Guyana Forestry Commission

Guyana REDD+ Monitoring Reporting & Verification System (MRVS)

Year 6 Interim Measures Report

1 January 2015 to 31 December 2016

Version 3

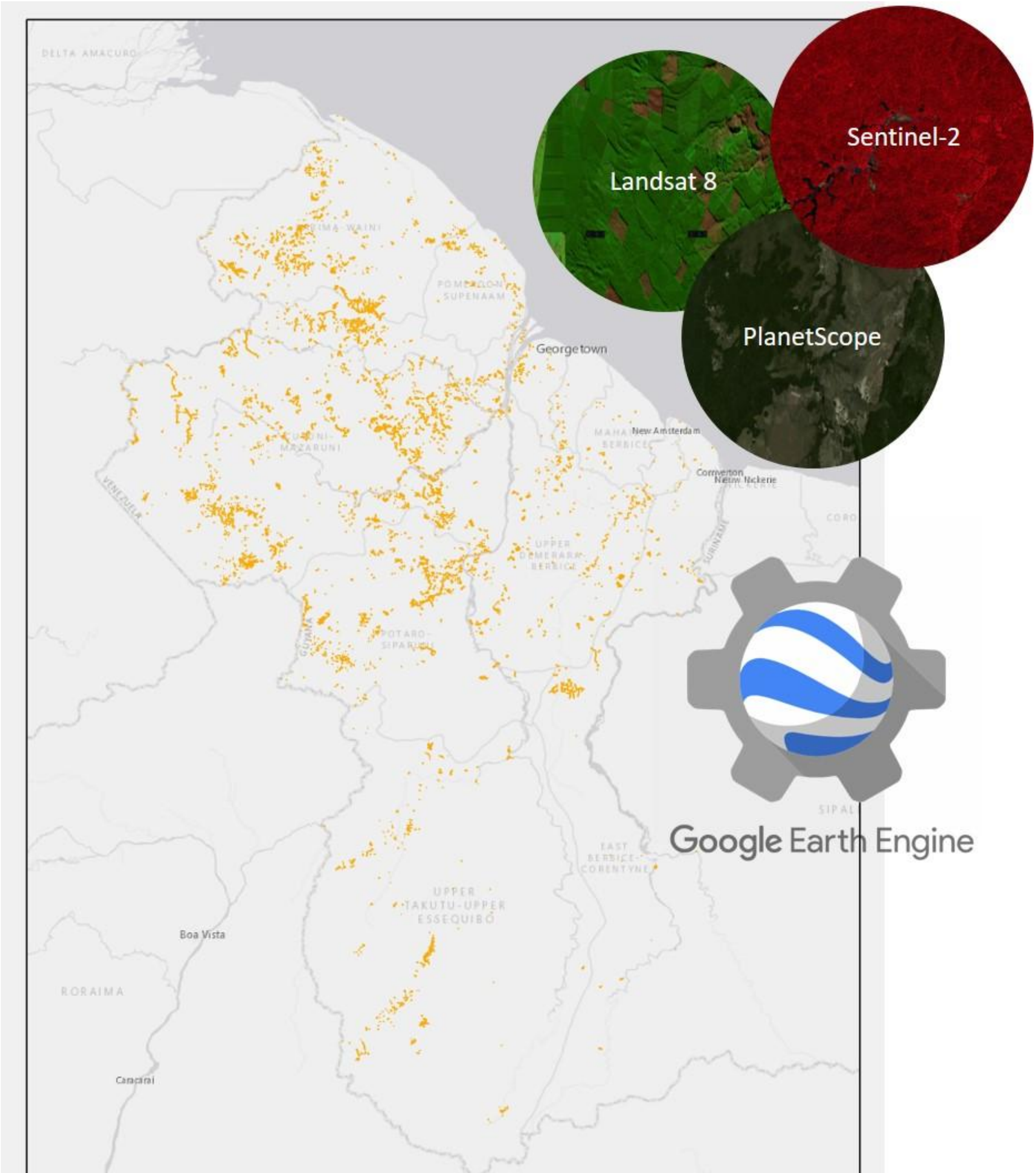

Illustration of Year 6 (2015-16) deforestation activity

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 sustaining 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, 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 as outlined by the areas expressed in the Joint Concept Note[1] or any other reporting framework agreed between Guyana and Norway, while streamlining these REDD+ performance indicators. It also represents advancement of the implementation of the actions outlined in the MRVS Roadmap Phase 2, towards mainstreaming the system.

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 is 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, six 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.

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 to develop a national forest carbon measurement

[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

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 in looking for new and emerging technical solutions to related MRVS areas, as well as to embrace the requirements of implementing a non-REDD+ payment option for the MRVS. This process has started in MRVS Year 6 and we thank you for keeping track on how these aspects are evolving.

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, 2015 to 31 December, 2016, 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.

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 sixth verification will take place in February 2018, and will be conducted annually for Years 6-9 of the MRVS.

Version 1 of the Report will be released for a 1-month period (20th December 2017 – 20th January, 2018) for feedback. Following the period of public review, Version 2 of the report has been developed to 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 by Det Norske Veritas (DNV-GL), an independent verification firm contracted by the Government of Norway. 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 has provided support and advice as directed by the GFC.

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Guyana Forestry Commission

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 Road Map establishes the stepwise progression and development of the MRVS for the next four years 2017 to 2020.

The framework for reporting continues to be the REDD+ Interim Indicators, as well as the reporting requirements as had been outlined in the 2009, 2011, and 2012 and 2015 versions of the Joint Concept Note (JCN).

The basis for comparison of the area-based interim measures is the 30 September 2009 Benchmark Map[4]. The first reporting period (termed Year 1) spanned 01 October 2009 to 30 September 2010. Thereafter for each preceding year from 2010 annual assessment were conducted to 2014. This report presents the findings of the sixth national assessment which spans a twenty-four (24) month period, 1 January 2015 to 31 December 2016.

The MRVS tracks forest change, both deforestation and degradation, by change driver. Deforestation is tracked through the interpretation of a national coverage of satellite imagery. Degradation estimates will be drawn from the results of the accuracy assessment which involves the interpretation of representative samples using high resolution imagery. This approach provides a robust measure of both deforestation and degradation, and was deemed necessary due to the pursuing of a low or no cost REDD+ implementation option – a key part of the Phase 2 objective.

Forest change of forest to non-forest excluding degradation between 1 January 2015 and 31 December 2016 is estimated at 18 416 ha. Over this period, this equates to an annualised deforestation rate of 0.050% which is lower than the Year 5 (2014) rate (0.065%). This rate is the lowest of all annual periods from 2010 to present, assessed to date. For this period, as in previous years an independent map accuracy assessment has been undertaken by a team from the University of Durham. The accuracy of the activity (area) data has been the focus of these assessments to date.

It is envisaged that the reference measure as well as the interim performance indicators will only apply while aspects of the MRVS are being developed and will be phased out and replaced by a full forest carbon accounting system as methodologies are further developed.

The main deforestation driver for the current forest year reported is mining (sites), which accounts for 74% of the deforestation in this period. The majority (94%) 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 6 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.

A summary of the key reporting measures and a brief description for these interim measures are outlined in Table S1. In this report, the analysis covers the benchmark period (1990-2009), the first year (Year 1) the second year (Year 2) the third year (Year 3) and the fourth year (Year 4) and fifth year (Year 5) and the sixth year of reporting.

Outputs and results are also provided for the intact forest landscape – IFL (Ref. measure. 2). The eligible IFL area of 7.6 million ha as calculated in the benchmark period is used for reference. All land cover changes are measured relative to the original IFL area.

Relevant measures are also reported for forest management indicators (measures Ref. 3 and 4). Where applicable, a reference measure has been included.

[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.

Table S1: Interim Measures

Measure Ref.	Reporting Measure	Indicator	Reporting Unit	Adopted Reference Measure	Year 2 Period	Year 3 Period	Year 4 Period	Year 5 Period	Year 6 Period (Annualised Results)	Difference between Year 6 & Reference Measure
1	Deforestation Indicator	Rate of conversion of forest area as compared to the agreed reference level.	*Rate of change (%)/yr*	0.275%	0.054%	0.079%	0.068%	0.065%	0.050%	0.23%
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	7 604 754 (66 ha loss)	7 604 580 (174 ha loss)	7 604 425 (155 ha loss)	7 604 314 (111 ha loss)	7 604 024 (290 ha loss)	- 796 ha (290 ha loss in Year 6)
2b		Determine the extent of degradation associated with new infrastructure such as mining, roads, settlements post the benchmark period[7].	*ha*	4 368	5 460	1 963	4 352	4 251	5 679[5]	-1 311
3	Forest Management	Timber volumes post 2008 as verified by independent forest monitoring (IFM). These are compared to the mean volume from 2003-2008	*t* CO_2	3 386 778[6]	3 685 376[7]	2 159 151	3 106 693	3 366 326	1,892,371	1,494,407 *t* CO_2
4	Emissions resulting from illegal logging activities	In the absence of hard data on volumes of illegally harvested wood, a default factor of 15% (as compared to the legally harvested volume)	*t* CO_2	411 856	18 289	11 217	11 533	13 823	9,140	402,716 *t* CO_2
5	Emissions resulting from anthropogenic forest fires	Area of forest burnt each year should decrease compared to current amount.	*ha/yr*	1 706[8]	28	208	395	265	762	944
6	Emissions resulting from subsistence forestry, land use and shifting cultivation lands	Emissions resulting from communities to meet their local needs may increase as a result of inter alia a shorter fallow cycle or area expansion. (I.e. slash and burn agriculture).	*ha/yr*	-	-	-	765	167	93	-

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[5] Includes 802 ha of degradation from natural causes over the 2 year period.
[6] Assessment completed based in Winrock International Report to the Guyana Forestry Commission, December 2011: ***Collateral Damage and Wood Products from Logging Practices in Guyana.*** This methodology only applies to emissions and not any removals due to re-growth of the logged forest. [2]. The same is the case for the Reference level for illegal logging for Years 2, 3 and 4.
[7]Computed for the period 1 October 2010 to 31 December 2011. (15 months)
[8] Degradation from forest fires is taken from an average over the past 20 years. This value is inclusive of all degradation drivers except for rotational shifting agriculture.

Encouragement of carbon sinks (Ref measure 7) is now under review. Reforestation of previously deforested sites is currently monitored using GIS once a deforestation site shows signs of being abandoned. Evidence suggests that these sites take a considerable time to regenerate. This is unsurprising due to the nature of the soil disturbance and displacement associated with mining activities. It is recommended that a long-term measurement plan be developed to monitor the carbon stock accumulation over time. The purpose of this plan would be to develop a realistic re-measurement interval. Once carbon stocks show signs of recovery, emission factors could be developed and linked to the GIS to provide a carbon stock estimation. The first instance of this measurement is recorded in Year 5. No measurement has been made in Year 6 due to the use of lower resolution Landsat images. Monitoring will recommence in Year 7 period.

Table S2: Impending Interim Measure

Measure Ref.	Reporting Measure	Indicator	Reporting Unit	Reference Measure	Year 2 to 4 Period	Year 5 Period	Year 6 Period	Difference between Year 5 & 6 Reference Measure
7	Encouragement of increasing carbon sink capacity of non-forest and forest land	Changes from non-forest land to forest (i.e. through plantations, land use change) or within forest land (sustainable forest management, enrichment planting)	Not considered relevant in the interim period.	N/A	N/A	73	N/A	NA

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APPENDICES

ACKNOWLEDGEMENTS

In addition to GFC, a number of agencies and individuals have assisted in providing inputs into the MRVS programme. GFC and Indufor would like to acknowledge the support of the Ministry of Natural Resources for its strategic guidance.

The continued support and oversight of the members of the MRVS Steering Committee is also acknowledged.

The GFC team would also like to acknowledge the following entities for their support:

- Guyana Geology and Mines Commission for providing location datasets for mining areas.
- Guyana Lands & Surveys Commission for providing spatial data relating to, settlements and agricultural leases.
- Conservation International, Guyana for their role in supporting the implementation of this, as well as other aspects of the Guyana MRVS, and for the exemplary efficiency and expertise in its collaborative role with the GFC.
- WWF for supporting work on CMRV.
- Winrock International for work on the forest carbon monitoring system.
- Other Partners

GLOSSARY

The following terms and abbreviations are used throughout the report.

CMRV	Communiy Monitroing Reporting and Verification
EITI	Extractive Industries Transparency Initiative
ESA	European Space Agency
Geo FCT	The Forest Carbon Tracking Task force
GFC	Guyana Forestry Commission
GGMC	Guyana Geology and Mines Commission
GIS	Geographic Information System
GLCF	Global Land Cover Facility
GL&SC	Guyana Lands & Surveys Commission
GOFC-GOLD	Global Observation of Forest and Land Cover Dynamics
GPS	Global Positioning System
GV	Green Vegetation
INPE	National Institute for Space Research in Brazil (Instituto Nacional de Pesquisas Espaciais)
IPCC	Inter-Governmental Panel on Climate Change
IRS (LISS)	Indian Remote Sensing Linear Self Scanning Sensor
KMCRG	Kanuku Mountain Community Representative Group
LAI	Leaf Area Index
LCDS	Low Carbon Development Strategy
LULUCF	Land Use, Land Use Change and Forestry
MERIS	Medium Resolution Imaging Spectrometer
MMU	Minimum Mapping Unit
MODIS	Moderate Resolution Imaging Spectroradiometer
MOU	Memorandum of Understanding
MRSid	Multi-resolution Seamless Image Database
MRVS	Monitoring Reporting and Verification System
MS	Multispectral
MSAVI	Modified Soil Adjusted Vegetation Index
NICFI	Norway's International Climate and Forest Initiative
NRDDB	North Rupununi District Development Board
Radar	Radio Detection and Ranging
REDD+	Reducing Emissions from Deforestation and Forest Degradation Plus Sustainable Forest Management
SAIL	Scattering by Arbitrarily Inclined Leaves
SAVI	Soil Adjusted Vegetation Index
SFA	State Forest Area
SMA	Spectral Mixture Analysis
SPOT	Satellite Pour l'Observation de la Terre
SRTM	Shuttle Radar Topography Mission
SWIR	Short Wave Infrared
UNFCCC	United Nations Framework Convention on Climate Change
UNREDD	United Nations REDD Programme
USGS	United States Geological Survey
VNIR	Visible and Near Infrared
WWF	Worldwide Fund for Nature

1. INTRODUCTION

1.1 Country Description

The total land area for Guyana is 21.1 million hectares (ha) and spans from 2 to 8° N and 57 to 61° W. Guyana shares common borders with three countries: to the north-west - Venezuela, the south-west - Brazil, and on the east - Suriname.

Guyana’s 460 km coastline faces the Atlantic on the northern part of the South American continent. The coastal plain is only about 16 km wide but is 459 km long.

It is dissected by 16 major rivers and numerous creeks and canals for irrigation and drainage. The main rivers that drain into the Atlantic Ocean include the Essequibo, Demerara, Berbice, and Corentyne. These rivers have the classic wide mouths, mangroves, and longitudinal sand banks so much associated with Amazonia, and mud flows are visible in the ocean from the air.

The geology in the center of the country is a white sand (*zanderij*) plateau lying over a crystalline plateau penetrated by intrusions of igneous rocks which cause the river rapids and falls.

1.2 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 aimed to achieve two goals:

1. Transform Guyana’s economy to deliver greater economic and social development for the people of Guyana by following a low carbon development path; and
2. 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 87% of its land area covered by forests, approximately 18.5 million ha. Historically, relatively low deforestation rates have been reported for Guyana.

Guyana currently records a comparatively low deforestation rate, reported in its Interim Measures MRVS Report, as ranging between 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 activity undertaken, as summarised in this Report, forms part of the sixth year 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.

1.3 Establishing Forested Area

Land classified as forest follows the definition as outlined in the Marrakech Accords (UNFCCC, 2001). Guyana has elected to classify land as forest if it meets the following criteria:

- Tree cover of minimum 30%
- At a minimum height of 5 m

- Over a minimum area of 1 ha.

In accordance with the JCN, the national forest cover as at 1990 based on this definition is used as a start point. The previous 2010 report prepared by GFC provides a detailed description of this process.

In summary, this process involved:

- Determination of the 1990 forest area using medium resolution satellite images (Landsat) by excluding non-forest areas (including existing infrastructure) as at 1990.
- From this point forward accounting for forest to non-forest land use changes that have occurred between 1990 and 2010 using a temporal series of satellite data.

The 2010 Interim Measures report estimated that as at the benchmark period (30 September 2009) the total forest area that met the above definition was 18.39 million ha (± 0.41 million ha). This figure was further verified by the University of Durham (UoD) with an indicative accuracy of (97.1%).

The 2012 (Year 3) assessment used a forest area (including State Land, State Forest and Amerindian Villages) of 18.50 million ha as the starting point. The increase in forest area resulted from the re-analysis of the 1990 forest / non-forest classification. These boundaries were updated using 5 m satellite imagery. This was a necessary change in order to ensure the delineation of mapped change events are at a consistent resolution with the updated forest/non-forest boundary. This means that historical change was included in the reported forest area figures until year two. From year three forward, the analysis does not take into account historical change mapped from Landsat as it was undertaken using RapidEye imagery. This entails comparing different analyses based on imagery of significantly different resolution. To generate a truly comparative figure, a full 'back cast' analysis of historical change events at the updated RapidEye resolution would be necessary. This is a comprehensive exercise and would essentially entail an extensive long-term analysis of all historical mapping periods, with reference to all historical imagery.

Any new land cover change for the Year 4 period has been subtracted from the revised forest area, as it was for Year 2. In year five there was a further shift in the basemap registration. This is due to updating from a GeoCover basemap at 30m resolution to a new basemap aligned with RapidEye's updated ground control points. This resulted in another minor revision in non- forest area. The non-forest area for Guyana has be updated and is benchmarked using this value.

A national coverage of RapidEye was first obtained in 2012 and 2013 - this constitutes a continued improvement on the historical Landsat data used. As with previous years this revision will be subject to independent audit, firstly by the accuracy assessors University of Durham (UoD) and secondly by the project verifiers Det Norske Veritas (DNV).

Similarly, in 2014 (Year 5) the forest area was again revised to a value of 18.48 million ha. This constitutes a difference of some 7 069 ha (gain) when compared to the Year 4 remaining forest area (18 475 478 ha) which would normally be used as the following year's (5) start forest area. The increase is largely a result of updates from RapidEye ground control points which has resulted in an increase in spatial accuracy of the imagery. This has resulted in a revision of the country boundary. Beyond that, the 2014 RapidEye has also enabled more accurate updates and allocation of forest and non-forest land classes which further justify the change. The presence of these area updates acknowledges that improvements are consistently being applied to the program where a genuine change has been recognized.

No changes have been applied to the start forest area for the Year 6. It takes the Year 5 end forest area (Year 5 start forest area less year 5 deforestation). The Year 6 start forest area is some 18.47 million ha.

1.4 MRVS Development & Progress

Several areas have been progressively improved over the period that interim measures are recorded. Over time the reporting formats have been improved and refined to accommodate impending measures such as shifting cultivation and afforestation.

Year 6 marked a number of changes in the process and data sources used under the MRVS. Over this period, forest change was monitored using a combination of Landsat and Sentinel images. As a result, areas of deforestation were mapped using these data sources and forest degradation was also included but this time, assessed using aerial surveys conducted as part of the Accuracy Assessment process.

It is proposed that the monitoring system will evolved to take advantage of the Sentinel satellites - 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.

The increased temporal resolution represents an important shift towards continuous monitoring of resources. The ability to monitor the same location repeatedly enables the detection of subtle changes in vegetation vigour and identification of trends. The real analytical efficiencies are accomplished by leveraging off cloud computing architecture which hosts and serves petabytes of historical and recently acquired images on-demand. With data held in this environment there is no need to individually review, download, or process and analyse satellite imagery as was the norm in the recent past.

These developments represent a major change in the way data is analysed – allowing on-demand processing while simultaneously accessing an ever-increasing repository of global datasets, satellite images, topographic and climatic observations

In following this approach further investment in data analysis and reporting tools and methodologies to monitor change are planned for Year 7 (2018).

A more specific overview of the development areas for the 2017 to 2020 is provided in Section 5.

On CMRV, The GFC has been working with counterparts including WWF, to advance work on CMRV. These will likely link to a potential new bilateral agreement and the Opt In Mechanism currently being developed by the Office of Climate Change. Among the main areas of progress in the year 6 that have advanced by the WWF are:

- The North Rupununi District Development Board's (NRDDB) 19 communities on 10 titled parcels (234,006 hectares of forest) have received training and facilitation to produce resource-use maps, village histories, village development and spatial plans sufficient to make them eligible to opt-in to a payment mechanism for forest carbon. They have also received training in FPIC, bookkeeping, conflict resolution and governance.
- 38 monitors, two from each of the 19 communities have completed their CMRV training and have gathered and compiled the data for their village's (updated) baseline.
- A CMRV resource center has been outfitted at Bina Hill to provide technical back up to the monitors and assistance in analysis and mapmaking
- Provided training and facilitation in opt-in readiness planning and capacity development for the Opt-in Pilot community of Muritaro.
- Beginning in February 2018, monitors will be trained from 16 KMCRG communities and Muritaro in CMRV.

It is intended that these efforts as well as support from the national MRVS will help to advance the readiness of potential new area into the national system.

Forest Carbon Monitoring

Over the period 2015-2016, work continued on the development of the forest carbon monitoring system. The following table summarises the main areas of progress.

Area of Work	Progress made to date
Continue routine monitoring of activity data and emission factors	This work has begun in 2017 and will be continued in 2018 on this area. A stratification update report has been prepared, exploring the potential need for revised stratification based on changes in potential for change and the road network that have occurred since original stratification was conducted. Additionally, for the first time, a definition of degradation has been developed, to be used going forward. For shifting cultivation, the need for revised stratification is largely associated with the definition of degradation, and whether it includes shifting cultivation. For mining degradation, a simplified accounting method is currently being developed, which will help to address need for revised stratification. Specifically, over the year 6 period, the following was completed: I. Review and revision conducted of the Standard Operating Procedures to address enhanced synergies. II. Tool on Emission Reporting updated to Year 6. III. Allometric equations being tabulated using data on additional 26 trees.
Improve emission factors for some specific processes (towards Tier 3)	This will be undertaken in 2018, and will follow from the simplified mining degradation method and the revised stratification (if needed). The team is currently analysing existing destructive sampling data to assess whether it would be more appropriate to use different allometric equations than have been used previously (to increase accuracy and reduce uncertainty). The results of this analysis may impact the emission factors as well.
Update Forest Biomass and Carbon Stocks data	As a part of its national REDD+ program, the Government of Guyana completed a forest carbon stratification in 2011 for the purposes of designing a sampling plan to accurately understand the country's forest carbon stocks. This stratification divided forest area into categories based on two factors: 1) the threat of deforestation, or potential for future land use change (PFC) that exists in the forest area, and 2) the accessibility to the forest area. The inclusion of different threat or PFC classes (high, medium and low) was based on the knowledge that, due to forest degradation, forest areas under higher PFC were likely to have lower carbon stocks than areas under low threat. In 2013, updated spatial input layers were used to update the stratification. Since 2013, development and deforestation has continued in Guyana and many of the input layers used as variables for the stratification map have changed—roads networks have expanded, concession boundaries have changed and areas that were once forest have undergone land use change. These changes create the need to update the stratification map for future monitoring periods of Guyana's REDD+ program to ensure more accurate accounting of changes in forest carbon stocks. In year 6, based on the analyses of the need for restratification and the potential to use revised allometric equations, along with the final simplified mining degradation methodology, the need for new field data is being reevaluated. This work has started in 2016-2017 with the collation of the year 6 activity data, assessment of the completeness and compatibility of year 6 with historical layers, and updated information collated on new roads. This work will be further advanced in 2018.

2. OVERVIEW OF GUYANA'S LAND CLASSES

There are four main tenure classifications in Guyana, the largest is state forest which is 59% of the total land area, followed by State Lands (20%) Amerindian lands (16%), and Protected Areas (5%).

State Forest Area

According to the Forest Act Section 3, Chapter 61:01, the State Forest Area is that area of State Land that is designated as State Forest. This area of State Forest has been gazetted.

