as new housing developments.

4.2 Forest Degradation

There is still some debate internationally over the definition of forest degradation. A commonly adopted definition outlined in IPCC (2003) report is:

"*A direct human-induced long-term loss (persisting for X years or more) of at least Y% of forest carbon stocks [and forest values] since time T and not qualifying as deforestation or an elected activity under Article 3.4 of the Kyoto Protocol* ".

The main sources of degradation are identified as:

- Harvesting of timber (reported since 2011 using the Gain Loss Method)
    - Associated with mining sites and road infrastructure.

Image evidence and fieldwork has shown that each of these drivers produce a significantly different type of forest degradation. Forest harvest operations are temporally persistent. Forest degradation surrounding new infrastructure is different in nature. Image evidence suggests that this type of degradation is dependent on the associated deforestation site.

5. FOREST CHANGE

The results presented, summarise the Year 8 period (1 January 2018 to 31 December 2018) forest change from deforestation and forest degradation impacts.

In terms of background the change for each period has been calculated by progressively subtracting the deforestation for each period from the forest cover as at 1990.

The forest cover estimated as at 1990 (18.47 million ha) was determined using manual interpretation of historical aerial photography and satellite images. This area was determined during the first national assessment (GFC 2010) and verified independently by Durham University (DU 2010 and 2011).

Overtime, the forest area has been updated after review of higher resolution satellite images. The outcome has been that the forest/non-forest boundaries are improved, but also the forest area changed - in particular at two points in time 2012 and 2014. In 2018, the forest area was revised to remove areas of historic shifting cultivation, as further study lead to the conclusion that these areas should be considered as non-forest.

Table 5-1 summarises for the entire country the total change and change expressed as a percentage of forest remaining. The forest area at the start of Year 8 is 18.07 million ha.

Table 5-1: National Area Deforested 1990 to 2018

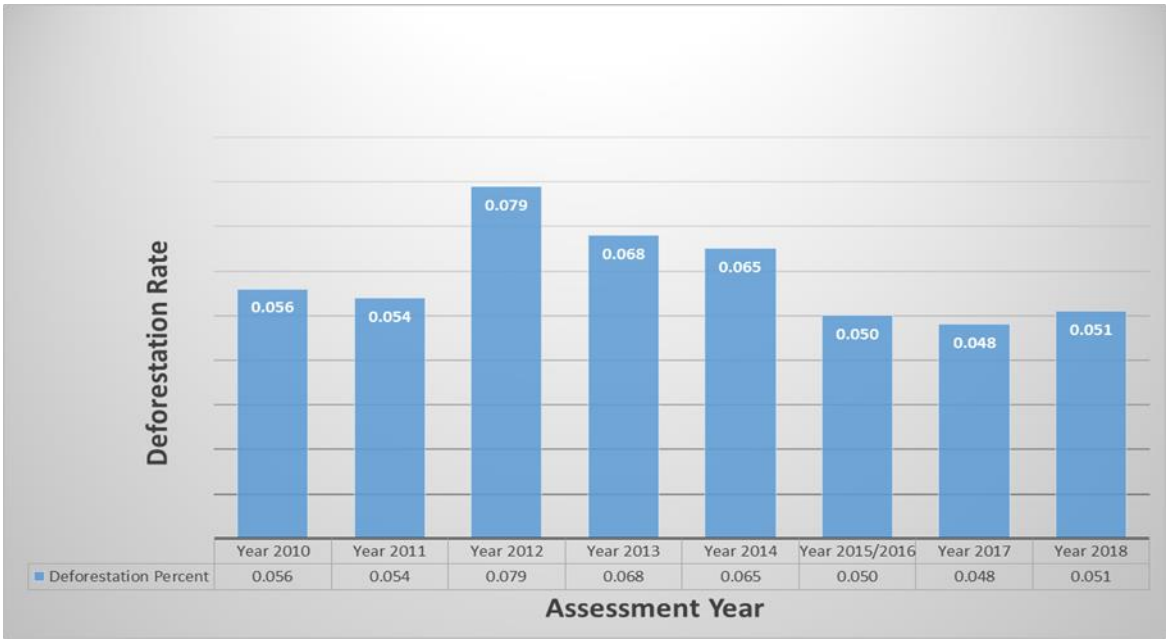
Reporting Period	Year	Years	Satellite Image Resolution	Forest Area	Annualised Change	
				('000 ha)		(%)
Initial forest area 1990	1990		30 m	18 473.39		
Benchmark (Sept 2009)	2009	19.75	30 m	18 398.48	74.92	0.021
Year 1 (Sept 2010)	2010	1	30 m	18 388.19	10.28	0.056
Year 2	2011	1.25	30 m & 5 m	18 378.30	9.88	0.054
Year 3	2012	1	5 m	*18 487.88	14.65	0.079
Year 4	2013	1	5 m	18 475.14	12.73	0.068
Year 5	2014	1	5 m	*18 470.57	11.98	0.065
Year 6	2015-16	2	10 m & 30 m	18 452.16	9.20	0.050
Year 7	2017	1	10 m & 30 m	18 442.96	8.85	0.048
Year 8	2018	1	10 m & 30 m	*18 070.08	9.22	0.051