State Lands

For purposes of this assessment, State Lands are identified as areas that are not included as part of the State Forest Area that are under the mandate of the State. This category predominantly includes State Lands, with isolated pockets of privately held land, but does not include titled Amerindian villages.

Protected Areas

To date, the four Protected Areas that come under the scope of the Protected Areas Act are: Iwokrama, Shell Beach, Kanuku Mountains and Kaieteur National Park. Altogether these account for a total of 1 141 000 ha designated as Protected Areas.

Titled Amerindian Land

The Amerindian Act 2006 provides for areas that are titled to Amerindian villages. It includes both initial titles as well as extensions that have been granted to these titled areas.

The areas are: State Forest Area (SFA) and State Lands which are calculated from the mapping analysis, is estimated at 14.8 million ha. This excludes Iwokrama, Kaieteur National Park and titled Amerindian Land. Combined, these forested areas make up 3.69 million ha. The location of these areas is shown in Map 2-1.

Distribution of Tenure & Land Classes

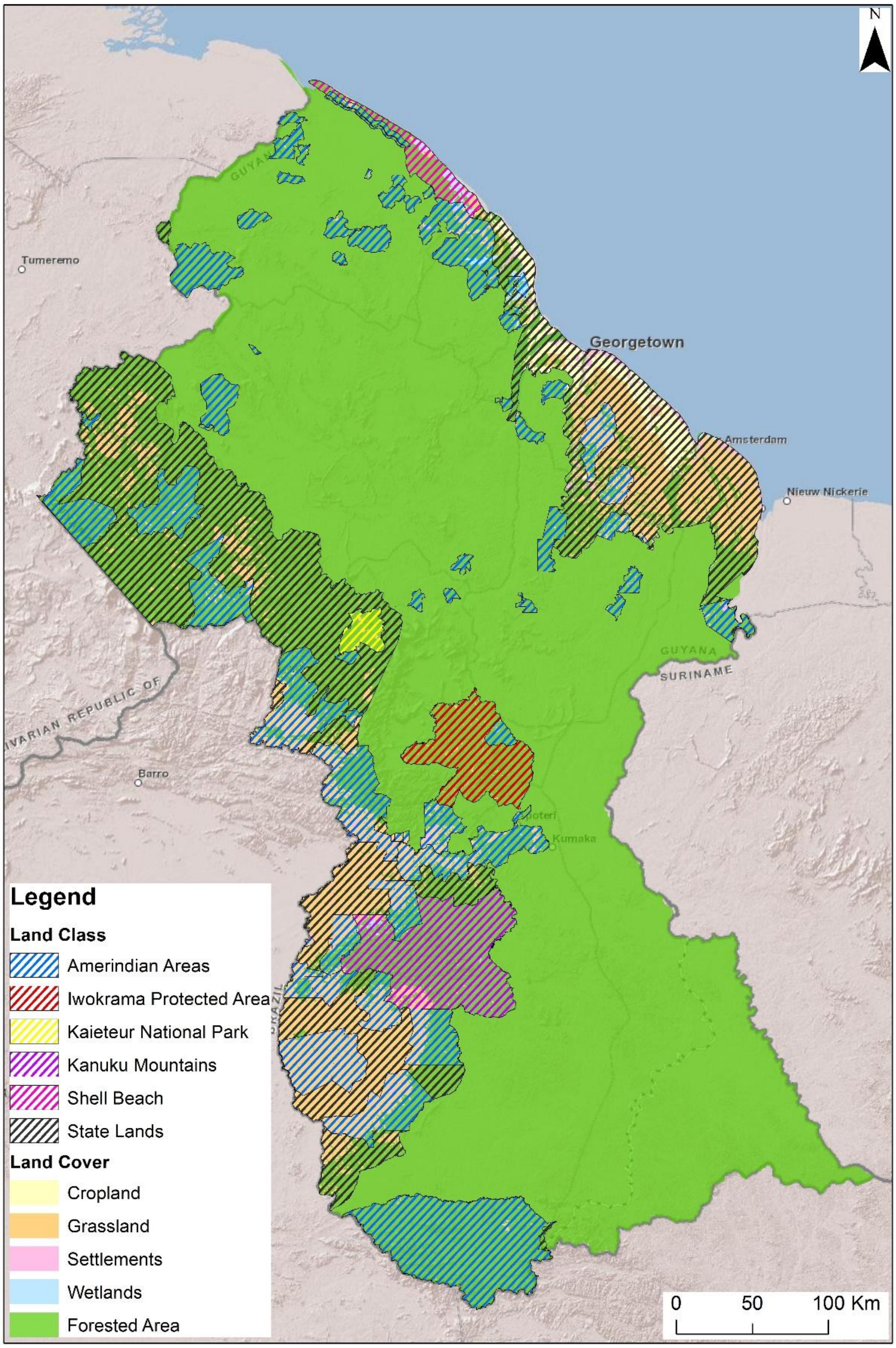
Table 2-1 is the current distribution of classes, as at the end of Year 6. The revised forest area in Table 2-1 includes the forest area lost during the Year 6 mapping period.

Non-forest classes may experience a shift from one (non-forest) class to another non-forest class. However, this is currently neither tracked nor mapped by GFC, changes are tracked from forest to non-forest and vice versa only.

Table 2-1: Year 6 End Land Class Distribution

2016 Land Classes	Forest	Non-Forest					
		Grassland	Cropland	Settlements	Wetlands	Other Land	Total
	(Area '000 ha)						
State Forest Area	10 979	1 233	132	35	150	37	12 566
Titled Amerindian lands *(*including newly titled lands*)	2 865	322	34	9	39	10	3 280
State Lands	3 610	406	43	11	49	12	4 132
Protected Areas*	998	112	12	3	14	3	1 142
Total Area	18 452	2 073	222	58	252	62	21 119

Map 2-1: Guyana's Land Classes



3. FOREST & LAND COVER DATASETS

For the interim measures report the total land area is separated into the forest and non-forest components as determined at 30 September 2009 (Benchmark). This was originally created from interpretation of the Landsat time series and refined using the RapidEye imagery in 2013. The non-forest area was further subdivided in 2014 into the relevant IPCC non-forest classes.

In developing the MRVS, it is important that forest and non-forest components are identified and mapped so that changes between the two classes can be monitored. For areas identified as forested, further stratification is generally required to divide forest types by their potential carbon storage capacity[9].

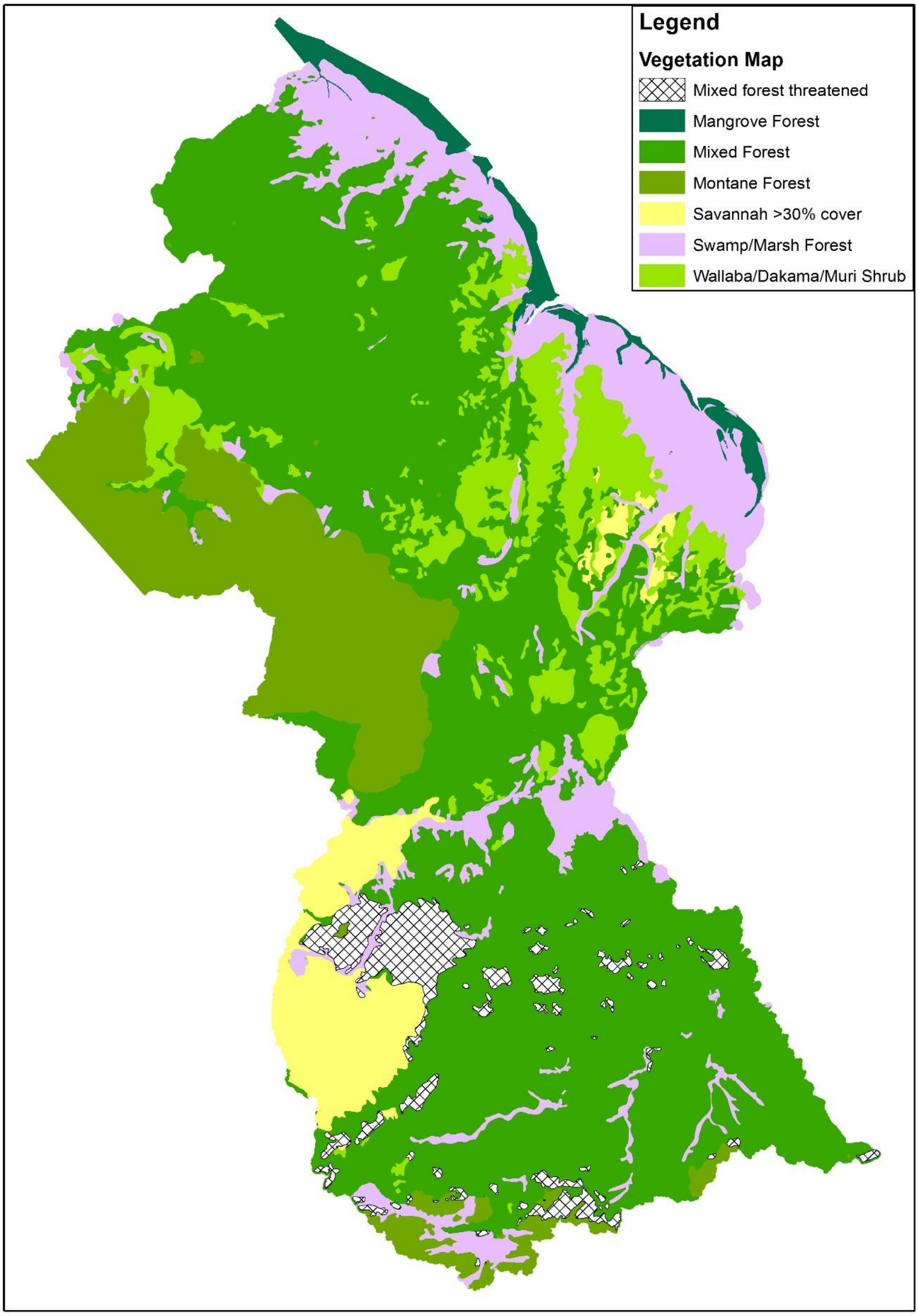
As a starting point in 2009 two datasets that depict the different forest types were considered. Both maps were produced in 2001 by Dr. Hans ter Steege, University of Utrecht, Netherlands, in collaboration with the GFC Forest Resources Information Unit (FRUI).

The first provides a detailed forest vegetation map for the entire State Forest Area (SFA) and was created from various existing vegetation maps. It was updated using interpretations of historical aerial photography and satellite radar imagery from the Japanese Earth Remote Sensing satellite (JERS 1). The maps completeness was supported by analysis of field data collected during the Commission's forest inventories.

At the same time a national forest and land use classification map at 1:1 000 000 scale was produced (Map 3-1). This is based mainly on national soil survey data made available by the National Agricultural Research Institute (NARI).

[9] In Guyana's case the forest carbon plots established by GFC and Winrock International show that the carbon stocks across forest types are similar. The basis for the carbon stock stratification is related to accessibility.

Map 3-1: Simplified National Vegetation Map 1:1 000 000 Scale



Using these maps GFC modified the classification schema to produce a simplified version. This conforms to the six broad land use categories in accordance with IPCC reporting guidelines (Table 3-1). A description of the land use categories is provided in Appendix 3.

Table 3-1: Preliminary Land Use Categories

Class	IPCC Landcover Class	Guyana Landcover Description
Forest Land	Forest Land	Mixed forest
		Wallaba/Dakama/Muri forest
		Swamp/Marsh forest
		Montane forest
		Mangrove forest
		Savannah Forest
		Shifting Agriculture systems
Non-forest	Cropland	Cropland
	Grassland	Tropical unmanaged grassland
		Tropical unmanaged shrubland
	Wetlands	Open Water
		Herbaceous unmanaged wetland
	Settlements	Human Settlement areas and roading
		Pre-1990 Mining Area
	Other land	Bare exposed rock outcrops
		Bareland

This map has been updated to better represent the forest and non-forest boundary as required to enable monitoring of forest change. Subsequent improvements have included the inclusion of annual forest loss areas, refinements to the river networks and further division of the non-forest area to better delineate agricultural lands.

The map is used to stratify the forest area which is in turn used to determine the number samples required to determine map accuracy and guide the placement of field plots designed to measure carbon stocks. The latter is an input required for the carbon forest monitoring system to determine the amount of CO_2 sequestered or emitted.

4. 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).

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. Moving forward, it is expected that Sentinel (2A/2B) will be the primary dataset, supplemented by Landsat.

This progression is outlined as follows:

- 1990 to 2000 – Landsat 30 m
- 2001 to 2005 – Landsat 30 m
- 2006 to 2009 September - Landsat 30 m
- 2009 – 2010 October (Year 1) - Landsat 30 m and DMC (22 & 32 m)
- 2010- 2011 December (Year 2) Landsat 30 m and RapidEye 5 m
- 2012 December (Year 3) RapidEye 5 m supplemented as necessary by Landsat 5 & 7
- 2013 December (Year 4) RapidEye 5 m supplemented as necessary by Landsat 8.
- 2014 December (Year 5) RapidEye 5 m supplemented as necessary by Landsat 8.
- 2015 – 2016 December (Year 6) Landsat 30 m and Sentinel 10 m – mapping deforestation, 25-60cm data from aerial survey, mapping forest degradation.

Over time several map products have been produced. The first, the Benchmark forest map, as determined through analysing change from 1990 to 2009. The Benchmark map provides a snapshot of forest area as at 30 September 2009.

The 'Year 1' map covers the first year after the benchmark map. For this period all forest to non-forest changes from 2009 to 2010 September were mapped spatially and reported. The main dataset used over this period was 30 m Landsat imagery.

For the 2010-11 assessment, higher resolution 5 m imagery was tasked over previously identified change areas. The area covered was 12 million ha which equated to 56% of Guyana's land area. The improved resolution enabled better identification of change boundaries, drivers of change and areas of forest degradation.

From 2012 to 2014 high resolution (5 m) coverage has been acquired over Guyana. This has enabled both change and the forest area to be mapped more accurately.

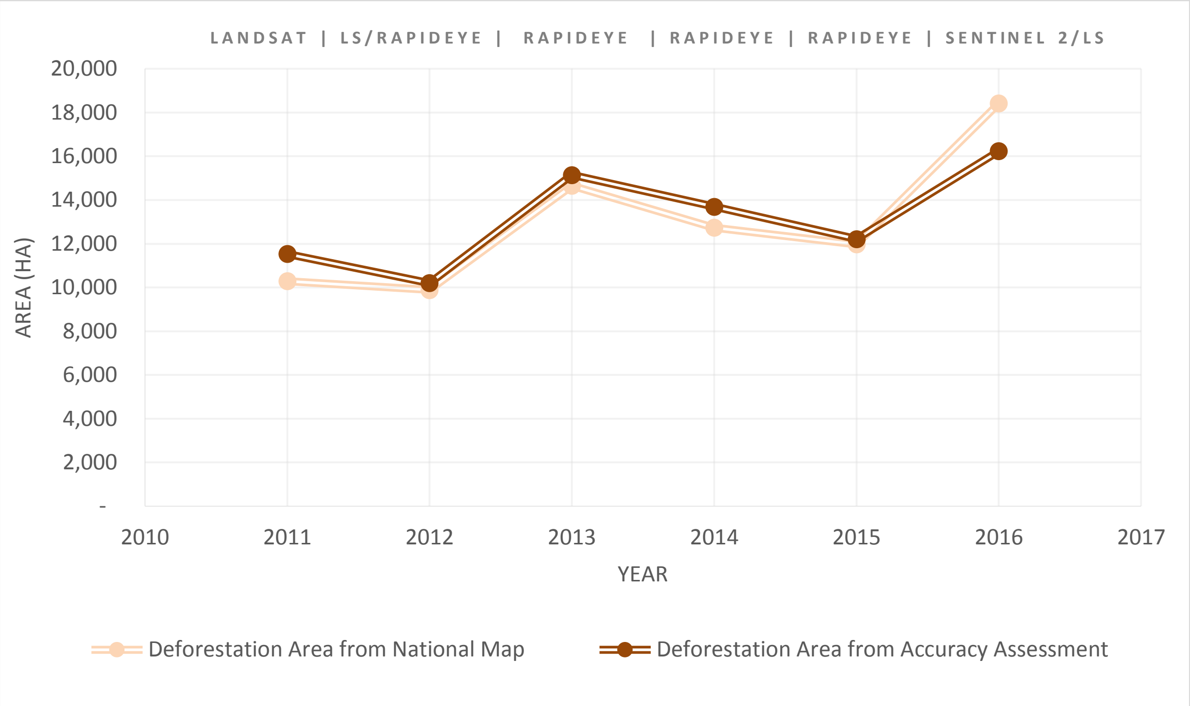
2014 onwards forest monitoring has been conducted using Landsat 8 and Sentinel 2A. Landsat 8 was used for the 2015 period due to insufficient coverage of Sentinel. Sentinel 2A image collection improved for the 2016 year. This position may change with the recent launch of Sentinel 2B (10 m resolution with an image swath of 280 km), effectively doubling the capture rate of Sentinel data.

The formalising the MRV phase II agreement which concluded in September 2017, between GoG/Norway/CI meant that no commercial arrangement with RapidEye was established back in 2016 for the 2015-2016 period. This meant that alternative imagery (Landsat and Sentinel) were evaluated and used to track deforestation events.

The Sentinel and Landsat imagery were assessed to ensure that they overlaid the existing change base maps. Any change events detected with the Landsat 30 m imagery were compared against Sentinel 2 images to confirm the deforestation boundaries. For deforestation the minimum mapping unit is 1 ha so both datasets are appropriate to detect changes of this size.

The spatial resolution of Sentinel is sufficient, in its native format RapidEye pixels are 6.5 m resolution and resampled to 5 m. The increased revisit of the Sentinel satellite (every 5 days) also assists to ensure that change areas are correctly detected, and boundaries defined. Further, the definition of forest has remained the same, the SoP for mapping has remained the same as previous years, and the Accuracy Assessment was also conducted using an independent dataset to the Sentinel dataset.

The assessment of the movement from Rapid Eye to Sentinel was captured through the independent results of the Accuracy Assessment. An analysis of the findings of the Accuracy Assessment, has confirmed that the accuracy of the mapped product from a Rapid Eye data source to a Sentinel coverage map has remained high in the year 6 period.



4.1 Data Structure, Operators and Training

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.

The Year 2 data report recommended a central repository for all spatial information for inter-agency use. GFC holds a consolidated geodatabase of all required GIS datasets. In the latter part of 2014 a partnership with FAO was initiated. This seeks to develop a working model to evaluate the Space Data Management System (SDMS). Potentially, SDMS allows for consolidated online storage of image products that are created during pre-processing. GFC is keen to evaluate this option and run the relevant SDMS modules in parallel to standard MRVS reporting methods adopted by GFC.

As with previous years the relevant datasets that are used for the analysis have been documented and archived. This includes brief metadata about the dataset, its location on the network and anticipated update frequency. Several datasets are actively used and reside on GFC's Forest Resource Information Unit (FRIU) network drive. These datasets are copied into a working folder at the beginning of each year. Care has been taken not to disrupt the structure of FRIU datasets and to avoid duplication of datasets.

GIS and remote sensing data and layers are stored on the dedicated NAS. Image metadata is recorded. Information recorded includes sensor, path and row, and processing applied. New folders are created as these scenes are processed using ENVI image processing software and all associated files generated are also retained.

All images are named using a common format that identifies the satellite, path and row, image date, provider, processing level (e.g. O = orthorectified) and any post-processing that has been applied to register the imagery to a terrain corrected base mosaic (W = warped/co-registered).

The satellite images are all full band stacks in DAT or GeoTiff format. The DAT format is used due to its interoperability between software.

GFC now has six GIS operators and a GIS manager. All desktop computers are running ArcGIS (10) as provided by ESRI under the LCDS assistance program. Two copies of ENVI have also been installed to enable image processing. In addition, several customised toolbars that assist with standardising or automating the mapping process have been developed.

4.2 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 Mininstry 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 Enviroment. This Department of Environment falls under the oversight of the Ministry of the Presidency.

Table 4-1: Agency Datasets Provided

	Agency	Role	Data Held
Ministry 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
	Guyana Lands and Surveys Commission (GL&SC)	Management of land titling and surveying of land	Land tenure, settlement extents and country boundary
Department of Environment	Protected Areas Commission	Management of Protected Areas System in Guyana	Spatial representations of all protected areas

Interim datasets have been provided by GFC, GGMC, GL&SC and thePAC.This is progressively updated as necessary.

4.3 Agency Responsibilities

Guyana Forestry Commission

The GFC is responsible for advising the Minister on issues relating to forest policy, forestry laws and regulations. The Commission is also responsible for the administration and management of all State Forest land. The work of the Commission is guided by a National Forest Plan that has been developed to address the National Forest Policy.

The Commission develops and monitors standards for forest sector operations, develops and implements forest protection and conservation strategies, oversees forest research and provides support and guidance to forest education and training.

The Forest Resource Information Unit (FRIU) holds a range of operational spatial datasets that are used to assist in the management of forest resources.

Guyana Geology Mines Commission

The main functions of GGMC are to:

- Promote mineral development
- Provide technical assistance and advice in mining, mineral processing, mineral utilization and marketing of mineral resources
- Conduct mineral exploration
- Research the areas of exploration and mining, and utilization of minerals and mineral products.

The GGMC also has a role in the enforcement of the conditions of Mining Licenses, Mining Permits, Mining Concessions, Prospecting Licenses (for Large Scale Operations), Prospecting Permits (for Medium and Small-Scale operations) and Quarry Licenses. It is responsible for the collection of rentals, fees, charges and levies payable under the Mining Act.

The GIS section at GGMC routinely collects information using field GPS units. The spatial layer developed holds information on the location of dredge sites and if available the person licensed to operate the dredge. The intention is that this dataset is updated quarterly.

GGMC also holds a spatial layer that defines the location of large and medium scale mining concessions and proposed reconnaissance areas.

The GGMC's role on the MRVS in this second phase is envisaged to include updating the MRVS platform with mining allocation information, receiving mapped deforestation and forest degradation layer and using these results to inform monitoring programmes, using the results to inform potential areas to be closed, and also next steps on EITI and other related programmes.

Guyana Lands & Surveys Commission

The Guyana Lands and Surveys Commission (GL&SC) remit includes the provision of land policy recommendations and draft land use plans to ensure orderly and efficient utilization of public land resources; advise on land surveying matters, and effective and efficient land administration.

- GL&SC also has a GIS unit that creates and provides geographic information. Several base datasets held by GL&SC have been identified as particularly useful. These include:
  - The extent of larger settlements, in particular, Georgetown
  - The location of registered agricultural leases
  - Historical aerial photography not held by GFC.
- Datasets from GGMC and GL&SC were consolidated into the GIS and used to assist with identification of areas undergoing change.

Section 4.4 provides details of image and GIS datasets considered relevant for the continued monitoring and mapping of temporal forest change in Guyana.

The GLSC role in the second phase of the MRVS will be to continuously update the MRVS platform with information regarding Amerindian Land titles and extension, as well as Agriculture Leases, and other allocation administered by the GLSC. Further, it is envisaged that the results of the MRVS will be used to inform current programmatic interventions of the Commission in developing the new National Land Policy and the National Land Use Plan for Guyana.

Protected Areas Commission

In 2012, following the passage of the Protected Areas Act, the Protected Areas Commission was established. The mandate of the PAC is to establish, manage, maintain, promote and expand the National Protected Areas System (NPAS). Under the Protected Areas Act, existing and new State owned protected areas, Amerindian protected areas, privately managed protected areas and urban parks such as the Botanical Gardens and Zoological Park comprise the NPAS, which will be managed by the Protected Areas Commission.

The PAC has an important role to play in the MRVS process whereby an important area of land allocation and management as classified under the MRVS relate to Protected Areas. As such, the MRVS Report on the forest cover change in these areas, as well as loss of IFL, relate directly to Protected Areas. This therefore makes the data inputs from the PAC important to the MRVS process and the results of the reporting, a useful data platform for the PAC.

The PAC's role in this second phase of the MRVS will be to continuously update the MRVS platform on the areas of protection status, and to use the results of the MRVS to enhance planning and decision making for protected areas, including in identifying new sites for protection.

4.4 Monitoring Datasets - Satellite Imagery

In keeping with international best practice, the method applied in this assessment utilizes a wall-to-wall approach that enables complete, consistent, and transparent monitoring of land use and land use changes over time. From 2011 to 2014, GFC commissioned RapidEye coverage to ensure national coverage at a resolution high enough to capture forest degradation as well as deforestation. However, for year 6 period 2015-2016, the GFC has used Sentinel 2A imagery to capture deforestation.

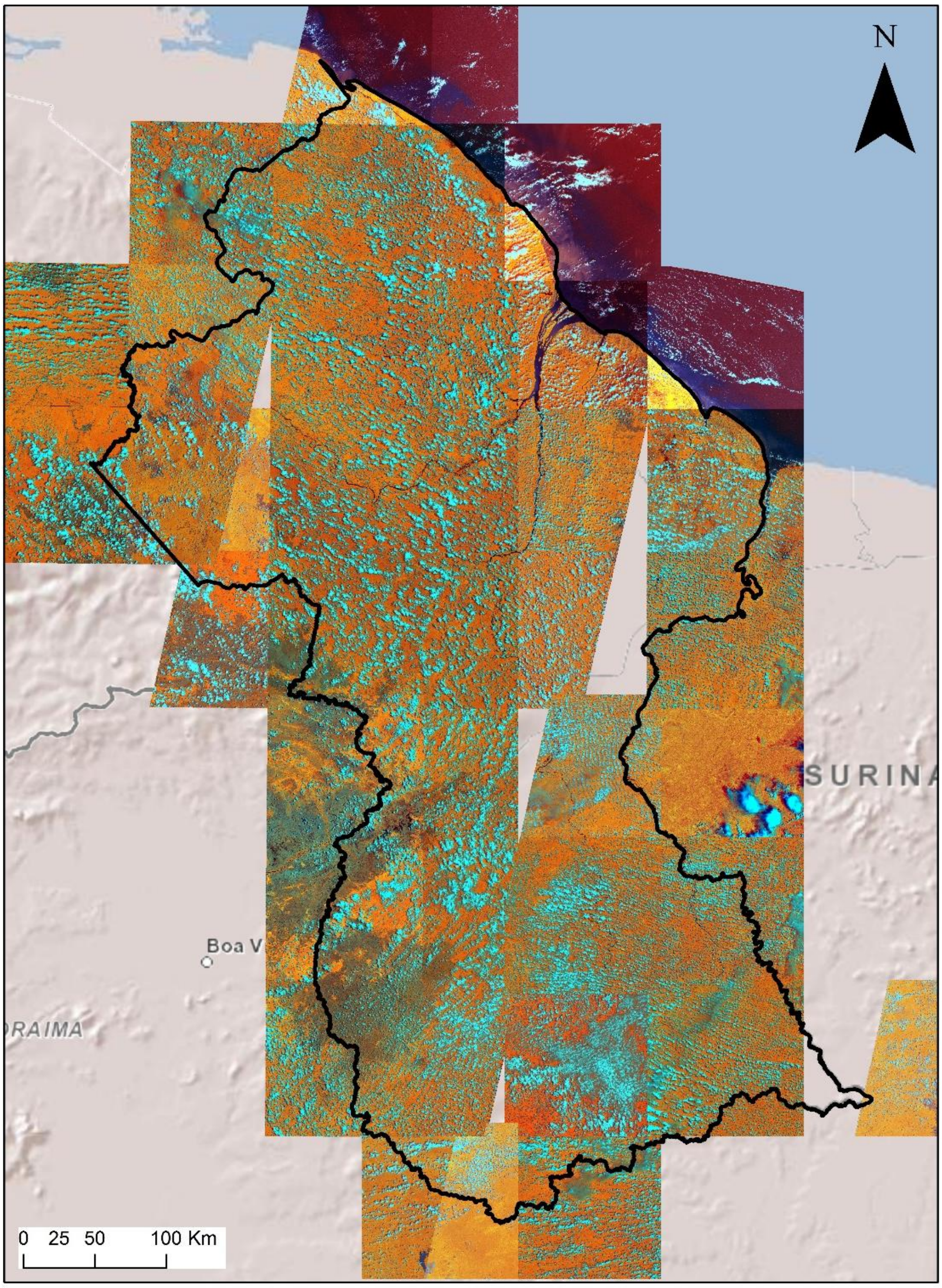
The Sentinel-2 mission is a land monitoring constellation of two satellites that provide high resolution (10 m) optical imagery that provides continuity for the current SPOT and Landsat missions.

The mission provides a global coverage of the Earth's land surface every 10 days with one satellite and 5 days with 2 satellites, making the data a valuable resource for monitoring forest change. The satellites are equipped with the state-of-the-art MSI (Multispectral Imager) instrument that offers high-resolution optical imagery.

Presently, the annual change reporting is geared towards satisfying a series of interim measures. This requires that changes in forest land to other land uses be reported relative to the 2009 Benchmark map. Currently changes occurring in land defined as non-forest are not reported. The basic premise is that eventually changes in the six IPCC categories will be reported for the LULUCF sector.

For the analysis a higher priority is placed on images acquired at the end of each years reporting period, with the majority of images acquired from September to December 2015-16. Due to the typically cloudy nature of satellite imagery over Guyana multiple scenes over the same location are required. Nearly all areas have three separate images covering each footprint. Wall to wall coverage of Landsat imagery for Guyana has been downloaded from the United States Geological Survey (USGS) online catalogue. Sentinel images are downloaded via Google Earth Engine's repository which is linked to ESA's data archive.

Figure 4-1: 2016 Sentinel Coverage



Landsat Data

Landsat 7 imagery at 30 m resolution offers comprehensive temporal coverage over Guyana. This imagery is archived and is freely available and can be sourced from either the United States Geological Survey. However, since May 2003 a scan line correction fault has caused a striping effect on the images. This fault has reduced the utility of Landsat 7 images for automated processing and mapping, although it is still practical to use it visually for monitoring temporal change. The Landsat 7 was utilized as supplementary data for the year 2015 since the Sentinel data was not yet available.

The Landsat Data Continuity Mission moved into its next phase on 11 February 2013 with the launch of Landsat 8. Landsat 8 provides freely available imagery at 30 m resolution. Landsat mission provides the most comprehensive temporal coverage over Guyana. This imagery is archived and is freely available and can be sourced from either the United States Geological Survey (USGS) or National Institute for Space Research (INPE) Brazil. Imagery sourced through USGS comes processed as "L1T" or terrain corrected (using SRTM 90 m DTM), whereas INPE imagery typically does not.

Landsat 8 includes 11 spectral bands from visible (~0.5µm) to thermal (~12µm) wavelengths. Although lower resolution than RapidEye and Sentinel it provides a suitable supplementary data source, and allows timing of change events to be determined.

Figure 4-8: 2015 Landsat 7 Coverage

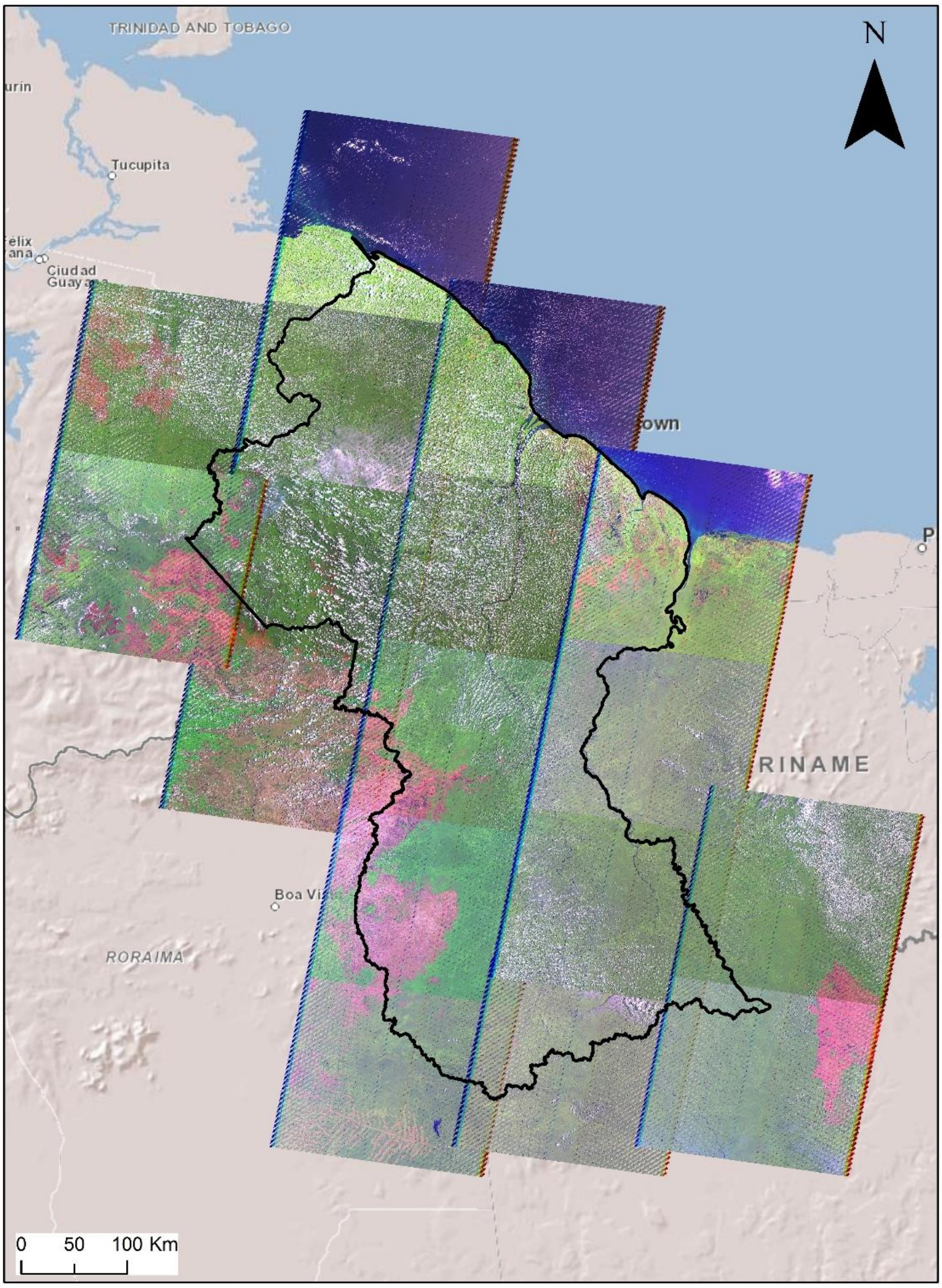


Figure 4-9: 2015 Landsat 8 Coverage

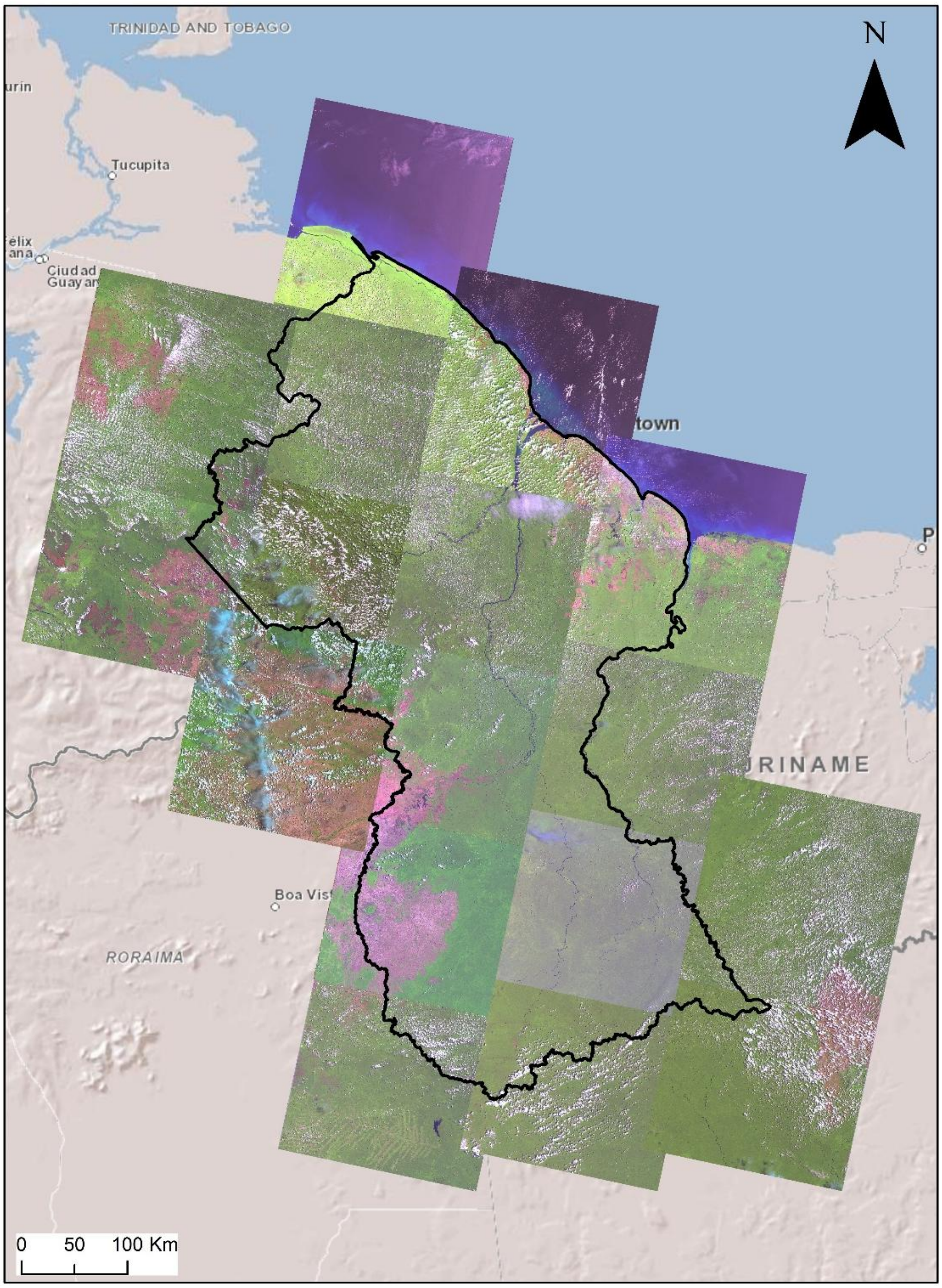
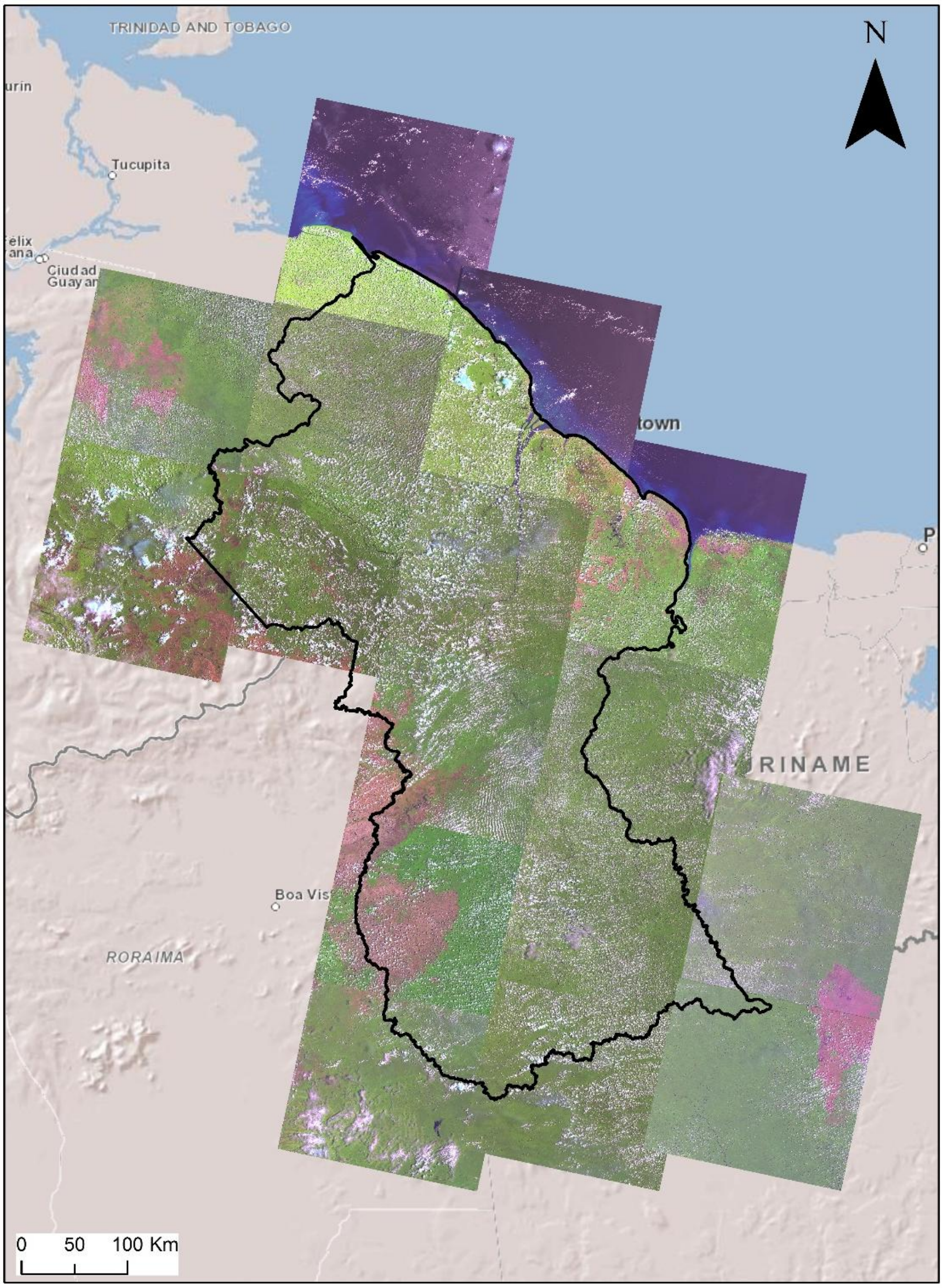


Figure 4-11: 2016 Landsat 8 Coverage



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.). This approach will be continued in year 6. The main refinements in year 6 were the use of the GGE platform for the download of Sentinel imagery, and the addition of the NDVI band in the image processing stage.

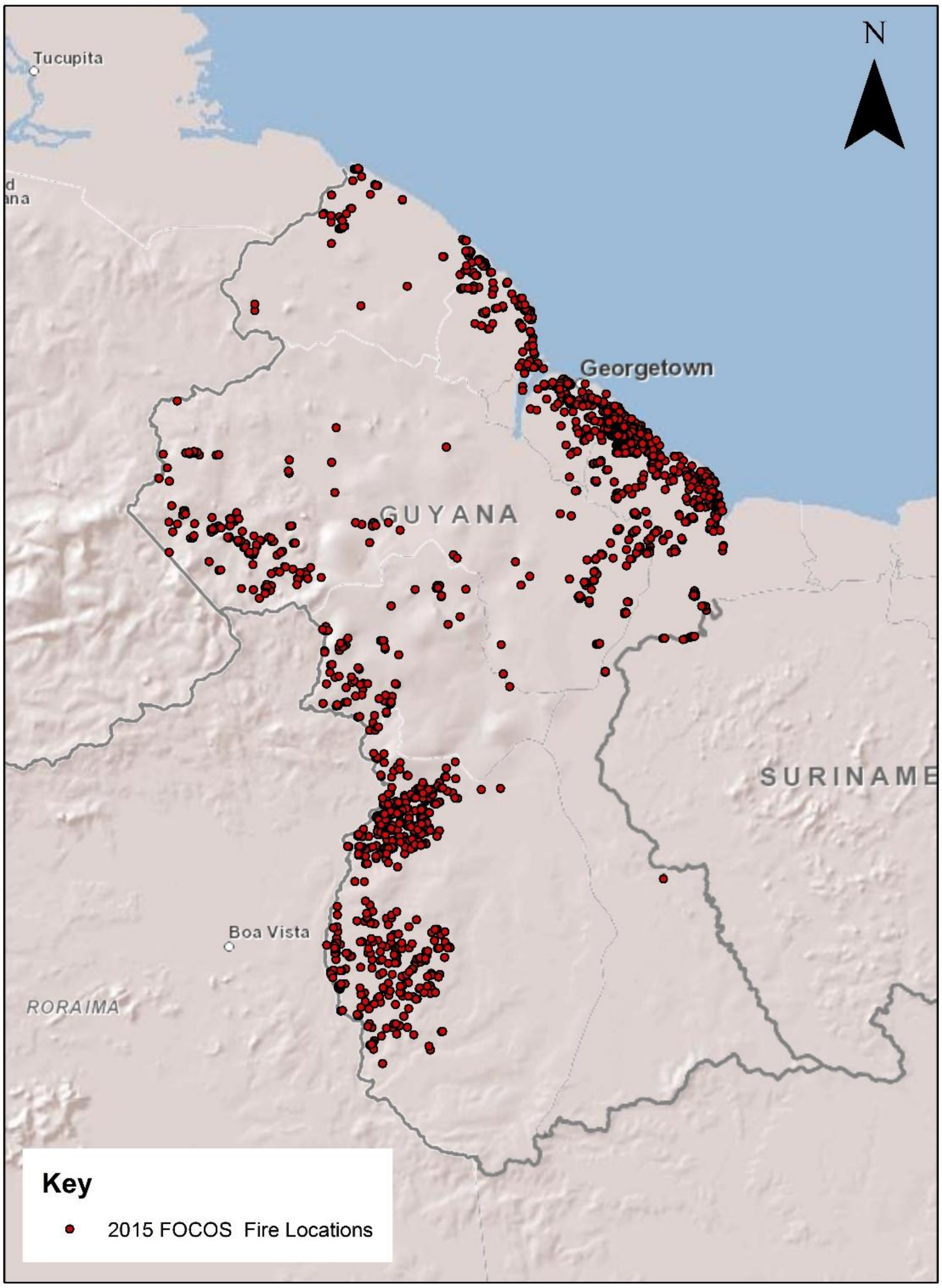
4.5 Additional Ancillary Satellite Images & Fire Datasets

The historical analyses utilised the Fire Information for Resource Management (FIRMS) dataset to assist with detecting fire locations. This information was acquired using the Moderate

Resolution Imaging Spectroradiometer (MODIS).[10] In year 6, this data was also sourced from a South American provider through the FOCOS data search tool. This dataset is used to identify fire risk areas. The presence of fire is confirmed using the images used for detecting forest loss. The maps below show the mapped fire location indicated by the satellites. These are then confirmed through the change detection process.

Figure 4-12 and 4-13 shows the identified fire locations for the analysis period.