*Continual forest area updates based on remapping, using higher resolution 5 m resolution imagery and removal of shifting cultivation areas.

Overall, Guyana's deforestation rate is low when compared to the rest of South America. FAO's 2015 Forest Resource Assessment (FRA) indicated that annual forest loss for the continent is around -0.43%/yr[7].

The following figure shows the annualised deforestation trends for all change periods. The trend shows that deforestation rates increased from the 1990 level, and in parallel with gold price increases peaked in 2012 (0.079%). Post 2012 the rate of change fell and in recent years fluctuated between 0.048 to 0.068%.

Figure 5-1: Annual Rate of Deforestation by Period from 1990 to 2018



5.1 Forest Change by Driver - Deforestation

Forest change caused by deforested is divided and assessed by driver. For this assessment degradation estimates use a sample-based approach.

Table 5-2 provides a breakdown by forest change drivers.

The temporal analysis provides a useful insight into deforestation trends relative to 1990. A more meaningful comparison is provided if the rates of change are divided by driver and annualised. In general, the following trends by driver are observed:

- In this reporting period, mining remains the largest contributor to deforestation, at 7624ha. The area of deforestation also includes roads used to access mining sites and areas of degradation that have been converted to deforestation. This includes roads that lead direct to mining sites.

- Forestry related change has remained relatively stable is around 356 ha. Forest roads, as in the case of earlier assessments, are attributed to a forestry driver rather than attributing this change to Infrastructure.

- Agricultural developments causing deforestation peaked at Year 5, with an increase to 817 ha. Over past two reporting periods it has been less than 500 ha rates akin to Years 3 and 4. This figure has remained relatively stable at 512 ha in the Year 8 reporting period.

- Deforestation from fire has increased slightly to around 661 ha. This represents a slight increase from the 500-ha reported in Year.

Table 5-2 – Change by Driver for Year 2018

Reporting Period	Year	Years	Satellite Image Resolution	Forest Area	Annualised Change	
				('000 ha)		(%)
Initial forest area 1990	1990		30 m	18 473.39		
Benchmark (Sept 2009)	2009	19.75	30 m	18 398.48	74.92	0.021
Year 1 (Sept 2010)	2010	1	30 m	18 388.19	10.28	0.056
Year 2	2011	1.25	30 m & 5 m	18 378.30	9.88	0.054
Year 3	2012	1	5 m	*18 487.88	14.65	0.079
Year 4	2013	1	5 m	18 475.14	12.73	0.068
Year 5	2014	1	5 m	*18 470.57	11.98	0.065
Year 6	2015-16	2	10 m & 30 m	18 452.16	9.20	0.050
Year 7	2017	1	10 m & 30 m	18 442.96	8.85	0.048
Year 8	2018	1	10 m & 30 m	*18 070.08	9.22	0.051

The distribution pattern also shows that areas of increased activity tend to be clustered around the existing road infrastructure and navigable rivers as both provide accessibility. Historically very little change has been observed beyond central Guyana. This trend continues, with only small areas of change observed in this region.

5.2 Forest Change Across Land Classes

The following table provides a summary by change driver and land class for the 2018 assessment.