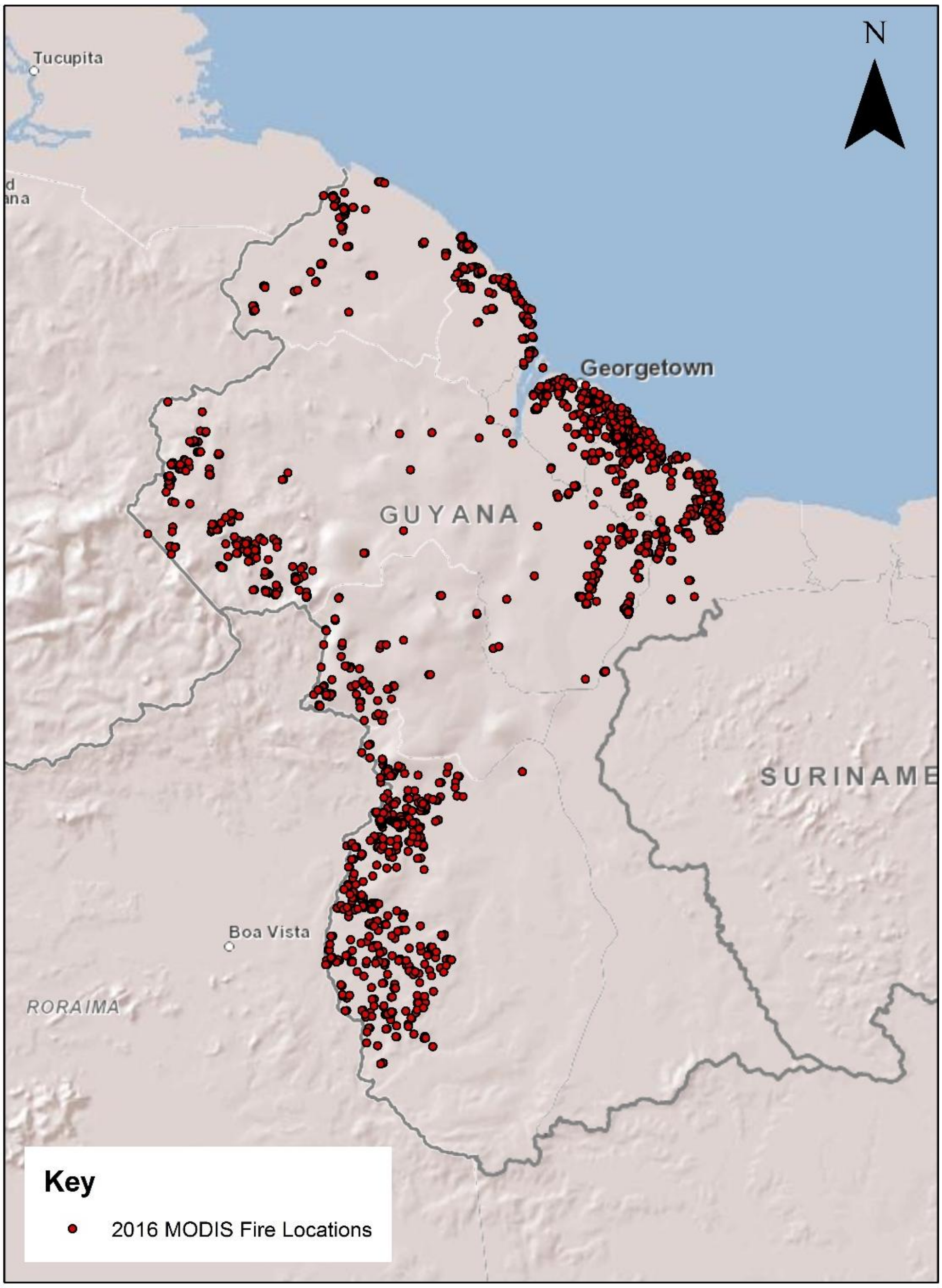
Figure 4-12: 2015 Potential Fire Location Data



The map above presents fire point locations identified by the FOCOS satellite.

[10] MODIS was primarily used as this was sufficient enough given the resolution to detect the fire occurrences. There was no specific need given this level of adequacy to use VIIRS. Also, MODIS was the primary data source for all historic and annual reporting periods for this purpose. FOCOS was used as a supplemental dataset.

Figure 4-13: Potential 2016 Fire Location Data



The map above presents fire point locations identified by the MODIS satellite.

4.6 Accuracy Assessment Datasets

The purpose of the Accuracy Assessment (AA) is to provide an assessment of the quality of the GFC's mapping of land cover land use change across Guyana. It is established practice that data used for accuracy assessment be either an independent interpretation of the same datasets used for the change mapping or, if available, higher resolution data. The results of the independent accuracy assessment and report are provided in Appendix 7.

From 2012 to 2014 high-resolution imagery has been captured using a Cessna mounted aerial multispectral imaging system. The camera system (Aeroptic) 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 stratified random sample that covers the majority of Guyana. The full sample coverage is achieved by including satellite images over areas where it is not possible to safely operate a small aircraft.

For 2015 and 2016 years no aerial capture was undertaken due to the expiry of financing under Phase 1. Consequently, for this period alternative options were evaluated, and PlanetScope images as provided by Planet Labs were used. The Planet constellation comprises approximately 200 satellites micro-satellites imaging areas at (approximately) 3 m resolution. The satellites follow two different orbits namely International Space Station (ISS) and Sun Synchronous Orbit (SSO). The SSO is common to many earth-observing satellites which have a set equator crossing time and acquire images only on descending orbit. The planet satellites in SSO cross equator at 9:30-11:30 acquiring images of an area almost same time in every revisit. The satellites in ISS however have no fixed equatorial crossing time.

For the accuracy assessment only, satellites in the SSO were considered. In keeping with previous years, the same sample transects were analysed. The locations of these transects were provided to Indufor by the independent accuracy assessment team from Durham University, UK. Multiple Planet images acquired (August to December 2016) over the sample site locations were provided to the accuracy assessment team for analysis.

In Year 6, the Accuracy Assessment involved the collection of 313 sample units randomly selected from three forest strata organised by risk of deforestation. The High Risk and Medium Risk strata was assessed using Planet imagery. The Low Risk stratum was assessed using repeat coverage Sentinel imagery.

5. MRVS PHASE II DEVELOPMENT AREAS 2017-2020

Since inception the MRVS has continually been developed and refined. The focus has been on improving the the forest monitoring system and methods as required to document forest change. As the MRVS moves into second phase (2017-2020). The aim is to progressively develop monitoring methods. Key development areas identified and started in year 6 (2017) include the following tasks. The status of each task is identified by the colour code applied with progress towards the milestone described in the following section.

Table 5-1: MRVS Task Overview

Task	Task Description	Milestone dates			
		Year 6-2017	Year 7 2018	Year 8-2019	Year 9-2020
1	Acquire Satellite Data Coverage of Guyana at National Scale for each assessment period. Incl. Data consolidation Report	Dec-31	Jun-30	Apr-30	Jun-30
		Oct-31	Jul-30	Jun-30	Jun-30
2	Conduct national mapping and assessment of change in Forest Area, incorporate advances as necessary and required	Dec-31	Nov-31	Oct-30	Oct-30
3	Continue support for map verification	Dec-31	Dec-31	Nov-30	Nov-30
4	Continue routine monitoring of emission factors	Dec-31			
5	Report on monitoring forest degradation. Refine the measurement and reporting of forest degradation, logging impacts and reforestation/regrowth	Dec-31	Dec-31		
6	Track REDD+ activities and their impacts		Oct-30		Oct-30
7	Revaluate and submit an improved reference level				Dec-31
8	Assess options for continued forest change monitoring in the "non-REDD+ payment" scenario. Pilot alternative monitoring option piloted years 8 and 9	Dec-31	Dec-31	Mar-30	Sep-30
9	Report and Incorporate new development areas	Dec-31			
10	Improve methodology for treatment of Shifting Cultivation, if deemed necessary	Dec-31			
11	Explore Options for near-real time monitoring for high priority sites.	Dec-31			
12	Explore options for development of an information platform for access to MRVS results and data.	Dec-31			
13	Develop platform and mechanism for use of MRVS data and results for forest concession monitoring and management	Dec-31	Sep-30		
14	Conduct pilot of use of MRVS data and results through conducting a review of a forest concession agreement	Dec-31			
15	Build capability of local communities and stakeholders to monitor forests		Jul-30	Jul-30	Jul-30
16	Explore options for the use of MRVS data to inform policy and land use management initiatives to address drivers of forest loss (including mining).			Aug-31	
17	Prepare scientific publications and syntheses - 3 science papers, two technical papers MRVS communication materials			Aug-31	Mar-30
18	Engage in South-South collaboration		Oct-30	Oct-30	Oct-30
19	Present lessons from the development and operations of Guyana's MRVS at key international fora.		Oct-30	Oct-30	Oct-30
LEGEND		Complete	In Progress	Post 2017 Planning	

5.1 Forest Mapping and Accuracy Assessment - Tasks 3.1.1 to 3.1.4

These tasks have been completed with the two-year assessment covering year 5 and 6. The deforestation mapping for this period has been completed by the GFC mapping team. The accuracy assessment which includes the calculation of the deforestation and degradation area and associated confidence limits has been completed by the Durham University team.

5.2 Continue Routine Monitoring of Emission Factors and Refine the Measurement of Degradation – Tasks 3.1.5 and 3.1.6

This task includes refinements to the monitoring of both shifting cultivation and degradation activities. It is intended that fieldwork to support this development will commence in 2018 and the findings will contribute to an updated report on shifting cultivation and degradation and as appropriate a revision of Standard Operating Procedures.

Shifting Cultivation

It is noted that there are currently no best practice methodologies for doing this, especially on a national-scale. The areas of focus include:

1. Reviewing the minimum mapping unit for shifting cultivation
2. Review of time series satellite images to determine the rotation length and extent of shifting cultivation.
3. Determine if there is a difference between rotational and pioneer
4. Coordinate with the forest carbon measurement team to determine an appropriate Emission Factor.

Forest Degradation

In 2018 it is proposed that a review of forest degradation drivers is undertaken to further consolidate the activities that fall under this category, namely, degradation due to mining, areas under forest management and areas degraded by fire. The main development is the availability of high resolution repeat observations as available from Sentinel series of satellites. The increased temporal frequency is expected to enable more frequent reporting.

The initial forest degradation method as applied to mining was developed in 2011. This work showed that in Guyana forest degradation around mining sites is unique, with the main contributors being the opening of roads linked to new infrastructure, and degradation mainly associated with mining activity - which is dynamic. The method adopted high resolution 5 m RapidEye to determine the impact of degradation, and was supported by field inspections that measured the stock changes caused by degradation. The field assessment involved the establishment of field transects 20 m in width from the edge of deforestation events. The field measurements suggest that infrastructure-related degradation is restricted to the immediate area around the deforestation site.

Monitoring Forest Degradation - Areas under Forest Management

The current interim measure uses post-2008 timber volumes applies the Gain Loss Method based on forest harvest and illegal logging volumes. These values are then compared to the mean volume from 2003-2008. Previous work evaluated the ability of RapidEye to provide supplemental information through the detection of harvest and roading activities. The field assessment covered a range of clearance activities associated with forest harvest. These included the formation of roads (primary, secondary and skid trails), log markets, and harvesting operations.

The main findings of this earlier work concluded that the current interim measure which uses the Gain Loss method be retained due to the following observations:

1. The assessment showed that individual canopy openings are too small for detection in high resolution imagery such as RapidEye. A possible exception is if the operations

are recent and the harvesting is clustered. However, even in such cases, the harvest yield is relatively low, and it is difficult to detect a change in forest cover.

2. The size of secondary access roads is small (road widths ~3-4 m). Unless detected during formation it is likely that these roads will remain undetected. It is possible to detect larger roads wider than 10 m.

The 2018 fieldwork aims to re-evaluate these findings by:

1. Using selected field sites to relate airborne and satellite imagery to field observations (using existing fieldwork SOPs).
2. Evaluating the ability of frequent satellite observations such as Sentinel 2, Planet Labs to detect and map degradation activities.

The outcome will as appropriate update the existing methods, SOPs and reporting IPCC GPG formats.

Monitoring Forest Degradation on Sites Affected by Fire

Currently the impacts of human induced or anthropogenic forest fires is included in the assessment of the associated emissions (Interim Measure 5). The interim performance indicator is the area burnt each year decreasing compared to the current area.

In Guyana the cause of fires (biomass burning) is associated with forest cover change which, based on local knowledge, is largely human induced. The current detection method uses information from the Fire Information for Resource Management System (FIRMS)

In 2012 the detection of forest fires changed to using high resolution 5 m imagery and FIRMS data. The successful detection of burnt areas depends on the intensity and the scale of the fire.

The land classes attributed can be either deforestation, if it leads to a permanent land use change from forest land to non-forest (>1 ha), or forest degradation, if the area burnt does not lead to a land cover change. Overall the fire detection methodology has been improved by the inclusion of higher resolution imagery.

These improvements have been incorporated into the mapping guidelines; the Standard Operating Procedures (SOP) and will be further evaluated in 2018 using Sentinel images.

Monitoring Reforestation of Mining Areas & Roads

Previous work has also evaluated reforestation, the plus in REDD+. The reforestation aspect looks at the potential for identifying regeneration (carbon stock accumulation) of abandoned mining sites and roads.

At that time changes in the vegetative cover were detected, however it was difficult to determine the composition or structure of this cover. Field inspections indicate that biomass recovery is slow (i.e. little measurable woody vegetation >2 cm recorded) due to the degree of disturbance.

The main findings of the 2011-2012 study indicated that:

1. The field inspections indicate that the rate of regeneration is very slow. In all historical mining sites visited (period 1990 to 2012) the forest cover had not regenerated to a state where the biomass is measurable.
2. Abandoned mining sites can be detected and monitored using high-resolution imagery.

It is proposed that in 2018 that these areas are re-evaluated using Sentinel 2 imagery. This analysis will be linked to the carbon stock monitor program.

5.3 Assess Options for Continued Forest Change Monitoring. Task 3.1.9

Improvements to the forest monitoring system are planned to start in 2018. These seek to consolidate results of previous efforts to test the use of low and no-cost technology options for the MRVS, explore new and emerging technology options, including new remote sensing products and Open Source software. The intention is to pilot the implementation of preferred option for new methods in parallel with current system for at least 2 years. Planned to be completed in year 7 and piloted in years 8 and 9.

Other related tasks are interlinked and build from previous MRVS developments. These are outlined in Table 5-2. Planning and analysis for several tasks has started as documented in Appendix 1.

Table 5-2: MRVS Tasks and Development Areas

Task	Description	Activities
3.1.10	Report and Incorporate new development areas	Further refinement of methods to quantify afforestation resulting from regenerating non-forest areas, and studies to show the carbon accumulation rate on abandoned mining sites. This work links in with Guyana's planned mining reclamation project and the consideration of appropriate emission factors. Integration of new satellite sensors into the MRV such as. Sentinel 2A & Planet Labs, as well as RADAR. An accuracy evaluation of Sentinel 2A is proposed prior to integration into future MRV reporting Tracking of degradation to assess the areas transitioning from degradation to deforestation and those areas that are reforesting. Incorporation of deforestation modelling methods to predict future deforestation patterns, building on work done to date based on both econometric modelling for mining and timber production and spatial modelling for mining
3.1.11	Improve methodology for treatment of Shifting Cultivation, if deemed necessary	As presented in Section 5.2
3.1.12	Explore Options for near-real time monitoring for high priority sites.	Test different data streams and their usefulness and integration for near-real time monitoring of forest changes and REDD+ implementation starting in high priority sites. - Develop a framework to use near-real time monitoring to ensure compliance of deforestation agents and link into the same data sharing platform. - Develop a framework to use near-real time monitoring to ensure compliance of deforestation agents. - Produce a Report documenting results of near real-time monitoring tests and pilot system.
3.1.13	Explore options for development of an information platform for access to MRVS results and data.	Using data housed under the MRVS from the period 1990 to 2014, collated under phase 1 of the MRVS, develop a platform for use of data and results at concession level. This platform could potentially be extended to encourage data sharing between agencies, communities and for hosting near-real time deforestation updates. - Explore options for further development of an information platform with the Ministry of Natural Resources. - Conduct a feasibility study and explore identified options from previous experiences (i.e. TerraAmazon or TerraCongo, Google EarthEngine) and develop a plan on which data to use for this purpose - Explore making Guyana's MRVS data and information (results) available through the Global Forest Watch platform.
3.1.14	Develop platform and mechanism for use of MRVS data and results for forest concession monitoring and management	Implement the platform and use it as active communication and feedback tool between the Ministry of Natural Resources, the Guyana Forestry Commission, and forest owner and managers. - Establish reporting framework for collating MRVS at concession level.

6. SPATIAL MAPPING OF LAND COVER CHANGE

The 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. For Year 6, deforestation was mapped manually using a combination of repeat coverage Landsat and Sentinel 2 images. The area of degradation was estimated using the accuracy assessment (See Appendix 7).

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

6.1 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 would not be considered deforested as they can regain the elected crown cover threshold.

The five historic anthropogenic change drivers that lead to deforestation include:

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

In Year 4, a new driver ‘settlements’ was added to the driver matrix. It allows the team to describe human settlement driven change such as new housing developments.

6.2 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* ".

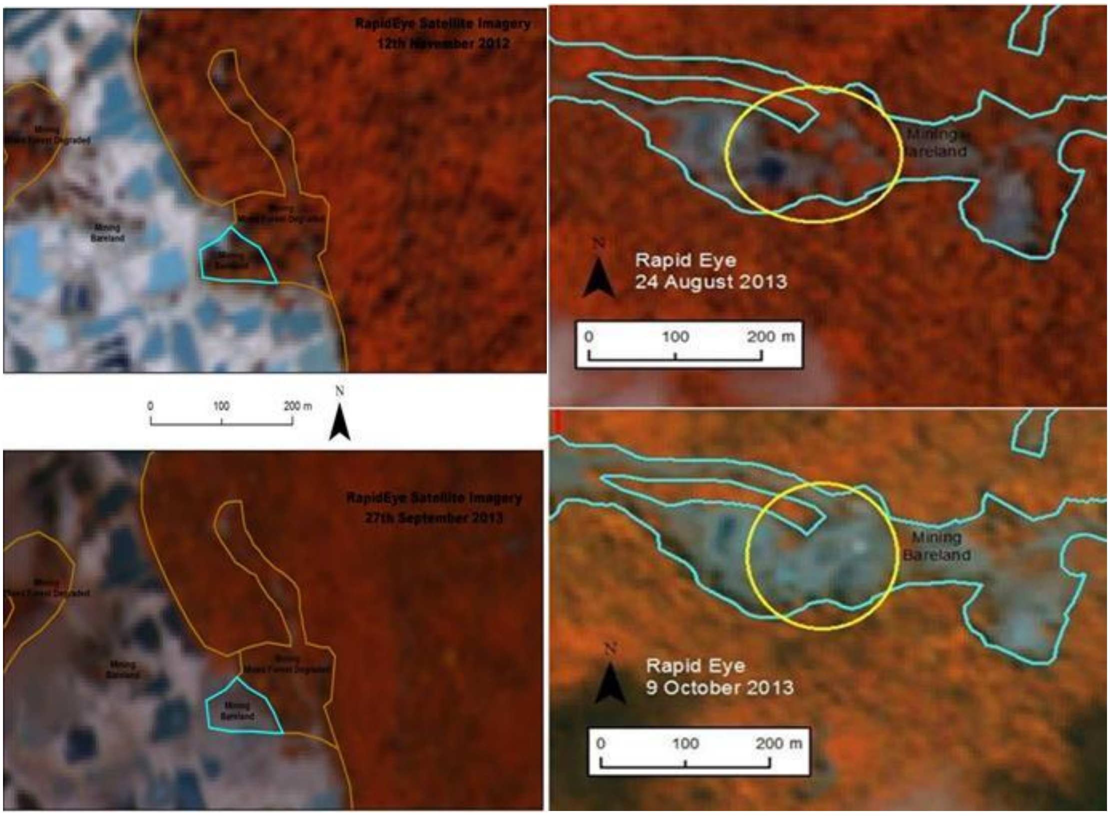
The main sources of degradation are identified as:

- Harvesting of timber (reported since 2011 using the Gain Loss Method)
- Shifting cultivation (prototype method developed in 2012)
- Fire
- Associated with mining sites and road infrastructure.

Image evidence and fieldwork over the last two years has shown that each of these drivers produce a significantly different type of forest degradation. Shifting agriculture and 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, and often is not persistent in nature. Often the sites are either in transition to deforestation or are only temporarily degraded.

Figure 5-1 shows two sites in transition from a degraded forest state to full deforestation.

Figure 5-1: Degradation Transitioning to Deforestation



In the above examples the edge of a deforestation site moves from a degraded to a deforested state. Figure 5-2 shows an abandoned mining site, only affected temporarily before moving back into a revegetated state.

Figure 5-2: Abandoned Mining Site

6.3 Change Analysis

To facilitate the analysis Guyana has been divided into a series of regularly spaced grids. The mapping process involves a systematic review of each 24 x 24 km tile, divided into 1 km x 1 km tiles at a resolution of 1:8000.

If cloud is present, then multiple images over that location are reviewed. The process involves a systematic tile-based manual change detection analysis in the GIS.

Each change is attributed with the acquisition date of the pre-and post change image, driver of change event, and resultant land use class. A set of mapping rules has been established that dictate how each event is classified and recorded in the GIS.

The input process is standardised using a customised GIS tool which provides a series of pre-set selections that are saved as feature classes. The mapping process is divided into mapping and QC. The QC team operates independently to the mapping team and is responsible for reviewing each tile as it is completed.

The following table provides an overview of drivers and associated deforestation or degradation activities that are reported spatially in the GIS as part of the MRVS. Appropriate methods have been established for all activities. Reforestation/Afforestation is the only activity not yet reported in the MRVS. The identification of the driver of specific land-use change depends on the characteristics of the change. Certainty is improved by considering the shape, location and context of the change in combination with its spectral properties.

Table 5-3: Summary of Activities & Drivers Captured in the GIS

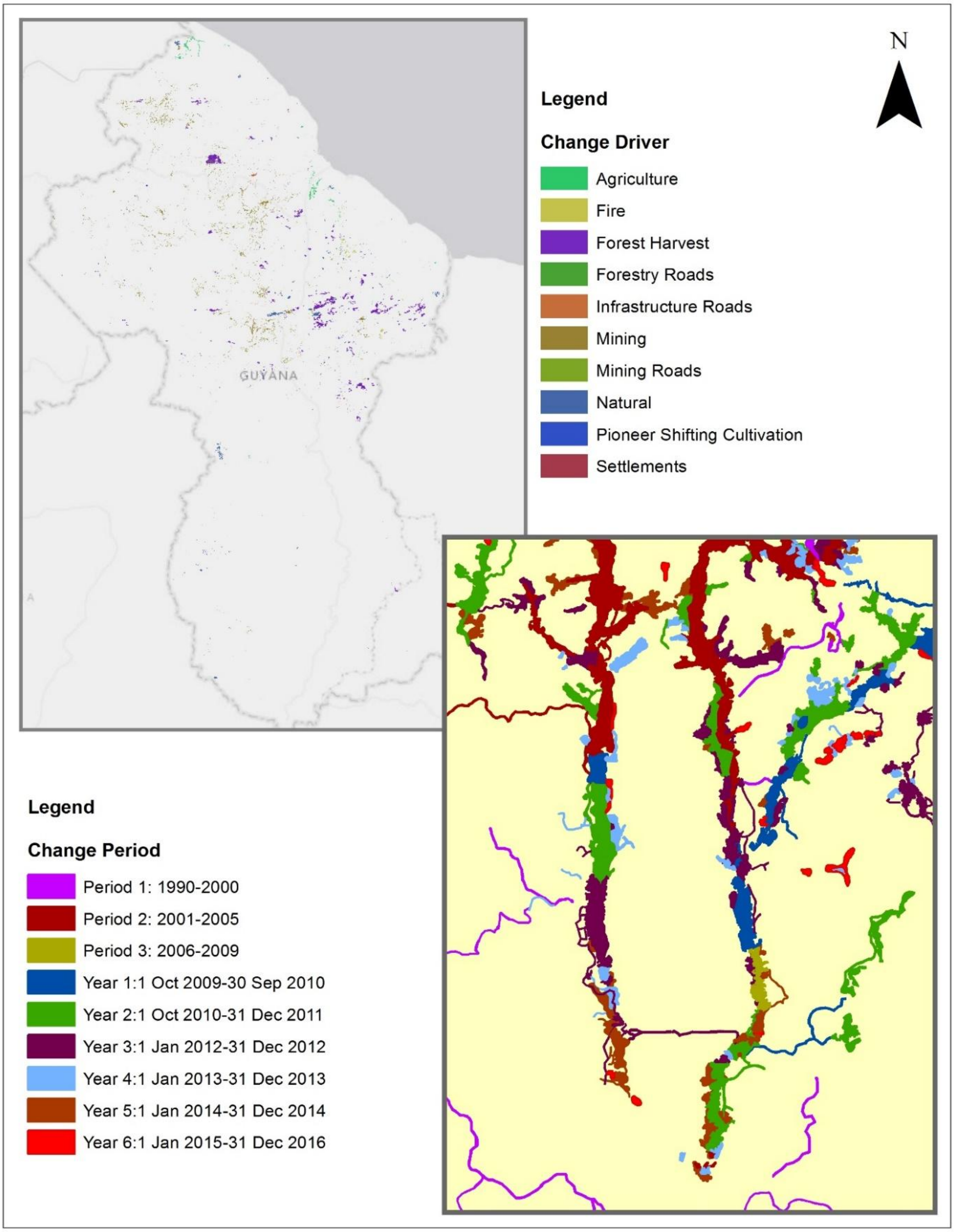
Activity	Driver	Criteria	Ancillary Info Available	Spatially Mapped	End Land Use Class
Forestry	SFM	Fall inside state forest area and is a registered concession	Annual harvest plans, GIS extent of concession, previously mapped layers, Satellite imagery	No. Volumetric measure used	Degraded forest by type
	Infrastructure	Roads > 10m		Yes	Settlements
Settlements	Settlements	Areas of new human settlement	Population data, image evidence.	Yes	Settlements
Mining	Infrastructure	Roads >10 m	Existing road network, Satellite imagery	Yes	Settlements
	Deforestation	Deforestation sites > 1 ha	Dredge sites, GIS extent of mining concessions, previously mapped layers, Satellite imagery	Yes	Bareland
	Degradation	Assess any area >0.5 ha within 100 m buffer around deforestation event &– road or new infrastructure -revisit sites post 2011to assess change	Existing infrastructure incl. deforestation sites post 2011, Satellite imagery	Mapped in the accuracy assessment	Degraded forest by type
Agriculture	Deforestation	Deforestation sites > 1 ha	Registered agricultural leases, Satellite imagery	Yes	Bareland or crop land
Fire	Deforestation	Deforestation sites > 1 ha	FIRMs fire points, spatial trends from preceding periods, Satellite imagery	Yes	Bareland or crop land
	Degradation	Degraded forest sites		Mapped in the accuracy assessment	Degraded forest by type
Infrastructure	Deforestation	Roads >10 m	Existing road network Satellite imagery	Yes	Settlements
	Degradation	Assess any area >0.5 ha within 100 m buffer around deforestation event – road or new infrastructure - revisit sites post 2011 to assess change	Existing deforestation sites, Satellite imagery	Mapped in the accuracy assessment	Degraded forest by type
Shifting Agriculture	Degradation	Assess historical patterns	Proximity to rural populations, water sources and Satellite imagery	Mapped in the accuracy assessment	Degraded forest by type
Reforestation/ Afforestation	Reforestation	Monitor abandoned deforestation sites	Historical land use change, Satellite images	Yes	Reforestation Forest or land cover by type
	Afforestation	Monitor historical non-forest areas	Satellite imagery	Yes	Afforestation by land cover class.