Table 5-3: 2018 Area Change by Driver & Land Class

Land Class	Area Change by Driver & Land Class						Total Change	Proportion of Total
	Forestry	Agriculture	Mining	Infrastructure	Fire	Settlements		
	Area (ha)							%
State Forest Area	324	123	6665	11	41	4	7168	78%
Titled Amerindian lands *(*including newly titled lands*)	15	46	485	8	323	0	877	8%
State Lands	3	342	467	47	296	3	1158	13%
Protected Areas*	14	0	10	0	0	0	24	0%
Total	**356**	**511**	**7627**	**66**	**660**	**7**	**9227**	**100%**
Change from previous period (%)	56%	7.1%	2.5%	-66.1%	31.5%	0%	4.2%	

Mining

As with the previous year's most of the deforestation activity occurs in the State Forest Area (SFA). Mining activities are consolidated in the centre of Guyana. The area mined has increased by 2.5% from the

previous assessment, but still sits well below the 2012 value which marked a point where the gold price was the highest since 1980. Post-2012 the price has declined to around USD1200/ounce. This combined with limited accessibility has gradually reduced the area mined.

Forestry
Most forestry activities are located inside the SFA. During this period, all deforestation events are associated with forestry harvest operations. The main causes of forest clearance include road and log market construction. The reported value 356 ha is an increase when compared to the previous year.

Under the existing interim measures, forest harvesting is reported in terms of carbon removal (tCO_2) rather than spatially. However, overall activity at the harvest block level (each 100 ha in size) across concessions is monitored.

Infrastructure
Infrastructure developments (66 ha) contributes a small area with the level change relatively stable between reporting periods. The area of clearance is in a similar location. The main change is related to road construction activities and tends to be near townships.

Agricultural Development
Agricultural developments lead to 511 ha deforestation, which is slight increase (7.1%) on the previous period. The main areas of development are located close to Georgetown and the north- eastern regions of Guyana. Development tends to be near river networks.

Biomass Burning - Fire
Fire events have increased slightly compared to the previous year (502 ha) with an area of 660 ha mapped. Spatially, they follow historic trends, where events occur in the white sand forest area surrounding Linden and extends towards the eastern border of Guyana.

It is possible that burning events may be a precursor to agricultural development or related to other clearance activities. Fire has also been observed in the non-forest savannah areas to the south of the country.

The large fire events are tied to a prolonged dry spell and are most commonly observed on the drier sand and grassland areas. Although Guyana has seen an increase in forest fires in 2018, it is not a large increase as seen in neighbouring countries.

The following map shows the temporal and spatial distribution of deforestation by driver (mining, forestry and agricultural and biomass burning) for 2018 reporting period. Mining dominates the map as it is the largest single driver of change.

5.3 Forest Degradation

Reporting on forest harvest continues to be done using the gain loss method. This method has been applied in this manner from Phase 1.

The methodology for reporting mining and infrastructure degradation has evolved since the inception of the MRVS. Improvement in the process have been introduced in a stepwise manner and through recognition of advances in imaging technologies (spatial and temporal) and estimation processes.

In year 8, (2018), in a move to embrace the objective of the MRVS Phase 2 to create a more cost sustainable system, a refined approach was developed to report on mining and infrastructure degradation. This approach was developed using the findings of two studies;

- A Technical Paper produced by Winrock International (2019), titled "Mining Degradation in Guyana", which built on conclusions of earlier work presented in Brown et al (2015)
- Brown, S., A. R. J. Mahmood, and K. Goslee., (2015). "Degradation around mined areas: Methods and data analyses for estimating emission factors". Submitted by Winrock International to the Guyana Forestry Commission.

These studies lead to the conclusion that mining in Guyana, predominantly for gold and bauxite, is the dominant driver of deforestation. Overall it is responsible for 71% of deforestation greenhouse gas emissions and 57% of total forest greenhouse gas emissions (in 2016).

Application of these studies indicates that emissions associated with mining forest degradation are small (much smaller than estimated in the MOU with Norway) and thus do not warrant high ongoing measurement costs. However, in keeping with Guyana's desire for completeness in its reporting, the emissions from forest degradation associated with mining are reported. The improved methodology instituted in 2018, uses the approach recommended in Brown et al. (2015) and calculate a 100 m buffer around all areas of mining deforestation and apply the emission factor of 8 t CO_2/ha (2.2 t C/ha). For areas under 1 hectare that are likely moving to full deforestation will be recorded once they reach this size threshold.