Previous assessments and specific projects show that the spatial distribution of change in Guyana follows a pattern and is clustered around existing access routes (GFC Year 1 & 2; 2010, 11; Watt & von Veh, 2009 & von Veh & Watt 2010).

Potentially there is some overlap between drivers as the exact cause of the forest change can be difficult to determine. This is particularly relevant when deciding on the driver of road construction when mining and forestry areas use the same access routes.

Supplementary GIS layers are also included in the decision-making process to reduce this uncertainty. The decision-based rules are outlined in the mapping guidance documentation. This documentation, held at GFC, provides a comprehensive overview of the mapping process and rules. The following example provides an overview of the detail captured in the GIS. Evident are temporal changes in forest cover due to a range of forest change drivers.

Figure 5-3: Example of Forest Change Mapping



6.4 Land Use Changes Not (Spatially) Recorded in the MRVS

There are several land cover changes that are not reported spatially in the MRVS at this stage. For completeness the general extent of these areas is mapped to ensure that they are not accounted for as measured land use change – these are listed as follow:

Forest Harvest

Forest harvest activities are accounted for using extraction records. Large concessionaires are required to submit annual plans to GFC that show intended harvesting activities. All blocks require approval before harvesting may commence. This information is recorded in the GIS by GFC and as practical are tracked using satellite imagery.

On the satellite imagery forestry activity within the State Forest Area is often first identified by the appearance of roading and the degradation caused by surrounding selective harvest areas.

These areas are delineated as a single polygon around the spatial extent of the impacted area (degradation as a result of forest harvest). Following this, a land use class of degraded forest by the forest type is assigned.

Natural Events

Natural events are considered non-anthropogenic change, so do not contribute to deforestation or degradation figures. These changes are typically non-uniform in shape and have no evidence of anthropogenic activity nearby. While these are not recorded in the MRVS, they are mapped in the GIS. These areas are attributed with a land class of degraded forest by forest type or bareland as appropriate.

Afforestation and Reforestation

These are recommended to be integrated when REDD+ Strategy implementation takes effect. In the interim, some consideration will be given to quantifying natural regeneration. However the emphasis will be on imlementaiton of REDD+ strategy actions that result in afforestation and reforestation impacts.

7. FOREST CHANGE

The results summarise the Year 6 period (1 January 2015 to 31 December 2016) forest change. This includes estimates of deforestation and degradation for all land eligible under Guyana’s LCDS.

As was first introduced in Year 4 and agreed under the JCN, infrastructure associated with the construction of the Amaila Falls hydro power development is itemised separately.

For reference, historical changes relating to the benchmark period (1990 to 30 September 2009 and Year 1 (01 October 2009 to 30 September 2010) are also provided.

Previously 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 area as necessary is continually updated using satellite images. This results the forest/non-forest boundaries being improved over time.

As with previous assessments forest is defined in accordance with Guyana's national definition of forest. This has remained consistent across the historic benchmark period, and Years 1, 2 and 3.

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 the University of Durham (UoD, 2010 and 2011). By 2011 the forest cover had reduced to 18.38 million ha due to deforestation. In 2012 the forest cover was reassessed using high resolution imagery resulting in the baseline figure increased to 18.5 million ha. Further updates were made in 2014, with the starting forest area revised to 18.48 million ha.

The results for each period are further divided by the five forest change drivers. This information is used to provide indicative trends for the periods analysed.

Additional factors that should be considered when evaluating the forest change results include:

- Forest change reported for the Year 6 period is based on interpretation of satellite images acquired for the last four months of 2015 and 2016.
- The reporting of reforestation of previously forested sites is still under review. This is currently in the design phase, and will be reviewed in 2018. Many of these sites are abandoned mining areas. Biomass recovery is known to be very slow. The areas are brought into the MRVS as deforested areas, meaning it is possible to revisit these sites and monitor vegetation changes over time. In this way it is possible to allocate carbon accumulation rates once these are established.
- The current SOP states that roads visible on the images >10 m in width should be included in the analysis. All roads are treated as deforestation events. Lower resolution images drawn from Landsat and Sentinel were used in this assessment. The implication is that some roads between 10 to 20 m in width will remain undetected. Any underestimates are likely to be identified in the accuracy assessment which uses 3 m Planet Labs imagery.

7.1 Changes in Guyana's Forested Area 1990-2014

Historical Analysis

The historical analysis indicates that the total area converted from forest to non-forest between 1990 and 2009 was 74 917 ha. This was calculated by subtracting the initial 1990 forest area as mapped in the GIS from the 2009 September forest area (~19.75 years).

This estimate included all forest to non-forest change i.e. detected mining, road infrastructure, agricultural conversion and fire events that result in deforestation. It does not include forest degradation caused by selective harvesting, fire or shifting agriculture.

The same approach and criteria was applied to calculate the area of deforestation from 2009 to 2010 (Year 1 period). The total area of deforestation for this period was calculated at 10 287 ha. In Year 2 the change figure was similar and reported as 9 891 ha, with a rise in deforestation seen in Year 3 to 14 655 ha. In Year 4 the total area of deforestation was 12 733 ha and Year 5 a decline to 11 975 ha, a decrease of some 758 ha when compared to Year 4.

7.2 Year 6 Analysis

For Year 6 the total area of deforestation over the 24-month period is calculated at 18 416 ha. From an annual perspective, this is 9 208 ha annually. This is a decrease of some 2 767 ha when compared to Year 5.

The total change and change expressed as a percentage of forest remaining is provided in Table 7-1.

Table 7-1: Area Deforested 1990 to 2016

Period	Years	Image Resolution	Forest Area ('000 ha)	Change ('000 ha)	Annualised Change Rate (%)
Initial forest area 1990		30 m	18 473.39		
Benchmark (Sept 2009)	19.75	30 m	18 398.48	74.92	0.021
Year 1 (Sept 2010)	1	30 m	18 388.19	10.28	0.056
Year 2 (Oct 2010 to Dec 2011)	1.25	30 m & 5 m	18 378.30	9.88	0.054
Year 3 (Jan 2012 to Dec 2012)	1	5 m	*18 487.88	14.65	0.079
Year 4 (Jan 2013 to Dec 2013)	1	5 m	18 475.14	12.73	0.068
Year 5 (Jan 2014 to Dec 2014)	1	5 m	**18 470.57	11.98	0.065
Year 6 (Jan 2015 to Dec 2016)	2	10 m & 30 m	18 452.16	18.42	0.050

*A new start forest area is used from year 2 to year 4 as the analyses were undertaken using 5m resolution imagery and a 5m resolution updated non-forest basemap. This is further explained in section 1.3

**A new start forest area is used from year 5 forward. This is further explained in section 1.3

Based on the initial 1990 forest area, the forest cover change for the cumulative 1990-2009 period is estimated at 0.41% (i.e.<1%). As with Year 1, the FAO (1995) equation as cited in Puyravaud (2003) has been used to calculate the annual rate of change. Puyravaud (2003) suggests an alternative to this equation, but at low rates of deforestation the two equations are essentially the same.

Equation 7-1: Rate of Forest Change

$$q = \left(\frac{A_2}{A_1}\right)^{1/(t_2-t_1)} - 1$$

Whereby the annual rate of change (%/yr or ha/yr) is calculated by determining the forest cover A_1 and A_2 at time periods t_1 and t_2.

If the 1990-2009 period is annualised this represents an average rate of change of about 3 800 ha per year, which is equivalent to a deforestation rate of 0.02% (loss) per year.

From this point the deforestation increased for the Year 1 period to 0.06% and has remained at a similar level for Year 2 (0.054%). The rate is in fact lower (0.043%) if the change is expressed as an annual rate rather than presented for the entire Year 2 period.

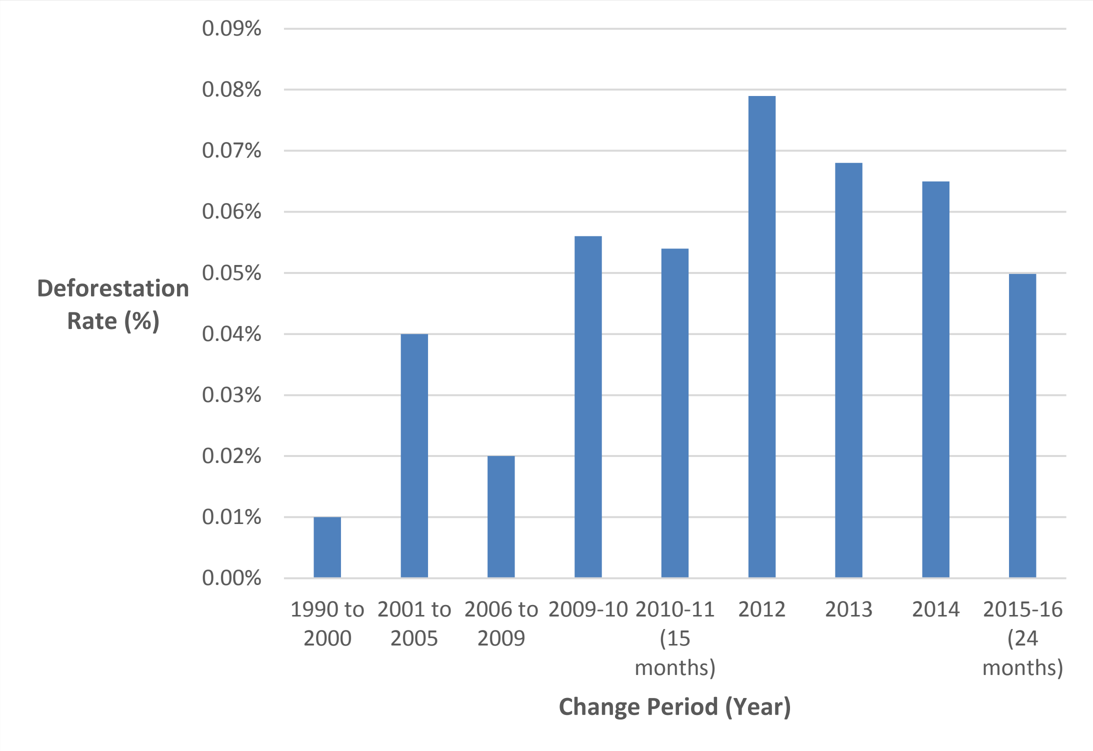
In Year 3 the deforestation rate increased relative to previous years to 0.079%, but in Year 4 a decrease has occurred to 0.068%

Overall, Guyana's Year 4 deforestation rate is low when compared to the rest of South America, which according to the FAO 2015 forest resource assessment (FRA) natural forest is tracking at an annual deforestation rate of -0.43%/yr[11].

The following figure shows the annualised deforestation trends for all change periods.

The trend shows that deforestation rates have increased since 1990 and peaked in 2012 (0.079%). Since 2012 (Year 3), there has been a steady decline in annual deforestation rates; 0.068% in Year 4, 0.065% in Year 5 and an annualised rate of 0.050% for Year 6.

Figure 7-1: Annual Rate of Deforestation by Period from 1990 to 2016



7.3 Forest Change by Driver

The forest change was divided and assessed by driver. For this assessment degradation values are drawn from the accuracy assessment results. Details of this methodology are included in Appendix 7.

Table 7-2 provides a breakdown by forest change drivers for Years 1 to 6. Interpretation of the change areas during the benchmark period identifies mining (which includes mining infrastructure) as the leading contributor of deforestation (~60% of the total), particularly between 2001 and 2005.

The area of deforestation attributed to mining (which includes mining infrastructure) has decreased from Year 5 (10 191) to Year 6 (6 782 ha - annualissed). Deforestation attributed to mining accounts for approximately 85% of all recorded deforestation in 2014 (Year 5) and 74% in year 6.

[11] Change rate based on 14 countries and territories – Guyana values not included in the report. Source http://www.fao.org/3/a-i4793e.pdf

Table 7-2: Forest Change Area by Period & Driver from 1990 to 2016[5]

Driver	Historical Period			Year 1	Year 2 2010-11 (15 months)		Year 3 2012		Year 4 2013		Year 5 2014		Year 6 2016 (24 months)	
	1990 to 2000	2001 to 2005	2006 to 2009	2009-10	Deforestation	Degradation	Deforestation	Degradation	Deforestation	Degradation	Deforestation	Degradation	Deforestation	Degrad.
	Area (ha)													
[1]Forestry (including forestry infrastructure)	6 094	8 420	4 784	294	233	147	240	113	330	85	204	62	313	
Agriculture (permanent)	2 030	2 852	1 797	513	52	-	440	0	424	-	817	-	379	
[2]Mining (includes mining infrastructure)	10 843	21 438	12 624	9 384	9 175	5 287	13 516	1 629	[2]11 251	2 955	10 191	3 674	6 782	5 679
Infrastructure	590	1 304	195	64	148	5	127	13	278	112	141	63	217	
Settlements									23	20	71	-	8	
Fire	1 708	235		32	58	28	184	208	96	395	259	265	1 509	762
Shifting Agriculture										765		167	-	93
Year 2 forest degradation converted to deforestation							148		67		22			
Year 3 forest degradation converted to deforestation									200		94			
[3]Year 4 forest degradation converted to deforestation											127			
[4]Amaila Falls Development (Infrastructure roads)					225				64	20	49	20	-	-
Area Change	**21 267**	**34 249**	**19 400**	**10 287**	**9 891**	**5 467**	**14 655**	**1 963**	**12 733**	**4 352**	**11 975**	**4 251**	**9 208**	**6 534**
Area Change less Shifting Agriculture										**3 587**		**4 064**		**6 441**
Total Forest Area of Guyana	18 473 394	18 452 127	18 417 878	18 398 478	18 388 190		**18 502 531**		18 487 876		[5]**18 482 547**		18 470 572	
[6]Total Forest Area of Guyana Remaining	18 452 127	18 417 878	18 398 478	18 388 190	18 378 299		18 487 876		18 475 143		18 470 572		[7]18 452 156	
Period Deforestation (%)	0.01%	0.04%	0.02%	0.056%	0.054%		0.079%		0.068%		0.065%		0.05%	

[1]Forestry infrastructure accounts for the full total of deforestation from forestry activities.

[2]Mining Infrastructure accounts for 918 ha in 2013 out of the total deforestation driven by mining of 11 518 ha, when Year 2 & 3 transitional areas are considered.

[3]Areas transitioning from degradation to deforestation have not been recorded in year 6 due to insufficient funding to purchase RapidEye images. This task will recommence in Year 7

[4]Amaila Falls Development has been split from other infrastructure driven change for reporting purposes. Development on this project ceased in 2015. No further clearance activities have been undertaken.

[5]Using the updated start forest area as derived from Year 5 mapping.

[6]Area change totals may vary between 1 to 3 hectares owing to the rounding of numbers.

[7]The quoted total forest area of Guyana remaining is the start forest area (18 470 572) less the 24-month deforestation value from Year 6. I.e. Year 6 area change multiplied by 2 since the table is annualised.

7.4 Forest Degradation

The area of degradation near deforestation events in Year 1 was estimated as 92 413 ha – which was calculated using the default method outlined in the Norway/Guyana JCN. In Year 2 infrastructure as measured from satellite imagery was estimated at 5 467 ha. This figure is substantially lower than the figure previously reported.

The difference is due to implementation of a revised and more precise methodology for degradation assessment. In the Year 1 assessment it was not possible to reliably measure degradation from Landsat type imagery (30 m) due to the resolution of the imagery, and the scale of degradation events in Guyana. From Year 2 onwards the approach was changed, and high-resolution imagery was used to identify forest degradation events.

In Year 5 the area degraded was 4 251 ha (4 064 excluding shifting agriculture) which is a slight decrease from 4 352 ha as reported in Year 4. The fluctuation in areas mapped as degraded does not track with the associated deforested area. It is thought this is due to significant areas near mining sites being degraded in initial activities and then deforested once the site is fully operational. The main driver of degradation in Year 5 was mining which accounts for 87% of all degradation mapped. This is expected as mining also accounts for the largest area of deforestation. The established trend is that forest degradation impacts are largely detected around mining areas.

For this assessment (Year 6), the results from the aerial survey, which have informed the accuracy assessment conducted, have been used. The methods follow the recommendations set out in the GOFC-GOLD guidelines to help identify and quantify uncertainty in the level and rate of deforestation and the amount of degraded forest area in Guyana over the period 01 January 2015 to 31 December 2016 (Interim Measures Period – Year 6). PlanetScope imagery supplemented the aerial survey dataset used to assess change.

Degradation values were calculated based on interpretation of the accuracy assessment samples. A general description is provided as follows: The original sample design was weighted so greater number of samples are interpreted in areas deemed to have a medium to high risk of change – as informed by the historical results of GFC's wall to wall mapping. The degradation value was calculated by reanalysis of the same sampling frame each time the assessment was repeated. In previous assessments the degradation values between GFC and the accuracy assessment fall within the confidence limits of the sampling approach. This correspondence adds a degree of confidence that the degradation events are being captured.

The estimated total area of change in the 24-month Year 6 period from forest to degraded forest (between Y5 and Y6) is 13 068 ha. This represents an annualised rate of 6 534 ha. Of the total degraded area, some 5 679 ha (or 77%) is associated with changes relating to new infrastructure. The largest contributor is mining, followed by roads and settlements. Emissions resulting from anthropogenic forest fires account for 762 ha whilst shifting cultivation contributes 93 ha of degradation, both as annualised rates.

7.5 Transition of Degraded Areas to Deforestation

In previous assessments areas of historical degradation have been revisited. This review checks for any changes in the forest cover and for any expansion. Table 7-3 provides a summary of the area of each land cover class deforested.

Degradation to deforestation was not updated for Year 6. This is because of the transition from RapidEye (Year 5) to Landsat & Sentinel (Year 6) presents issues when tracking this type of change. This is primarily because of the shift to lower resolution satellite data, which results in loss of detail.

Degradation mapped using RapidEye (5 m resolution) will appear as an improvement when reviewed using lower resolution satellite data. This was particularly obvious when using Landsat (30 m) to map change, where Sentinel (10 m) coverage was scarce or impeded by cloud. Due to this inconsistency, it was decided that this transition would not be mapped as it would result in a notable level of uncertainty.

The implementation of Sentinel from Year 6 onwards provides standardised spatial resolution for forthcoming assessments.[12]

Table 7-3: Transition of Degradation to Deforestation Assessment Year 3 to 5

Period	Driver	Start Land Cover Class	Year 3 Deforested (ha)	Year 4 Deforested (ha)	Year 5 Deforested (ha)
Year 2 Degradation Areas	Mining	Mixed Forest Degraded	112	63	22
		Montane Forest Degraded	32	2	-
		Swamp/Marsh Forest Degraded	<1	-	-
		Wallaba/Dakama/Muri Degraded	5	2	-
Total Area (ha)			**148**	**67**	**22**
Year 3 Degradation Areas	Mining	Mixed Forest Degraded		190	87
		Montane Forest Degraded		8	2
		Swamp/Marsh Forest Degraded		1	3
		Wallaba/Dakama/Muri Degraded		2	2
Total Area (ha)				**200**	**94**
Year 4 Degradation Areas	Mining	Mixed Forest Degraded			103
		Montane Forest Degraded			21
		Swamp/Marsh Forest Degraded			1
		Wallaba/Dakama/Muri Degraded			2
Total Area (ha)					**127**

The changes recorded all occur around existing mining areas. Initial evidence suggests that forest areas are degraded during the initial activities. If the areas are fully operationalised, then it is probable that these areas recover. Alternatively, if mining proceeds, the areas are converted to deforestation. Further evaluation work is required to better understand the temporal dynamics – i.e. the time taken to deforestation, and if not deforested the carbon emissions due to degradation activities.

7.6 National Trends

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 using Equation 7-1. In general, the following trends by driver are observed:

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[12] Tracking of legacy polygons of degradation to deforestation areas, will not be done post year 6, since the sample based approach will be used to map forest degradation.

- Forestry related change has remained relatively stable from Years 1 to 6. 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. However, for Year 6 this drops back to (379 ha) rates akin to Years 3 and 4.
- In Year 6, mining remains the largest contributor to deforestation, but has dropped significantly to one the lowest annualised reported rates (6 782 ha). 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.
- Deforestation from fire has remained relatively stable up to Year 5. However, in Year 6 several large fires were identified which have significantly inflated this number (1 509 ha).

Table 7-4: Annualised Rate of Forest Change by Period & Driver from 1990 to 2016

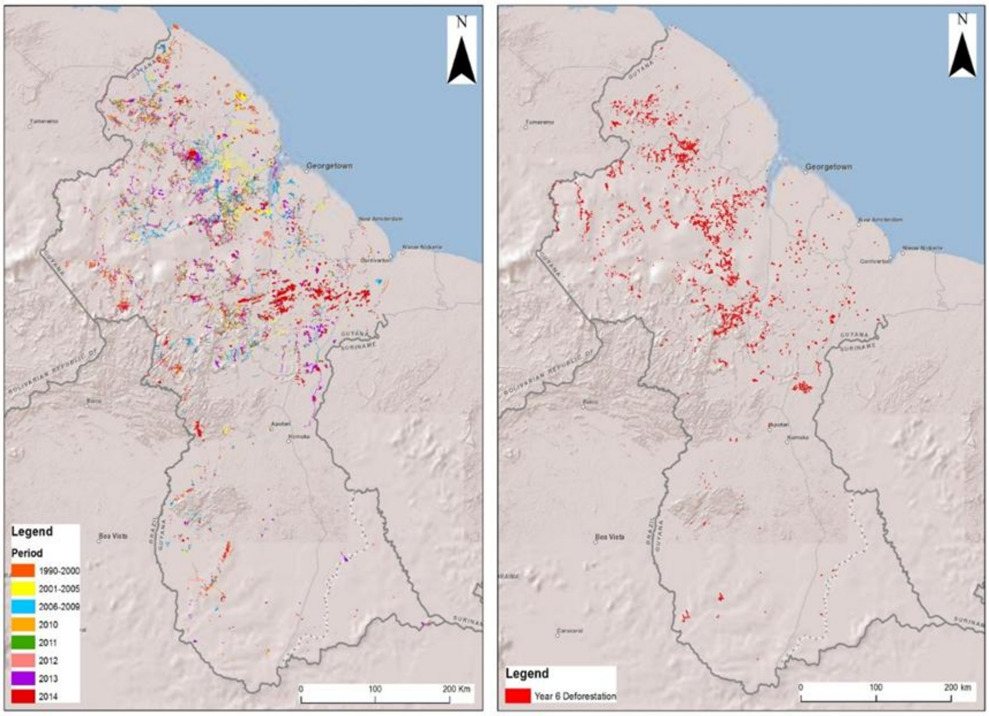
Change Period	Change Period	Annualised Rate of Change by Driver						Annual Rate of Change (ha)
		Forestry	Agriculture	Mining	Infrastructure	Fire	Settlements	
	(Years)	Annual Area (ha)						
1990-2000	10	609	203	1 084	59	171	-	2 127
2001-2005	5	1 684	570	4 288	261	47	-	6 850
2006-2009	4.8	1 007	378	2 658	41	-	-	4 084
2009-10	1	294	513	9 384	64	32	-	10 287
2010-11	1.25	186	41	7 340	298	46	-	7 912
2012	1	240	440	13 664	127	184	-	14 655
2013	1	330	424	11 518	342	96	23	12 733
2014	1	204	817	10 191	141	259	71	11 975
2015-16	**2**	**313**	**379**	**6 782**	**217**	**1 509**	**8**	**9 208**

7.7 Deforestation & Degradation Patterns

The temporal analysis of deforestation from 1990 to 2016 are presented in Map 7-1. The map, which presents change from all drivers, shows that most of the change is clustered[13] and that new areas tend to be developed near existing activities. Most Year 6 deforestation activities fall close to or inside the footprint of historical change areas in the north and west of the country.

[13]For the purposes of display the areas of deforestation have been buffered to make them more visible.

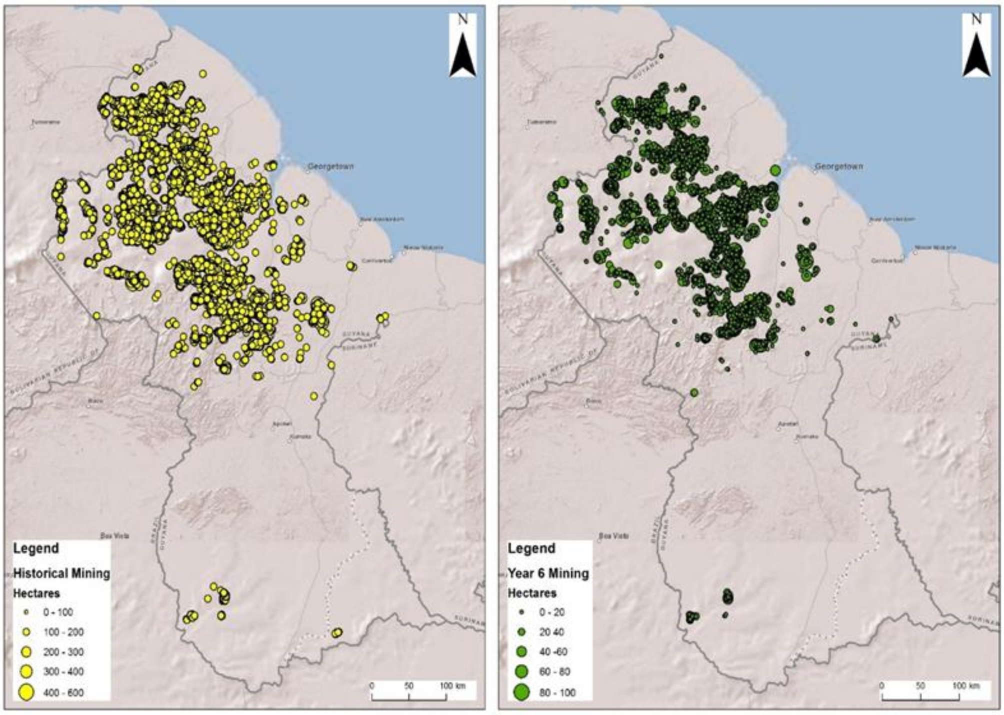
Map 7-1: Historical & Year 6 Forest Change



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.

The following series of maps show the temporal and spatial distribution of deforestation by driver (mining, forestry and agricultural and biomass burning). The relative size of the change is represented by scaling the symbol proportional to the area it represents.

Map 7-2: Mining Spatial & Temporal Distribution Historical and Year 6



Mining

The spatial trend on Map 7-2 shows that mining activities, including associated road construction, are concentrated in the northwest of the country. Forest change related to mining includes mining sites and any infrastructure associated with the operation, and historical degraded areas that have been converted to deforestation. This includes any roads that lead directly to mining.

As with the previous years most of the deforestation activity occurs in the State Forest Area (SFA). Mining activities are consolidated in the centre of Guyana. Additional mining is observed to the west of the core mining area.

Among the main factors that have continued to the decrease in deforestation from mining has been the shift towards more large-scale mining - two main large-scale operators are in full operation. The move to EITI has led to several preparedness efforts at the mining sector level, to strengthen governance and management. There has been emphasis on looking at effective implementation of codes and guidelines and the field monitoring has also expanded. Other factors that also contributed are the decline in prices and the challenges in access experienced by miners. Deforestation has declined from 2012 (when the price of Gold was USD1,900/ounce) which marked a point where the gold price was the highest since 1980. Post 2012 the price has declined to around USD1300/ounce. This combined with limited accessibility has gradually reduced the yearly increase in the area mined.

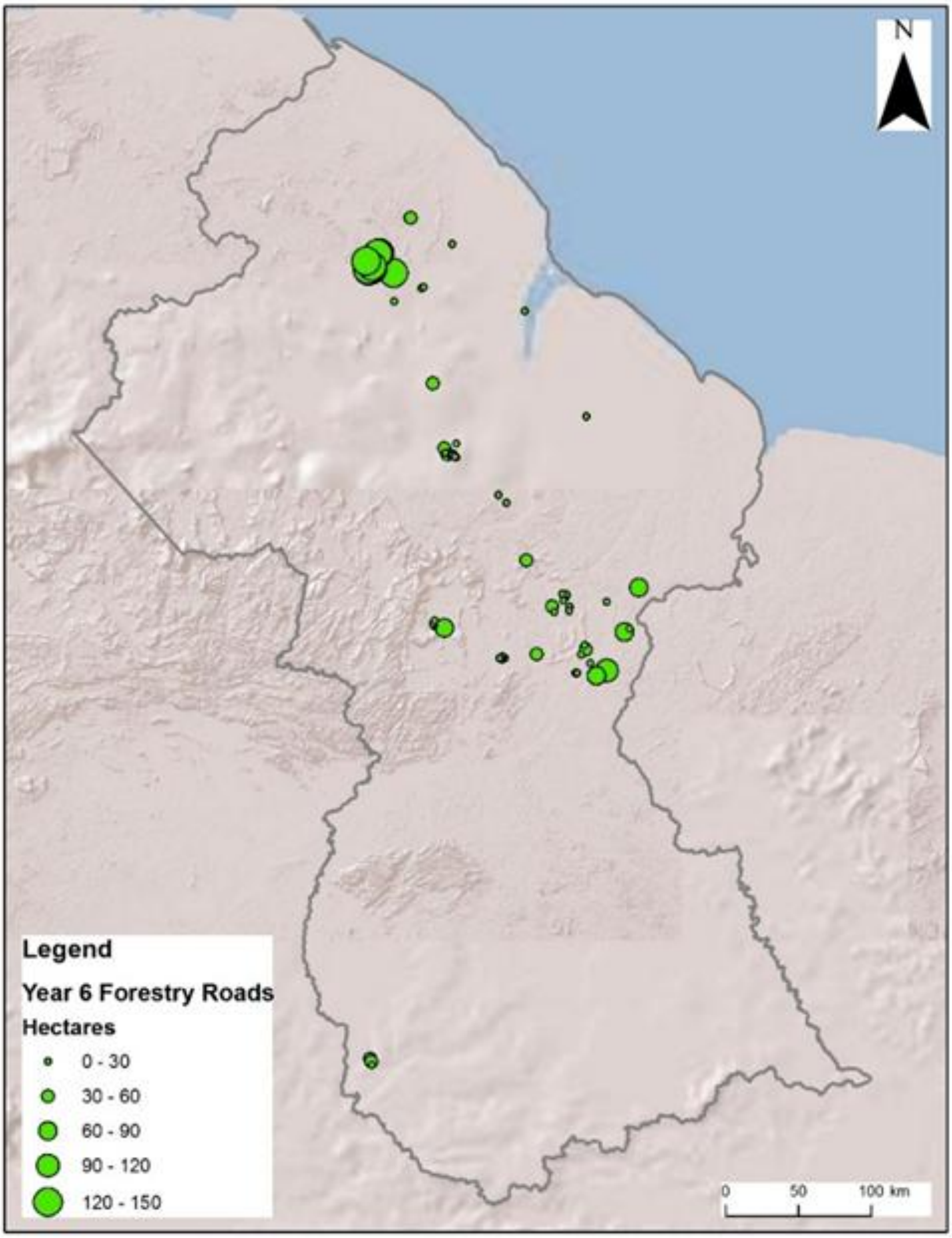
Forestry

Map 7-3 shows the majority of forestry activities are located inside the SFA. During the Year 6 period, all deforestation events are associated with forestry harvest operations. The main causes of forest clearance include road and log market construction. The reported Year 6 value (of 627 ha annualised as 313 ha) is a marginal increase when compared to year 5 but is lower than year 4.

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 (100 ha) across concessions is monitored.

Forest harvesting in general has declined and is linked to some forest concessions ceasing operations.

Map 7-3: Forestry Spatial & Temporal Distribution in Year 6

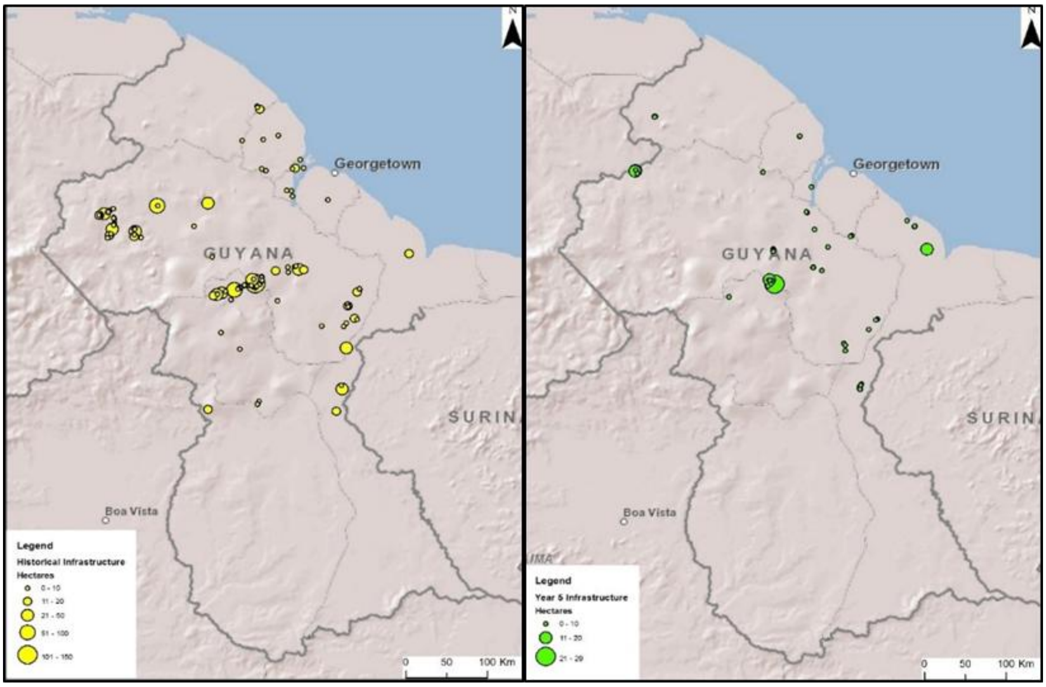


Infrastructure

In Year 6, infrastructure developments (217 ha) have increased compared to Year 5 (141 ha). The area of clearance is in a similar location. The main change is related to road construction activities and tends to be near townships. Map 7-4 shows the distribution of infrastructure developments.

There have been a few new hinterland roads constructed to enhance access to villages.

Map 7-4: Infrastructure Roads Spatial & Temporal Distribution Historical to Year 6

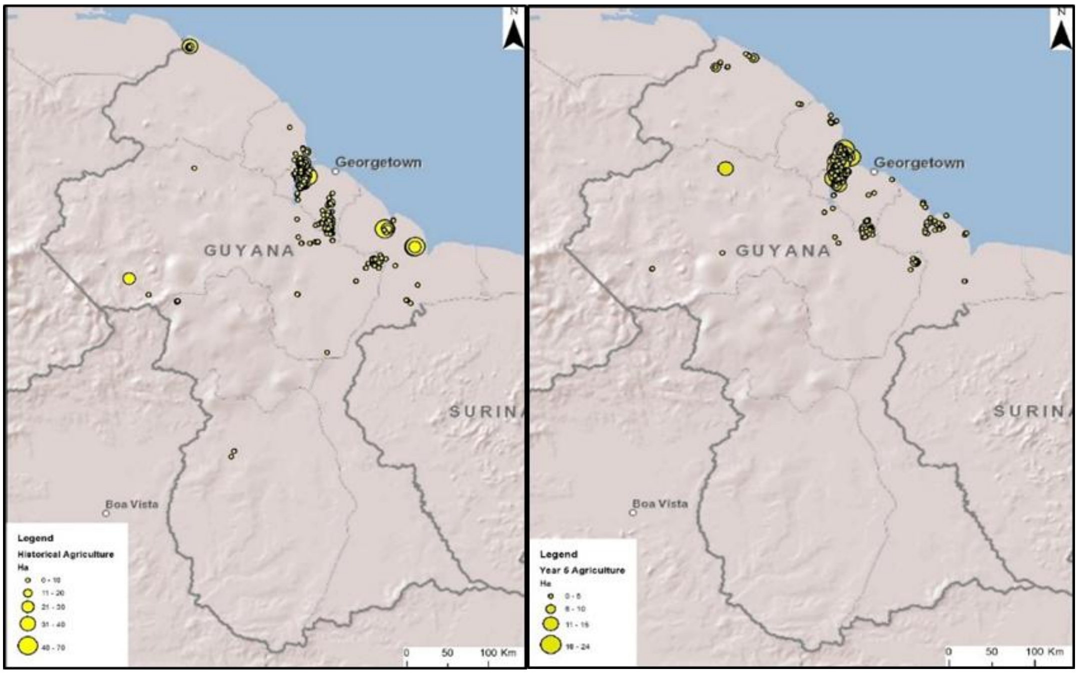


Agricultural Development

In Year 6 agricultural developments leading to deforestation have decreased to 379 ha. This is the lowest reported rate since Year 2. The main areas of development are located close to Georgetown and the north-eastern regions of Guyana. Development tends to be near river networks.

There has been an overall consolidation of agriculture on existing lands and this has resulted in the decreasing level of new areas of clearance in the year 6.

Map 7-5: Agriculture Development Spatial & Temporal Distribution Historical and Year 6



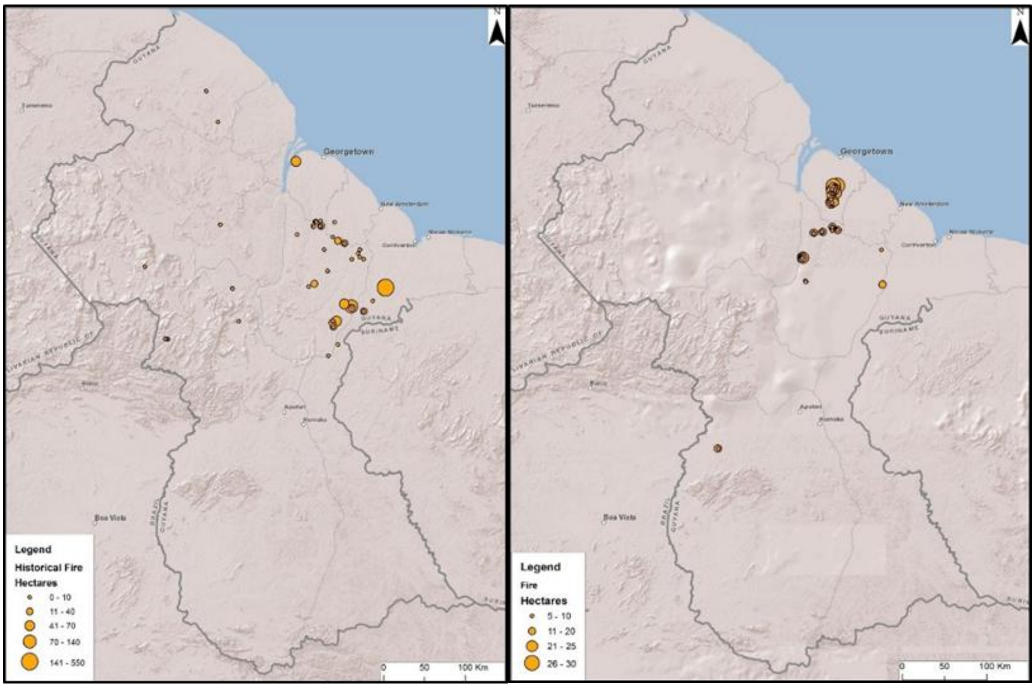
Biomass Burning - Fire

Year 6 mapping captured several significant fire events, resulting in the highest annualised rate of change by fire (1 509 ha). 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. Map 7-5 shows the distribution of fires resulting in deforestation.

The large fire events are tied to prolonged dry spell and more commonly observed on the drier sand and grassland areas.

Map 7-6: Biomass Burning - Fire Temporal and Spatial Distribution Historical to Year 6



7.8 State Forest Area

Historical Change

In the previous assessment the total change in SFA between 1990 and 2009 was estimated at 63 646 ha. Overall the SFA accounted for 85% of all deforestation for the benchmark period. Annualised this represented a change rate of 3 200 ha/yr which is equivalent to a deforestation rate of - 0.03%/yr. During the Year 1 period, deforestation in the SFA was calculated at 8 910 ha. Overall 87% of all change for the year occurred inside the SFA.

A similar trend was seen in Year 2 with around 9 362 ha cleared, and a deforestation rate within this sub category of 0.076% (note that this is calculated as a proportion of the land area making up this sub category), which is very similar to Year 1. A small increase is due to the transfer of forested area under the State Forest Estate category to Amerindian titled land. In Year 3 forest change was dominated by mining (95%) followed by forestry activities (2%).

Infrastructure development, fire and agriculture are less prominent and contribute around 3% of the deforestation observed. In Year 4 the trend continued with 94% of deforestation attributed to mining activities. Degradation surrounding new infrastructure such as mining sites has increased from 1 499 ha in Year 3 to 2 616 ha in Year 4.

Year 5 reporting is similar to Year 4. Mining continues to be the main driver for deforestation at 92% of total deforestation. Degradation contributed to mining accounts for some 91%. Infrastructure development, forestry and agriculture make up some 4% of Year 5 deforestation, with the latter increasing from the Year 4 rate of 69 ha to 112 ha. Compared to Year 4, degradation has increased by 328 ha, again largely as a result of mining.

In Year 6, the total SFA deforestation rate is 15 281 ha over 24 months. Annualised, this rate is 7 641 ha and accounts for 83% of total deforestation. Mining sees a significant decrease with an annualised rate of 5 824 ha (11 648 over 24 months). As a result, deforestation attributed to mining contributes to some 76% of all deforestation activates, in contrast to previous years where the contribution usually exceeded 90%. Several large forest fires were identified during the Year 6 assessment period. As a result, some 1 217 ha (annualised rate) contributes to 16% of all deforestation activities for this period. The previous highest rate was recorded in Year 5 (259 ha). The remaining drivers are tracking similar to previous change rates.

Table 7-5 Annualised Year 6 SFA Total Forest Change by Driver from 1990 to 2016[14]

Driver	Year 1 2009-10	Year 2 2010-11		Year 3 2012		Year 4 2013		Year 5 2014		Year 6 2015-16
	Deforested	Deforested	Degraded	Deforested	Degraded	Deforested	Degraded	Deforested	Degraded	Deforested
	Area (ha)									
Forestry	270	211	147	229	113	318	85	199	62	285
Agriculture (permanent)	3	33	-	102	-	69	-	112	-	120
Mining	8 582	8 788	5 038	12 179	1 499	10 202	2 616	9 326	3 391	5 824
Infrastructure	24	322	5	44	13	283	108	113	63	188
Fire (deforestation)	32	5	4	145	125	22	284	60	173	1 217
Settlements						11	20	28	-	6
Shifting Agriculture							287		39	-
Degradation (Year 2) converted to deforestation				148		62		22		
Degradation (Year 3) converted to deforestation						194		93		
Degradation (Year 4) converted to deforestation								125		
Amaila Falls Development (Infrastructure roads)		255				64	20	49	20	-
Area Deforested	8 910	9 362	5 194	12 848	1 749	11 161	3 400	10 127	3 748	7 641
Total Forested SFA Area (ha)	12 417 718	12 341 893		12 341 893		12 329 045		12 249 224		12 230 896
Total Forested SFA Remaining (ha)	12 408 807	12 332 530		12 329 045		12 317 884		12 239 097		12 215 615
Period Deforestation rate (%)	0.07%	0.08%		0.10%		0.09%		0.08%		0.06%

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[1]Amaila Fals total included in year 5 deforestation values.

[14] Area change totals may vary between 1 to 3 hectares owing to the rounding of numbers.

7.9 Changes in Guyana's State Lands

Historical Change

For the period spanning 1990 to 2009 a deforestation figure of 8 162 ha was reported. This equated to approximately 11% of all deforestation for the benchmark period. Annualised this represented a change rate of 463 ha/yr or an equivalent deforestation rate of 0.01%/ yr. For Year 1 deforestation in State Lands was calculated at 741 ha.

In Year 2 the total area deforested had decreased to 202 ha. Like the SFA, the main contributor to deforestation is mining which accounted for approximately 59% of the change. This is followed by infrastructure in the form of roads, agriculture, fires and lastly forestry.

In Year 3 the level of deforestation increased to 749 ha which is similar to the value reported in 2009-10. The deforestation was shared equally between agriculture and mining. In Year 4 the deforestation figure increased to 912 ha accounting for 8% of total deforestation. Forest degradation also saw an upward trend from 85 ha in Year 3 to 219 ha in Year 4. In Year 4 this accounted for around 5% of all mapped forest degradation.

In Year 5 the deforestation figure increased to 1 331 ha accounting for 11% of total deforestation. Forest degradation increased from 219 ha in Year 4 to 271 ha in Year 5. In Year 5 this accounted for around 6% of all mapped forest degradation. The following table provides a breakdown by driver for the benchmark and Year 1, 2, 3, 4 and 5 periods.

In Year 6, the total State Lands deforestation rate is 1 992 ha over 24 months. Annualised, this rate is 996 ha and accounts for 11% of total deforestation. A notable difference is the increase in mining activities across State Lands, which is some 577 ha (annualised). This is largest reported rate which contributes to 58% of all change within State Lands. Within State Lands, fire contributes to 206 ha of deforestation and accounts for the second largest proportion, at 21%. Deforestation driven by agriculture has decreased to 191 ha. This is significantly lower than the Year 5 value (671 ha).