Facultatively this required estimating an immediate degradation emission for all new mines, and for mines where expansion has occurred the buffer area should be calculated with and without the most recent expansion and the forest degradation emissions calculated only on the expanded area. This approach is highly conservative as it assumes there is zero regrowth which is very unlikely.

6. EMISSIONS REPORTING AND ACTIVITY DATA

On 9 November 2009 Guyana and Norway agreed on a framework that establishes the pathway of REDD+ implementation. Under this framework several forest-based interim measures have been established.

In 2015, a revised Joint Concept Note (JCN) under the Guyana/Norway Agreement was issued and replaced the JCN of 2012. The revised JCN updated the progress in key areas of work including on the MRVS. REDD+ Interim Indicators and reporting requirements, as had been outlined in the 2009 JCN, were maintained.

The intention is that these interim measures will be phased out as the MRVS is established[6]. The basis for comparison of most of the interim measures is the 30 September 2009 benchmark map[7]. The first reporting period (Year 1) is set from 1 Oct 2009 to 30 Sept 2010.

A summary of the key reporting measures and brief description for these interim measures are outlined in Table 6-1. Whilst reporting continues on Interim Indicators as originally agreed to under the Guyana Norway Agreement Framework, in keeping with the commitment to move to full emissions reporting, for the first time, in this Year 8 report, a complete emissions reporting table for all drivers of deforestation and forest degradation impacts has been presented.

Table 6-1 (a): MRVS Results 2018 (Year 8)

Measure Ref.	Reporting Measure on Spatial Indicators	Indicator	Reporting Unit	Adopted Reference Measure	Year 8	Difference between Year 7 & Reference Measure
					2018	Difference
1	Deforestation Indicator	Rate of conversion of forest area as compared to the agreed reference level.	*Rate of change (%)/yr*	0.275%	0.051%	0.22%
2	Degradation Indicators	National area of Intact Forest Landscape (IFL). Change in IFL post Year 1, following consideration of exclusion areas.	*ha*	7 604 820	7 603 568 (214 ha loss)	214 ha loss in year 2018

[6] The participants agree that these indicators will evolve as more scientific and methodological certainty is gathered concerning the means of verification for each indicator, in particular the capability of the MRV system at different stages of development.
[7] Originally the benchmark map was set at February 2009, but due to the lack of cloud-free data the period was extended to Sept 2010.

Table 6-1 (b): MRVS Results 2018 (Year 8)

Driver	Area (ha)	EF (t CO_2/ha)	Emissions (t CO_2/ha)
Deforestation			
Mining	6,936.3	1,045.1	7,249,092
Mining Infrastructure	687.6	1,045.1	718,593
Forestry	355.9	1,045.1	371,931
Infrastructure	67.1	1,045.1	70,176
Agriculture	511.8	1,104.2	565,122
Settlements	7.1	1,045.1	7,452
Fire	661.2	804.2	531,782
Deforestation Total	9,227.1		9,514,149
Degradation			
Timber harvest			1,830,856
Illegal logging			10,682
Mining degradation		8.1	164,523
Degradation Total			2,006,061
TOTAL CO_2 EMISSIONS FOR GUYANA FOR 2018 FROM FOREST SECTOR			**11,520,210**

6.1 Gross Deforestation

Emissions from the loss of forests are identified as among the largest per unit emissions from terrestrial carbon loss in tropical forests. Above ground biomass and below ground biomass combined represent approximately 82% in Above Ground Biomass and Below Ground Biomass including dead wood, litter, and soil to 30 cm which account for the remaining percent[11]. Several key performance indicators and definitions have been developed as follows.

- Comparison of the conversion rate of forest area as compared to agreed reference level as set out in the JCN.
- Forest area as defined by Guyana in accordance with Marrakesh Accords.
- Conversion of natural forest to tree plantations shall count as deforestation with full loss of carbon.
- Forest area converted to new infrastructure, including logging roads, shall count as deforestation with full carbon loss.

6.2 Intact Forest Landscape

The interim measure provided to monitor degradation is based on the definition of Intact Forest Landscapes (IFL).

"*IFL is defined as a territory within today's global extent of forest cover which contains forest and non-forest ecosystems minimally influenced by human economic activity, with an area of at least 500 km^2 (50 000 ha) and a minimal width of 10 km (measured as the diameter of a circle that is entirely inscribed within the boundaries of the territory)*".

For this report the same benchmark IFL area was used. The analysis identified 214 ha of deforestation in IFL areas. When the Intact Forest Landscape was established in Guyana the total area was estimated at 7.60 million ha.

7. Improved Methodology for Mining and Infrastructure Degradation

Mining in Guyana, predominantly for gold and bauxite, is the dominant driver of deforestation and is responsible for 71% of deforestation greenhouse gas emissions and 57% of total forest greenhouse gas emissions (in 2016). It is a reasonable expectation therefore that forests surrounding mining sites are damaged and the resulting forest degradation emissions have the potential to be significant. Analysis of remote sensing data has shown that there is some forest degradation associated with mining activity in Guyana (GFC and Indufor 2012[8]).

The original Memorandum of Understanding (MOU) between the Governments of Norway and Guyana specified that the area of 500 m buffers around annual deforestation from mining be reported. In addition, they specified that 50% reduction of the carbon stock in these buffers would occur due to degradation.

Field work has shown that degradation from mining in Guyana is concentrated in a limited area around active deforestation from mining (GFC and Indufor 2012 and Brown et al 2015[9]). Winrock and the GFC[10]) concluded that given the low relative annual emissions from forest degradation associated with mining that a simplified approach using buffer areas around mining deforestation should be used. The field work and analyses of Brown et al (2015) determined that applying an emission factor to a 100 m buffer around each individual polygon of deforestation due to mining is an appropriate and conservative approach. This analysis is conducted in ArcMap 10.7 using Guyana's yearly forest change dataset.

The original dataset is multipart, such that one attribute of loss defined by date of observation and driver contained multiple polygons of various sizes. To conduct the analysis, the multipart dataset must be split to a single part such that each attribute was associated with a single polygon. Polygons with an area of 1 ha or greater, the driver of mining, and the relevant year are selected for further analysis. Using the buffer coverage tool, a 100m buffer is defined using the 'no dissolve feature'. This preserves the associated attribute information and creates overlapping polygons. The 'erase tool' is then used to remove any areas of loss from the specified year that overlaps the 100 m buffers. The assumption here as supported by field measurements (transects) is that the forested area within 100 m of mining is within the degradation zone unless it is lost to another driver, such as road creation.

The dataset is then spatially dissolved so that the degradation zones of adjacent loss polygons are merged. The area of the dissolved polygon represents the total area of a 100 m degradation buffer around deforestation parcels due to mining, excluding all polygons of loss due to other drivers.

This area is the activity data for degradation from mining activity. The emission factor of 8 t CO_2/ha (2.2 t C/ha), derived from the field work described in Brown et al, (2015), is then applied to the activity data to produce the estimate of emissions from mining degradation across Guyana. This also means that for areas under 1 hectare that are likely moving to full deforestation by mining, these areas will be recorded when it reaches this state.

The approach requires estimating an immediate degradation emission for all new mines, and for mines where expansion has occurred the buffer area is calculated with and without the most recent expansion

[8] GFC and Indufor 2012. Guyana REDD+ Monitoring, Reporting and Verification System (MRVS): Year 2 Interim Measures Report, Version 3. Available from: http://www.forestry.gov.gy/Downloads/

[9] Brown, S., A. R. J. Mahmood, and K. Goslee. 2015. Degradation around mined areas: Methods and data analyses for estimating emission factors. Submitted by Winrock International to Guyana Forestry Commission.

[10] Winrock International. 2019. Recommendations Paper: Mining Degradation in Guyana. Submitted by Winrock International to the Guyana Forestry Commission

and the forest degradation emissions calculated only on the expanded area. This approach should be seen as highly conservative as it assumes there is zero regrowth which is very unlikely.

7.1 Forest Management

Forest management includes selective logging activities in natural or semi-natural forests. The intention of this measure is to ensure sustainable management of forest with net zero emissions or positive carbon balance in the long term. The requirement is that areas under SFM be rigorously monitored and activities documented such as harvest estimates. The following information is documented by the GFC and available for review for the period 1 January 2018 to 31 December 2018, with the annualised total presented:

- Production by forest concession
- Total production.