Table 7-6: Annualised Year 6 State Lands Forest Change by Driver from 1990 to 2016[15]

Driver	Year 1 2009-10	Year 2 2010-11		Year 3 2012		Year 4 2013		Year 5 2014		Year 6 2015-16
	Deforested	Deforested	Degraded	Deforested	Degraded	Deforested	Degraded	Deforested	Degraded	Deforested
	Area (ha)									
Forestry	24	7	-	6	-	1	-	5	-	16
Agriculture (permanent)	510	19	-	324	-	353	-	671	-	191
Mining	175	120	26	331	38	443	131	392	114	577
Infrastructure	32	47	-	49	-	33	24	22	-	6
Fire (deforestation)	-	9	4	39	47	70	57	199	93	206
Settlements						12	-	40	-	1
Shifting Agriculture							7		64	-
Degradation (Year 2) converted to deforestation		-				-		-		
Degradation (Year 3) converted to deforestation						-		1		
Degradation (Year 4) converted to deforestation								-		
Amalia Falls Development (Infrastructure roads)								-	-	-
Area Deforested	741	202	30	749	85	912	219	1 331	271	996
Total Forested SFA Area (ha)	3 087 324	3 084 306		3 084 306		3 084 104		2 559 890		2 598 779
Total Forested SFA Remaining (ha)	3 086 583	3 084 104		3 084 104		3 083192		2 558 560		2 596 787
Period Deforestation rate (%)	0.02%	0.01%		0.02%		0.03%		0.05%		0.04%

[15] Area change totals may vary between 1 to 3 hectares owing to the rounding of numbers.

7.10 Amerindian Areas

Forest change and degradation is also monitored for Amerindian areas.

Forest change has been mapped across the titled Amerindian areas. The trend indicates that Year 4 deforestation (660 ha) and the annual rate (0.03%) have increased relative to Year 1 and 2, but the area is less than that mapped in Year 3 (1056 ha).

Mining dominates the change areas and contributes around 92% of the total change for Year 4. The area of forest degradation (734 ha) is dominated by shifting agriculture[16] (62% of the area). Shifting cultivation is often observed in the areas surrounding Amerindian communities. Degradation associated with mining operations contributes 208 ha of the total (~28%).

Mining again dominates the change areas and contributes around 91% of the total deforestation for Year 5. The area of forest degradation (219 ha) is also dominated by mining activity (155 ha or 71%) with the remaining classified as shifting agriculture (64 ha or 29%). Shifting agriculture is often observed in the areas surrounding Amerindian communities.

In Year 6, the total Amerindian Areas deforestation rate is 1 113 ha over 24 months. Annualised, this rate is 556 ha and accounts for 6% of total deforestation. Following on from historic trends, mining continues to be the lead driver at 378 ha, contributing to 68% of total deforestation. However, it should be noted that mining has progressively decreased since Year 3 (1 005 ha). Deforestation from fire and agriculture are the second and third largest contributors, at 82 and 68 ha respectively.

[16] Shifting cultivation was reported for the first time in Year 4.

Table 7-7: Annualised Year 6 Amerindian Area Forest Change by Driver from 1990 to 2016[17]

Driver	Year 1 2009-10	Year 2 2010-11		Year 3 2012		Year 4 2013		Year 5 2014		Year 6 2015-16
	Deforested	Deforested	Degraded	Deforested	Degraded	Deforested	Degraded	Deforested	Degraded	Deforested
	Area (ha)									
Forestry	-	15	-	4	-	11	-	-	-	4
Agriculture (permanent)	-	-	-	13	-	2	-	34	-	68
Mining	627	267	216	1 005	92	606	208	458	155	378
Infrastructure	8	-	-	34	-	26	1	6	-	24
Fire (deforestation)	0	44	20	0	36	4	54	-	-	82
Settlements						-	-	3	-	1
Shifting Agriculture							471		64	-
Degradation (Year 2) converted to deforestation		-		-		5		-		
Degradation (Year 3) converted to deforestation						6		1		
Degradation (Year 4) converted to deforestation								3		
Amaila Falls Development (Infrastructure roads)								-	-	-
Area Deforested	635	326	236	1056	129	660	734	503	219	556
Total Forested SFA Area (ha)	2 488 415	2 546 852		2 546 852		2 546 526		2 582 440		2 561 873
Total Forested SFA Remaining (ha)	2 487 780	2 546 526		2 546 526		2 545 866		2 581 936		2 560 760
Period Deforestation rate (%)	0.03%	0.01%		0.04%		0.03%		0.02%		0.02%

[17] Area change totals may vary between 1 to 3 hectares owing to the rounding of numbers.

8. VERIFYING FOREST CHANGE MAPPING & INTERIM MEASURES

As part of the MRVS reporting process an independent accuracy assessment is also conducted. The results of the accuracy assessment will be reviewed by independent auditors.

The Accuracy Assessment scope dictates that a third party not involved in the change mapping assesses deforestation, forest degradation and forest area change estimates for each period. Specifically, the terms of reference asked that confidence limits be attached to the forest area estimates.

The methods applied in this report follow the recommendations set out in the GOFC-GOLD guidelines. The aim is to help identify and quantify uncertainty in the level and rate of deforestation and the amount of degraded forest area in Guyana over the period 1 January 2015 to 31 December 2016 (Interim Measures Period – Years 6 and 7).

This year high-resolution Planet Labs imagery (see section 4.6) and aerial survey datasets have been used to assess the wall-to-wall mapping of Guyana undertaken by the Guyana Forestry Commission (GFC).

8.1 Accuracy Assessment Conclusions & Recommendations

The following are the main conclusions and recommendations from the Accuracy Assessment process:

1. The estimates of deforestation based on the mapping undertaken by GFC based largely on interpretation of Landsat and Sentinel-2 imagery is of a good standard.
2. The methods used by GFC, and assisted by IAP, follow the good practice recommendations set out in the GOFC-GOLD guidelines and considerable effort has been made to acquire cloud free imagery towards the end of the census period January 2015 to December 2016 (Year 6).
3. The estimate of the total area of change in the 24-month Year 6 period from forest to non-forest and degraded forest to non-forest is 16 239 ha, with a standard error of 1 940 ha and a 95% confidence interval (12 436 ha; 20 041 ha).
4. The estimate of the annualised rate of deforestation that occurred over the Year 6 (24 month) period is 0.0548% with a standard error of 0.0064% and a 95% confidence interval (0.0423%; 0.0673%).
5. The estimate the total area of change in the 24-month Year 6 period from forest to degraded forest between Y5 and Y6 is 13 068 ha, with a standard error of 1 850 ha and a 95% confidence interval (11 046 ha; 18 297 ha).
6. No changes were detected with samples located within the boundary of the Intact Forest Landscape.
7. The PlanetScope data provided sufficient detail (spatial resolution) to assess the Landsat and Sentine-2 mapping as provided by GFC.

9. INTERIM MEASURES

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[18].

The basis for comparison of a majority of the interim measures is the 30 September 2009 benchmark map[19]. The first reporting period (Year 1) is set from 1 Oct 2009 to 30 Sept 2010. The means of monitoring and estimation during the interim period are identified as medium resolution satellite images. This includes: a time series of Landsat TM and ETM+, a composite of daily acquired MODIS (250 m resolution) taken as close as possible to the end of the benchmark reporting period September 2009.

For Year 2, RapidEye was tasked over the most actively changing areas (12 million ha). As with preceding periods Landsat, MODIS and ASAR radar data were also used to ensure a full national coverage.

From year 3 onwards a national coverage of RapidEye was commissioned. Images were acquired from August to December in 2012 and 2013.

A summary of the key reporting measures and brief description for these interim measures are outlined in Table 9-1. The calculations to determine the rate of deforestation (ref. measure 1) are reported in Section 7.

Outputs and results are provided for the Intact Forest Landscape (ref. measure 2) and forest management indicators (ref. measure 3 and 4) are outlined in this section.

For forest degradation, a sample-based approach from the accuracy assessment was used to derive this value. For Year 6, this was performed using PlanetScope satellite imagery. For the Year 1 assessment the default measure was applied which meant degradation was calculated by applying a 500 m buffer around mining sites and roads.

[18] 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.

[19] 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 9-1: Reported Interim Measures

Measure Ref.	Reporting Measure	Indicator	Reporting Unit	Adopted Reference Measure	Year 2 Period	Year 3 Period	Year 4 Period	Year 5 Period	Year 6 Period (Annualised Results)	Difference between Year 6 & Reference Measure
1	Deforestation Indicator	Rate of conversion of forest area as compared to the agreed reference level.	*Rate of change (%)/yr*	0.275%	0.054%	0.079%	0.068%	0.065%	0.050%	0.23%
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	7 604 754 (66 ha loss)	7 604 580 (174 ha loss)	7 604 425 (155 ha loss)	7 604 314 (111 ha loss)	7 604 024 (290 ha loss)	- 796 ha (290 ha loss in Year 6)
2b		Determine the extent of degradation associated with new infrastructure such as mining, roads, settlements post the benchmark period[7].	*ha*	4 368	5 460	1 963	4 352	4 251	5 679[20]	-1 311
3	Forest Management	Timber volumes post 2008 as verified by independent forest monitoring (IFM). These are compared to the mean volume from 2003-2008	*t* CO_2	3 386 778[21]	3 685 376[22]	2 159 151	3 106 693	3 366 326	1,892,371	1,494,407 *t* CO_2
4	Emissions resulting from illegal logging activities	In the absence of hard data on volumes of illegally harvested wood, a default factor of 15% (as compared to the legally harvested volume)	*t* CO_2	411 856	18 289	11 217	11 533	13 823	9,140	402,716 *t* CO_2
5	Emissions resulting from anthropogenic forest fires	Area of forest burnt each year should decrease compared to current amount.	*ha/yr*	1 706[23]	28	208	395	265	762	944
6	Emissions resulting from subs. forestry, land use and SF	Emissions resulting from communities to meet their local needs may increase as a result of inter alia a shorter fallow cycle or area expansion. (I.e. slash and burn agriculture).	*ha/yr*	-	-	-	765	167	93	-

[21] Assessment completed based in Winrock International Report to the Guyana Forestry Commission, December 2011: ***Collateral Damage and Wood Products from Logging Practices in Guyana.*** This methodology only applies to emissions and not any removals due to re-growth of the logged forest. [2]. The same is the case for the Reference level for illegal logging for Years 2, 3 and 4.
[22]Computed for the period 1 October 2010 to 31 December 2011. (15 months)
[23] Degradation from forest fires is taken from an average over the past 20 years. This value is inclusive of all degradation drivers except for rotational shifting agriculture.

9.1 Interim Reporting Indicators

The following provides a description, justification and performance measurement for each of the seven indicators. Historically only the first five of the seven measures are reported, with IM6 being added and reported in Year 4.

9.2 Gross Deforestation – Measure 1

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[24]. Several key performance indicators and definitions have been developed as follows.

Interim Performance Indicators

- 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.

Gross Deforestation Monitoring Requirements

Using the benchmark forest cover map as a base (30 September 2009) the intention is to identify activity data related to:

- Expansion of human infrastructure (e.g. new roads, settlements and mining and agricultural expansion.

Monitoring Approach

The accepted approach as outlined in the JCN, uses medium resolution images to identify new areas of development at a one-hectare scale.

9.3 Degradation Indicators - Measure 2

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)*".

The reason for this indicator stems from the concept that degradation of intact forest through human activities will produce a net loss of carbon and is often the precursor to further processes causing long-term decreases in carbon stocks.

Furthermore, preserving intact forests will contribute to the protection of biodiversity. The extent of Intact Forest was determined at the end of September 2010. It is a requirement that the total area of intact forest must remain constant from this date. In determining the IFL, only those areas that meet the forest definition are included.

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[24]Results derived from field study conducted in Guyana as part of the Forest Carbon Monitoring System.

Within the areas that qualify as IFL, the following rules (first 4 bullets are elimination criteria) are defined:

- Settlements (including a buffer zone of 1 km).
- Infrastructure used for transportation between settlements or for industrial development of natural resources, including roads (except unpaved trails), railways, navigable waterways (including seashore), pipelines, and power transmission lines (including in all cases a buffer zone of 1 km on either side).
- Agriculture and timber production used for local use.
- Industrial activities during the last 30-70 years, such as logging, mining, oil and gas exploration and extraction, peat extraction, etc.

Areas with evidence of low-intensity and old disturbances are treated as subject to "background" influence and are eligible for inclusion in an IFL. Sources of background influence include local shifting cultivation activities, diffuse grazing by domestic animals, low-intensity village-based selective logging, and hunting.

9.4 IFL Data Sources & Methods

The following provides a description of process and datasets used to generate the IFL. The datasets used were available as at 2010. Since the generation of the reference IFL layer GFC has continued to improve the quality of the base datasets and moved to high-resolution countrywide coverage. This has enabled continuous monitoring of forest change (deforestation and degradation) at a national level. It is proposed that the IFL be replaced in the near term to reflect these improvements.

The areas excluded from IFL are:

Settlements

The population of Guyana is approximately 782 000, of which 90% reside on the narrow coastal strip (approximately 10% of the total land area of Guyana). Guyana's coastal strip ranges from 10 to 40 miles (16 to 64 km) in width.

Settlement extents were provided by GL&SC for six municipalities. In addition, the Bureau of Statistics provided 2002 census data for settlements with population >1000 people. The approximate extent of these settlements was determined from satellite imagery. The national Gazetteer which provides a spatial location of settlements was used to identify the remaining settlements. Included are Amerindian titled areas that were digitised as at 2009.

Infrastructure, Mining & Navigable Rivers

Infrastructure used for transport was identified using satellite images and assisted by GPS tracks. Infrastructure associated with SFM is not subtracted from the IFL unless it connects settlements. Only those roads that can be mapped from medium resolution satellite imagery or those leading to settlements have been included.

Historical and current mining areas and the associated infrastructure from 1990 to 30 September 2009 are subtracted from the IFL. These areas have been mapped from medium resolution satellite imagery

Navigable waterways and seashore are as defined from medium resolution images and 1995-96 radar imagery. Only those rivers identified from satellite imagery (~30 m width) have been included in the analysis. All of the rivers mapped in Year 1 are considered navigable.

Permanent Agriculture & Forest Production

Areas of permanent agriculture as identified from satellite imagery and supported by available agricultural leases are digitised from paper maps by GL&SC. Forest production areas under

SFM are held by GFC and are available in a GIS format. These areas are excluded from the IFL.

Industrial-scale Exploitation of Resources

Industrial-scale exploitation of timber (clear-felling with no natural regeneration), peat extraction and oil exploration are not practiced in Guyana in the period under review.

Background Sources

Background sources such as shifting cultivation. Shifting cultivation areas have been defined from medium resolution satellite imagery.

9.5 Calculation of the Year 6 Intact Forest Landscape

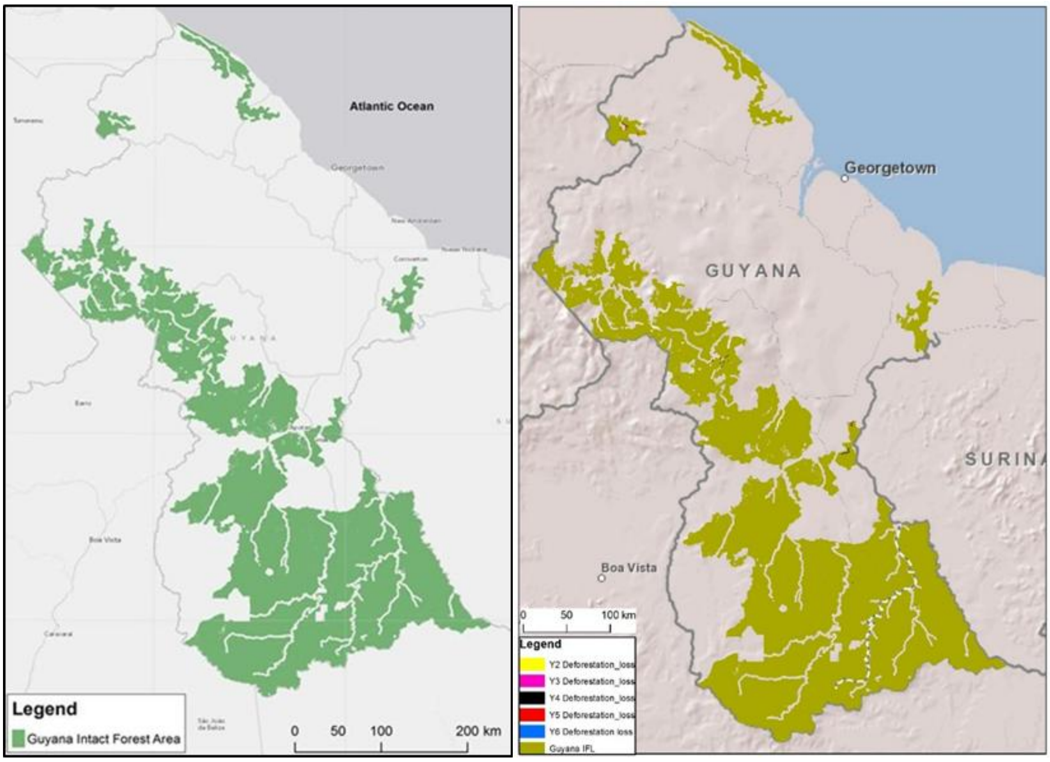
In accordance with the interim indicators the total area of intact forest must remain constant from the benchmark date (30 September 2009) onwards. Any change in area shall be accounted for as deforestation with full loss of carbon. The intention of the IFL is to allow a user to determine whether a specific activity falls within or outside an IFL with a margin of error of less than 1 km.

In Year 6 and 7 the same benchmark IFL area was used. The analysis identified 290 ha of deforestation, 177 ha of which was mapped in Amerindian areas and 107 ha in State Lands.

It is proposed that deforestation located in Amerindian areas is not counted in calculating the reduction in financial remuneration. These areas are part of Guyana's continuous land titling and demarcation programme.

Map 9-1 (left) shows the extent of the benchmark IFL as created for the Year 1 period. At this point the total intact forest landscape area in Guyana was estimated at 7.60 million ha. The second map identifies the deforestation that has occurred inside the IFL since Year 1.

Map 9-1: Intact Forest Landscape Maps



9.6 Carbon Loss as Indirect Effect of New Infrastructure – Measure 2b

The carbon loss associated with new infrastructure was determined by buffering the extent of areas detected in the medium resolution imagery by 500 m. This is the default option if the extent of degradation cannot be mapped. This was the case for Year 1 as there were a very limited number of high resolution scenes available over Guyana.

For the Year 2 assessment, high resolution 5 m imagery was tasked and over 12 million ha were acquired. This area covered the most actively changing areas. The approach taken for Year 2 was to visually assess the satellite imagery surrounding new infrastructure for signs of forest degradation. Analysis of the images and follow up fieldwork indicated that degradation around new infrastructure was fragmented and was directly related to the deforestation activity.

The degradation impact was localised and did not extend further than 40 m from the deforestation site. Based on these findings a conservative 100 m buffer was applied around all new Year 2 infrastructure. Any forest degradation observed inside this buffer was mapped.

In Year 3, 4 and 5 this approach was retained. Furthermore, areas of degradation identified in Year 2 and 3 were revisited and reassessed for change.

The MRVS for Year 5 has, within mapping protocols, integrated the assessment of re-entry of existing mines and has included the results of this assessment within the total degradation reported for Year 5. Forest degradation that occurred in Year 5 has been mapped when surrounding Year 2, Year 3 and Year 4 infrastructure and mining.

Interim Performance Indicators

- Determine the extent of degradation associated with new infrastructure such as mining, roads and settlements.
- If it cannot be determined from medium resolution imagery (either directly, or using a remote sensing technique) then a buffer of 500 m is applied from the external edge of each deforestation site. A 50% loss in biomass is assumed.

The area of degradation for the Year 1 period (1 Oct 2009 to 30 Sept 2010) was estimated at 92 413 ha. This area does not necessarily reflect forest degradation in a practical sense as it is based on applying the 500 m buffer around all detected deforestation events greater than one hectare.

The Year 2 area is considerably lower at 5 460 ha. This can be attributed to the method applied which is based on interpretation of high-resolution satellite images rather than the calculation and application of a generic buffer to all new infrastructure.

Degradation continued to fall in Year 3 with only 1 963 ha mapped. Of interest in Year 3 is the fact that areas of previous degradation have been deforested (141 ha). Under Interim Measures 50% of the carbon loss over these areas has already been accounted. In Year 5 the area was 4 251 ha which is some 117 ha below the reference measure and 101 ha less than Year 4 reported degradation. As noted in Section 5.6 further work is required to better understand the temporal dynamics of degradation and the carbon emissions should the area not be deforested.

The Year 6 assessment for gross deforestation and forest degradation in Guyana used a stratified random sampling design. Stratification was based on past patterns of deforestation from Period 1 (1990) though to Year 4 (Dec 2013), where the primary drivers of land cover change are alluvial gold mining, logging, anthropogenic fire, agriculture and associated infrastructure including roads. For Year 6, the degradation value is derived from the sample based approach.

9.7 Forest Management – Measure 3

Management

Under interim measures, 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 2015 to 31 December 2016, with the annualised total presented:

- Production by forest concession
- Total production.

The reporting requirements include data on extracted timber volumes post 2008 and are available for verification. These are compared against the mean volume from 2003-2008. Any increase in extracted volume above the 2003-2008 mean is accounted for as an increase in carbon emissions. This is unless otherwise documented using the Gain Loss or stock difference methods as described by the IPCC for forests remaining forests. In addition to harvested volume, a default expansion factor shall be used to account for losses due to harvesting i.e. collateral damage. This is unless it can be shown this is already accounted for in the recorded extracted volume.

Production volumes are recorded on declaration/removal permits, issued by the GFC to forest concession and private property holders. Upon declaration, the harvested produce is verified, permits collected and checked and sent to the GFC's Head Office, followed by data input into the central database. The permits include details on the product, species, volume, log tracking tags number used, removal and transportation information, and in the case of large timber concessions, more specific information on the location of the harvesting. Production reports are generated by various categories including total volume, submitted to various groups of stakeholders and used in national reporting. Details on the main processes are provided below:

Monitoring of Extracted Volume: Monitoring in the forest sector is coordinated and executed by the GFC and occurs at four main levels: forest concession monitoring, monitoring through the transportation network, monitoring of sawmills and lumberyards, and monitoring ports of export.

For forest harvesting and transport, monitoring is done at station level, at concession level and supplemented by random monitoring by the GFC's Internal Audit Unit and supervisory staff. At all active large concessions, resident forest officers perform the function of ensuring that all monitoring and legality procedures are strictly complied with. In instances of breach, an investigation is conducted and, based on the outcome, action is instituted according to GFC's standard procedures for illegal actions and procedural breaches.

Prior to harvesting, all forest concessions must be in possession of valid removal permit forms. Permit numbers are unique to operators and are issued along with unique log tracking tags. Production volumes are declared at designated GFC offices with checks made to verify legality of origin and completion of relevant documents, including removal permit, production register and log tracking. Removal permits require that operators declare: date of removal, type of product, species, volume, destination, vehicle type, vehicle number, name of driver/captain, tags, diameter of forest product (in case of logs) and other relevant information. This is one of the initial control mechanisms that is in place whereby monitoring is done for proper documentation and also on the declared produce, etc. Control and quality checks are also undertaken at another level once entered in the centralised database for production. Removal permits, and log tracking tags are only valid for a certain period and audit for use beyond that time is also an important part of the QA/QC checks conducted by the GFC. The unique identity of each tag and permit by operator also allows QA/QC to be conducted for individual operators' use. Thus, checks are allowed across time, by operator and by produce being declared.

In the case of large forest concessions, only approved blocks (100 ha) in Annual Plans are allowed to be harvested in a given year. Harvesting outside of those blocks, even if these areas are within the legally issued concessions, is not permitted. As such, this forms part of the QA/QC process for large concessions (Timber Sales Agreements and Wood Cutting Leases). As one prerequisite for approval of Annual Plans, forest inventory information at the pre-harvest level must be submitted, accompanied by details regarding the proposed operations for that 12-month period, such as maps, plans for road establishment, skid trail alignment etc. The QA/QC process that is executed at this initial stage requires the application of the guidelines for Annual Plans which must be complied with prior to any such approval being granted. A new addition to the monitoring mechanism has been the use of bar code scanners that allow for more real-time tracking of legality of origin of forest produce.