The reported difference between the annual mean for the period 2003-2008 and the assessment year of 1 January 2018 to 31 December 2018, presented an an annualised total, is shown in the table below. For this period t CO_2 has reduced by 1,830,856t CO_2.

Table 7-1: Interim Indicator on Forest Management

Period	Description	Volume (t CO_2)
1 January 2018 – 31 December 2018	t CO_2 emissions arising from timber harvesting	1,830,856
2003-2008 (annual average)	t CO_2 emissions arising from timber harvesting	3 386 778
Difference (t CO_2)		**1,555,922**

7.2 Illegal Logging

The rate of illegal logging for the assessment Year 8, 1 January 2018 to 31 December 2018, is informed by a custom designed database that is updated monthly, and subject to routine internal audits. This database records infractions of illegal logging in Guyana in all areas. This level for the reporting period 401,174 t CO_2, less than the historic period level.

Table 7-2: Interim Indicator on Illegal Logging

Period	Description	Volume (t CO_2)
1 January 2018 – 31 December 2018	t CO_2 emissions arising from illegal logging	10,682
2003-2008 (annual average)	t CO_2 emissions arising from illegal logging	411 856
Difference (t CO_2)		**401,174**

Reporting on illegal logging activities is done via the GFC's 36 forest stations located strategically countrywide, as well as by field, monitoring and audit teams, through the execution of both routine and random monitoring exercises. The determination of illegal logging activities is made by the application of standard GFC procedures. The infractions are recorded, verified and audited at several levels. All infractions are summarised in the illegal logging database and result in a total volume being reported as illegal logging for any defined time period.

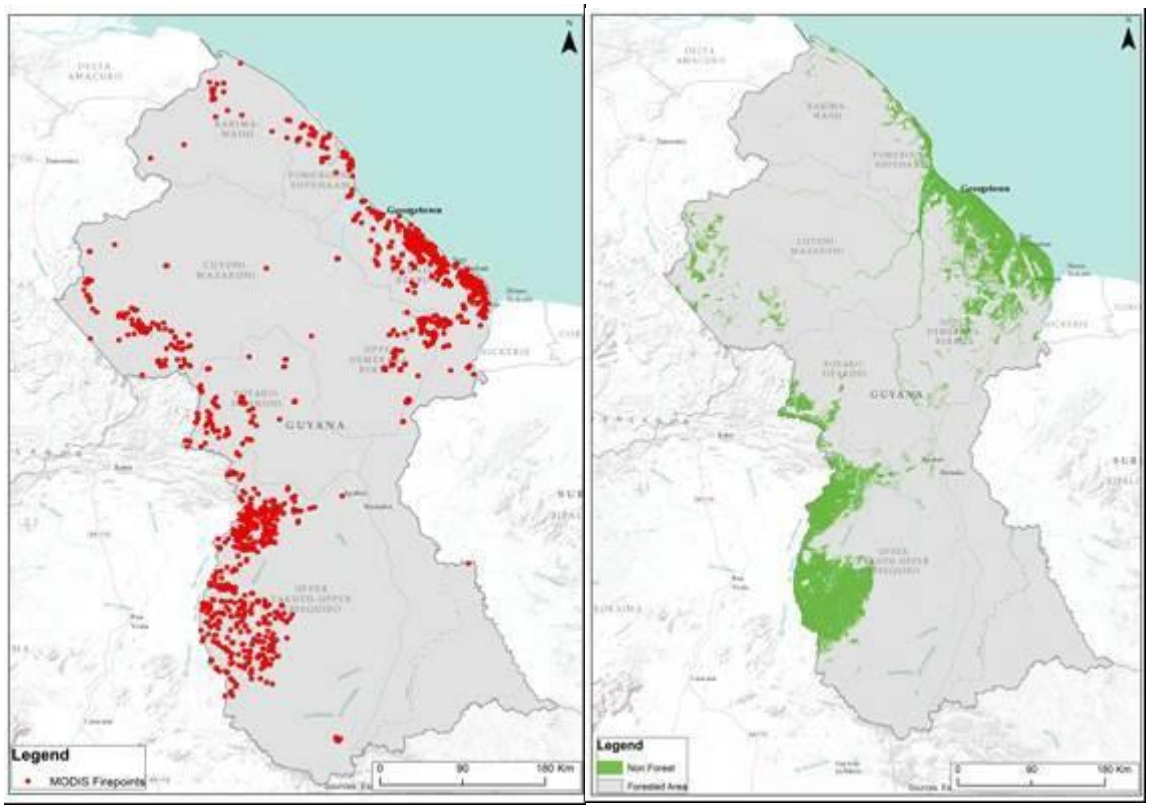
7.3 Forest Fires

The FIRMS fire point data from MODIS was used to identify potential fire locations. In addition, a systematic review of all fire points was undertaken to validate the presence of fire and establish the extent using Sentinel imagery. This is an accepted approach that is documented in the GOFC- GOLD sourcebook

Over this 19-year period a total of 33 700 ha of forest was identified as degraded by burning[11]. This equated to a mean annual area of 1 700 ha. The mean area burnt was accepted as a suitable Interim Measures benchmark against which all subsequent change could be compared. In this reporting period the area deforested by forest fires is 661ha.

Overall, fire is an immaterial change driver in Guyana with almost all fires occurring within non-forest/grassland landscapes as shown.

Figure 7-1: Non Forest Area & FIRMS Fire Data 2018



The main non-forest areas are in the south along the Brazilian border and closer to Georgetown on the coastal fringe.

Improved methodology for treatment of Shifting Cultivation

Shifting cultivation is a common agricultural system in tropical forest regions whereby a cycle exists of land being cleared of forest then cultivated temporarily before being abandoned and allowed to revert to natural vegetation. After a period with forest cover the land is cleared again for cultivation, restarting the cycle.

[11] This does not include areas deforested because of fire events. This has been recorded as deforestation. The .El Niño weather pattern is known to have occurred during this period.

This cycling enables continuous cultivation, even when the soil in one area has been exhausted, with fallow periods allowing soil to recover some level of fertility.

The critical initial determination must be made on whether shifting cultivation represents a forest or an agricultural land use. Arguments can be made in both directions given the details of the shifting cultivation cycle:

- The land use could be viewed as forest because, for the majority of time, it has tree cover and any deforestation is only a temporary unstocking;
- The land use could be viewed as agriculture. The area is deforested and then moves into an agricultural system. This system does include trees, but those trees are never able to return to a forested condition because the cycle involves regular clearing.

Guyana's forest definition is as follows:

Land exceeding 1 hectare with trees exceeding 5m in height and 30% crown cover but not classified as agriculture, infrastructure, or settlements.

The relevant part of the forest definition is "not classified as agriculture". While the fallow part of a shifting cultivation cycle is not itself agriculture, the entire cycle is. The system is agricultural, and the fallow period only exists to allow ongoing production of agricultural commodities. The direct consequence of Guyana's forest definition is that shifting cultivation should be considered agriculture and therefore:

- The first conversion of natural forest to shifting cultivation is **deforestation**. This is termed pioneer shifting cultivation in Guyana's NFMS;
- Any increases or decreases in length of the fallow cycle or the associated carbon stocks of the fallow cycle are within the **agricultural land use** and therefore not relevant to REDD+.

This approach provides multiple advantages to measurement, reporting and verification in Guyana. Namely:

1. Removed risk of incorrectly inflated deforestation numbers where an artificially high emission factor is used when a shifting cultivation parcel is re-cleared but is mistaken for natural forest;
2. Removed complexity of having to track fallow parcels and determine whether stocks are increasing or decreasing as a result of the fallow cycle, lengthening cycles due to soil degradation, shortening cycles due to land pressures, or parcels being abandoned back to forest;
3. Removed risk of double and triple counting deforestation where the same pixels are repeatedly cleared.

Based on remote sensing analyses over the last 20 years, zones of shifting cultivation will be identified and shifting cultivation parcels will be categorized as non-forest and subsequently not included in the National Forest Monitoring System (NFMS). For this reason, the forest/non forest layer has been revised for Year 8 with this taken account of.

For the zone surrounding existing shifting cultivation, the NFMS will include identification on an annual basis of pixels transitioning from natural forest to shifting cultivation – termed pioneer shifting cultivation. These pixels will be given a greenhouse gas emission and subsequently will be categorized as non-forest. Based on this assessment Winrock recommended that GFC adopts an average long-term shifting cultivation carbon stock of 6.1 ± 0.1 t C/ha. This has been applied in the reporting for year 2018.