In the case of Amerindian lands and private property, the documentary procedures outlined above as regards to removal permitting and log tracking, are only required if the produce is being moved outside the boundaries of the area. From this point onwards, the procedures that apply to State Forest concessions, apply to this produce as well.

Data Collection: Following receipt of removal permits and production registers, monthly submissions are made to GFC's Head Office for data entry. There is a dedicated unit in the GFC's Management Information System section that is responsible for performing the function of data collection, recording, and quality control. Data is entered in SQL databases custom designed for production totals. This database has built in programmatic QA/QC controls that allow automatic validation and red flagging of tags being used by unauthorised operators, or permits being incorrectly, incompletely or otherwise misused, and cross-checking of basic entry issues including levels of production conversion rates, etc.

As a second stage of QA/QC all entries are validated, and the validated data is then secured in a storage area in the database. There are security features at several levels of the database operations including a read/write only function for authorised users, and change tracking of production information by staff, as well as others. At the end of every month, data is posted to the archives and a separate unit of the GFC is responsible for cross-checking volume totals by species, concession and by period, and preparing the necessary report for external consumption.

Forest Produce included in IMR: in tabulating the declared volumes for forest management, the following primary products that are extracted from the forest were:

- Logs
- Lumber (chainsawn lumber)
- Roundwood (piles, poles, posts, spars)
- Splitwood (shingles, staves)
- Fuelwood (charcoal, firewood)

Logging Damage – Default Factor

In 2011 progress was made in developing a methodology and finalising factors to assess Collateral Damage in a Technical Report developed by Winrock International for the GFC: *Collateral Damage and Wood Products from Logging Practices in Guyana,* December 2011.

The objective of the report is to examine how emission factors were developed that relate total biomass damaged (collateral damage) and thus carbon emissions, to the volume of timber extracted. This relationship will allow the estimation of the total emissions generated by selective logging for different concession sizes across the entirety of Guyana. The following field data have been collected with which the emission factors have been developed:

1. Measurements in a sample of logging gaps to collect data on the extracted timber biomass and carbon in the timber tree and the incidental carbon damage to surrounding trees.

2. Estimating the carbon impact caused by the logging operations such as skid trails. Although selective logging clears forest for roads and decks, their emissions will be estimated through the stock-change method based on estimates of area deforested by logging infrastructure determined in the land cover change monitoring.

Accounting for the impact of selective logging on carbon stocks involves the estimation of a number of different components:

- Biomass removed in the commercial tree felled – emission.
- Incidental dead wood created as a result of tree felling – emission.
- Damage from logging skid trails – emission.
- Carbon stored in wood products from extracted timber by product class – removal.
- Regrowth resulting from gaps created by tree felling - removal.

The **emissions** from selective logging are expressed in equation form as follows:

Emissions, t CO_2/yr = {[Vol x WD x CF x (1-LTP)] + [Vol x LDF] + [Lng x LIF]}*3.67 (Eq. 1)

Where:

Vol = volume of timber over bark extracted (m^3)

WD = wood density (t/m^3)

CF = carbon fraction

LTP = proportion of extracted wood in long term products still in use after 100 yr (dimensionless)

LDF = logging damage factor—dead biomass left behind in gap from felled tree and incidental damage (t C/m^3 extracted)

Lng = total length of skid trails constructed to extract Vol (km)

LIF = logging infrastructure factor—dead biomass caused by construction of infrastructure (t C/km of skid trail to extract the Vol)

3.67 = conversion factor for t carbon to t carbon dioxide

Wood in long term products

Not all the carbon in harvested timber gets emitted to the atmosphere because a proportion of the wood removed may be stored in long term wood products. Total carbon stored permanently into wood products can be estimated as follows.

$$C_{WP} = C * (1 - WW) * (1 - SLF) * (1 - OF) \quad \text{(Eq. 2)}[25]$$

Where:

$C_{WP:}$ = Carbon stock in long-term wood products pool (stock remaining in wood products after 100 years and assumed to be permanent); t C ha^{-1}

C = Mean stock of extracted biomass carbon by class of wood product; t C ha^{-1}

WW = Wood waste. The fraction immediately emitted through mill inefficiency by class of wood product

SLF = Fraction of wood products with a short life that will be emitted to the atmosphere within 5 years of timber harvest by class of wood product

[25]This is directly from the VCS (Verified Carbon Standard) approved methodology for wood products –6CP-W Wood Products November 2010

OF = Fraction of wood products that will be emitted to the atmosphere between 5 and 100 years of timber harvest by class of wood product

The methodology presented here is a module in an approved (double verified) set of modules for REDD projects posted on the Verified Carbon Standard (VCS) set of methodologies. The reported difference between the annual mean for the period 2003-2008 and the assessment year of 1 January 2015 to 31 December 2016, presented an an annualised total, is shown in the table below. For this period t CO_2 has reduced by 1,494,407t CO_2.

Table 9-2: Interim Indicator on Forest Management

Period	Description	Volume (t CO_2)
1 January 2015 – 31 December 2016	t CO_2 emissions arising from timber harvesting	1,892,371
2003-2008 (annual average)	t CO_2 emissions arising from timber harvesting	3 386 778
Difference (t CO_2)		**1,494,407**

9.8 Emissions Resulting from Illegal Logging Activities – Measure 4

Areas and processes of illegal logging must be monitored and documented as far as practicable. Monitoring and estimation of such areas is recommended to be done by assessing the volumes of illegally harvested wood. In the absence of hard data, a default factor of 15% (as compared to the legally harvested volume) is required to be used. It is stated in the Joint Concept Note that this factor can be adjusted upwards and downwards pending documentation on illegally harvested volumes, inter alia from Independent Forest Monitoring. Additionally, medium resolution satellite imagery can be used for detecting human infrastructure and targeted sampling of high-resolution satellite images for selected sites.

In the historic reporting, the default level of 15% of harvested production of 705 347 m^3 corresponding to 411 856 t CO_2, is used in the absence of a complete database of illegal activities being in place at that time. This level includes provision for collateral damage arising from logging activities. Production volumes are recorded in custom designed databases which are updated monthly by the GFC, subject to internal verification, and are backed up and stored monthly offsite.

The rate of illegal logging for the assessment Year 6, 1 January 2015 to 31 December 2016, 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 402,716 t CO_2, less than the historic period level.

Table 9-3 Interim Indicator on Illegal Logging

Period	Description	Volume (t CO_2)
1 January 2015 – 31 December 2016 (annualised)	t CO_2 emissions arising from illegal logging	9,140
2003-2008 (annual average)	t CO_2 emissions arising from illegal logging	411 856
Difference (t CO_2)		**402,716**

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.

Explanatory Note 1

The following steps are taken in the computation of gross emissions from forest management activities:

Step 1: Compile background data to inform computations

- Compile annual production of forest products
- Compile annual area under harvest of various categories of Operators taking into consideration blocks under harvest by large concessions, small forest concessions areas, and titled Amerindian Areas involved in forestry activities.
- Compute Yield in cubic meters per hectares by dividing the harvest level by the area size.

Step 2: Computing impact of incidental impact and collateral damage emanating from logging activities. Factors derived from data collected from 121 Logging Plots.

- Compute total skid trails constructed during the assessment period.
- Applying a logging damage factor of 0.95 t C/m3, and a logging infrastructure factor of 32.84 t C/km, derive total gross carbon emission impact from collateral damage and logging infrastructure by:

  (Area under harvest in hectares **X** Average Yield per ha in cubic meters) **X** Logging Damage Factor of 0.95 t C/m3)

  X (length of skid trails of that year in km **X** logging infrastructure factor of 32.84 t C/km)

Step 2 results in t C of collateral damage and infrastructure impacts from forest harvest, which then multiplied by 3.67 as the multiplier of t C to CO2, is the total CO2 emanating from forest management activities resulting from collateral damage and forest infrastructure.

Step 3: Computing the actual impact of extracted wood including provision for storage in long term wood products. Long term wood products storage computation based on Winjum et al 1998.

- Compute total gross emissions emanating from wood extracted by:

(Area under harvest in hectares **X** Average Yield per ha in cubic meters)

X (Average carbon storage value per cubic meters of 0.4 t C/m3) – (Carbon Stored in Long Term Wood Products computed by method proposed in Winjum et al 1998)

Step 3 results in the computation of total gross emissions taking account of wood stored in Long Term Wood Products and is converted to CO2 by multiplying the above product by 3.67.

Step 4: Computing the total CO2 emissions from total forest management

- Results of Step 2 + Results of Step 3

Explanatory Note 2

The following steps are taken in the computation of the total emissions from illegal logging activities:

Step 1: Compile background data to inform computations

- Compile annual illegal logging timber volume
- Compile annual area under harvest of various categories that may have been subject to illegal logging.
- Compute Yield in cubic meters per hectares by dividing the illegal logging production by the area size

Step 2: Computing impact of collateral damage emanating from illegal logging activities. Factors derived from data collected from 121 Logging Plots.

- Applying a logging damage factor of 0.95 t C/m3, derive total gross carbon emission impact from collateral damage by:

  (Area under harvest in hectares **X** Average Yield per ha in cubic meters)
  X Logging Damage Factor of 0.95 t C/m3)

Step 2 results in t C of collateral damage from illegal logging activities, which then multiplied by 3.67 as the multiplier of t C to CO2, is the total CO2 emanating from illegal logging activities resulting from collateral damage.

Step 3: Computing the actual impact of extracted wood including provision for storage in long term wood products. Long term wood products storage computation based on Winjum et al 1998.

- Compute total gross emissions emanating from wood extracted by:

  (Area under harvest in hectares **X** Average Yield per ha in cubic meters)

X (Average carbon storage value per cubic meters of 0.4 t C/m3) – (Carbon Stored in Long Term Wood Products computed by method proposed in Winjum et al 1998)

Step 3 results in the computation of total gross emissions taking account of wood stored in Long Term Wood Products and is converted to CO2 by multiplying the above product by 3.67.

Step 4: Computing the total CO2 emissions from total illegal logging

- Results of Step 2 + Results of Step 3

9.9 Emissions from Anthropogenic Forest Fires – Measure 5

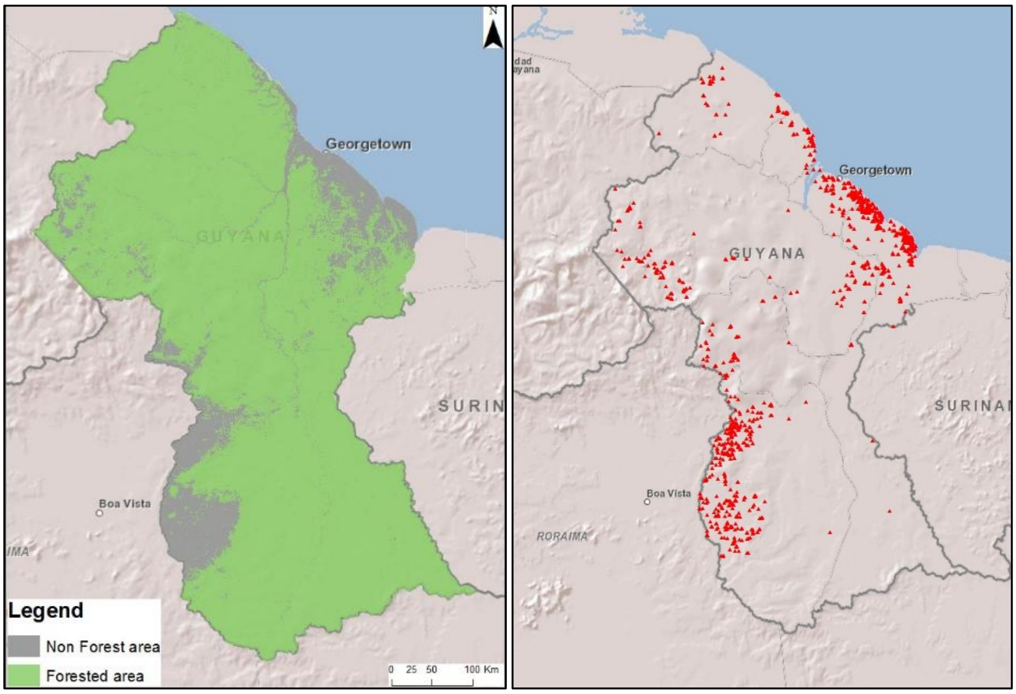
The FIRMS fire point data from MODIS was used to identify potential fire locations (Map 9-2). In addition, a systematic review of all fire points was undertaken to validate the presence of fire and establish the extent using Sentinel imagery. This is an accepted approach that is documented in the GOFC-GOLD sourcebook.

The initial approach used to set a reference level was to calculate the area burnt for the 1990 to September 2009 period. Over this 19-year period a total of 33 700 ha of forest was identified as degraded by burning[26]. 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 Year 2 a considerably lower area of 28 ha was mapped. In Year 3 the area degraded by fire increased to 208 ha and further to 395 ha in Year 4. In Year 5 the area degraded by fire was 173 ha which is lower than reported in the previous two years.

Overall, fire is an immaterial change driver in Guyana with almost all fires occurring within non-forest/grassland landscapes as shown in Map 9-2.

Map 9-2: Non Forest Area & FIRMS Fire Data 2010-2016



The main non-forest areas as determined from the 2012 RapidEye imagery are located in the south along the Brazilian border and closer to Georgetown on the coastal fringe.

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

10. ONGOING MONITORING PLAN & QA/QC PROCESSES

A formal QA/QC process has been continually developed over time. The process ensures that the national change analysis is consistent and repeatable. The key elements of the process include:

- Development of the monitoring plan to ensure the provision of satellite data to cover the reporting period.
- Continued review of new satellite imagery options and evaluation.
- Facilitating data sharing between agencies through inter-agency training.
- Inclusion of over-flights and capture of geo-referenced oblique photos to confirm vegetation types and change. A database is being built over time containing many thousand aerial oblique photos over different land-cover types in Guyana.
- Integration of a high-resolution datasets including satellite images and images collected by an airborne camera system to enable an unbiased assessment of map products.
- Upgrading of GPS units to assist with photographic documentation, and geo-tagging.
- Development of routines to automate processing of remote sensing datasets.
- Development of standardized toolbars to enable consistent attribution of change and documentation of drivers of change. Incorporation of GIS datasets in a geodatabase.
- Development of training materials to assist with the attribution of change Review of appropriate peer-review documentation to ensure best practices are adopted in developing methods
- Development of fully aligned IPCC format reporting area change output from an operational MRVS.

The process maps the change, then merges the tiles back together to form the updated master layer. A feature dataset is created for each tile.

Once each tile is complete it is merged with the new master, an important step is to ensure the edges of the merged tiles are consistent in attribution and topology.

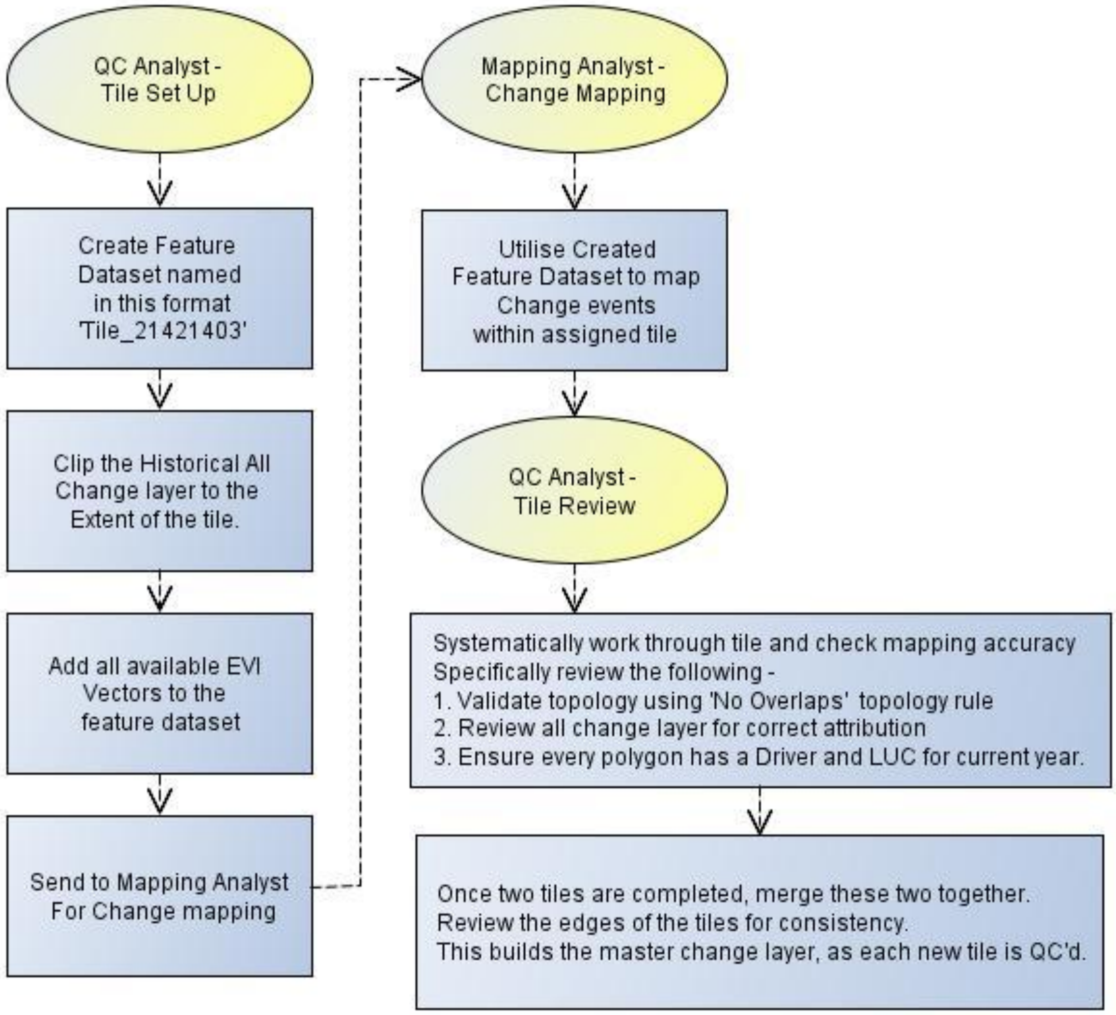
The following description, accompanied by

Figure 10-1 summarises the standard QC procedures.

QC Process:

1. Stitch master datasets together, ensuring consistency.
2. Select rivers and non-forest and clip to remove overlaps.
3. Clip master to country boundary.
4. Self-intersect the layer to find any final overlaps.
5. Calculate areas and delete any areas under 25 m^2 these are considered invalid slivers.
6. Harmonise table to ensure drivers LUCs are consistent.
7. Intersect with land class layer.

Figure 10-1: QC Process Outline



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Appendix 1

Development Areas Update 2017-2020

Development Areas 2017 Update

The following development areas are identified for the 2017-2020 period. Progress has been made on aspects of Task 3.1.12 and 3.1.13. Other tasks logically follow on from the continued development of a forest monitoring system that is uses frequent observations. A summary of activities that are underway that relate to tasks 3.1.12 and 3.1.13 are documented.

Table 2017-2020 Development Areas

Task	Description	Activities
3.1.10	Report and Incorporate new development areas	Further refinement of methods to quantify afforestation resulting from regenerating non-forest areas, and studies to show the carbon accumulation rate on abandoned mining sites. This work links in with Guyana's planned mining reclamation project and the consideration of appropriate emission factors. Integration of new satellite sensors into the MRV such as. Sentinel 2A & Planet Labs, as well as RADAR. An accuracy evaluation of Sentinel 2A is proposed prior to integration into future MRV reporting Tracking of degradation to assess the areas transitioning from degradation to deforestation and those areas that are reforesting. Incorporation of deforestation modelling methods to predict future deforestation patterns, building on work done to date based on both econometric modelling for mining and timber production and spatial modelling for mining
3.1.11	Improve methodology for treatment of Shifting Cultivation, if deemed necessary	As presented in Section 5.2 of the report
3.1.12	Explore Options for near-real time monitoring for high priority sites.	Test different data streams and their usefulness and integration for near-real time monitoring of forest changes and REDD+ implementation starting in high priority sites. - Develop a framework to use near-real time monitoring to ensure compliance of deforestation agents and link into the same data sharing platform. - Develop a framework to use near-real time monitoring to ensure compliance of deforestation agents. - Produce a Report documenting results of near real-time monitoring tests and pilot system.
3.1.13	Explore options for development of an information platform for access to MRVS results and data.	Using data housed under the MRVS from the period 1990 to 2014, collated under phase 1 of the MRVS, develop a platform for use of data and results at the concession level. This platform could potentially be extended to encourage data sharing between agencies, communities and for hosting near-real time deforestation updates. - Explore options for further development of an information platform with the Ministry of Natural Resources. - Conduct a feasibility study and explore identified options from previous experiences (i.e. TerraAmazon or TerraCongo, Google Earth Engine) and develop a plan on which data to use for this purpose - Explore making Guyana's MRVS data and information (results) available through the Global Forest Watch platform.
3.1.14	Develop platform and mechanism for use of MRVS data and results for forest concession monitoring and management	Implement the platform and use it as active communication and feedback tool between the Ministry of Natural Resources, the Guyana Forestry Commission, and forest owner and managers. - Establish reporting framework for collating MRVS at concession level.
3.1.15	Conduct pilot of use of MRVS data and results through conducting a review of a forest concession agreement	Focus group discussions to determine how stakeholders GGMC, GFC and MNR interpret the policies and apply enforcement measures. The purpose to gain an overview of how well the policies are understood and implemented.

Task 3.1.12 Explore Options for Near-real Time Monitoring for High Priority Sites

Alternative Image Options

The capability of forest countries to monitor and report change varies - “one size does not fit all”. The lessons learnt from Norway’s bilateral agreements have identified several challenges (NICFI Real-time Evaluations) that merit consideration and reflection on how to best achieve a reduction in global forest deforestation.

Recent improvements in the ability to rapidly process large volumes of satellite imagery to produce 30 m global forest change maps (Hansen et al 2013) signal a shift in monitoring capabilities. A key prerequisite is, however, a continuous a supply of well calibrated satellite imagery that is free and easily accessible. The landmark decision by USGS in 2008 to open the historical Landsat archives to the global community made this a reality. This situation continues to improve.

Sentinel

Today there are a variety of EO satellites in orbit although almost all, except for Landsat, are commercial and require tasking. The situation has change with the recent launch of Sentinel-2A (23rd June 2015, with operational data capture in October 2015), followed by Sentinel-2B an identical satellite. Like Landsat, Sentinel provides imagery that is both free and readily accessible to the public.

This constellation provides two additional EO satellites capable of imaging the same location every five days at 10 m resolution. The specifications of Sentinel 2 (A & B) make it ideal as a replacement for the current use of Landsat as the supplement image for mapping. Furthermore, at 10 m resolution, it could be reasonably justified as a potential replacement for RapidEye.

Year 6 analysis has made good use of Sentinel with the intention to start routinely using it for forest change and potentially the monitoring of degradation. Planet Labs datasets are also being actively evaluated and tested.

Planet Labs

In recent years improvements in technology have led to a decrease in the development costs of satellites. This is evident with the deployment of micro-satellites which is best demonstrated by Planet Labs.

Planet Labs operates a network of satellites known as ‘doves’. These are micro satellites measuring roughly 10 cm high x 10 cm wide and 30 cm in length.

They aim to provide high resolution imagery using a large constellation of doves. This effectively decreases the revisit time and increases temporal resolution. The data sharing policy and pricing of Planet Labs imagery is still being developed. For the time being Planet data has been used by GFC over two test sites and also as a source of data for the Year 6 accuracy assessment.

The launch timeline and constellation development are as follows;

- 2013: Launched 71 doves
- 2014: Built 95 new doves.
- 2015-2018: 100+ new doves are commissioned aiming to provide daily capture at 3-5 m resolution.

Over time the technical specifications and design characteristics have been altered based on evaluation of the data produced. The build process has rapidly improved and incorporates progressive refinements of hardware and software and extension of the receiving station network. In 2015 Planet Labs began establishing a reseller network and distributing engineering grade imagery via a beta version of the online catalogue. The constellation has since continued to improve, and data is now routinely collected and distributed via Planet’s online catalogue.

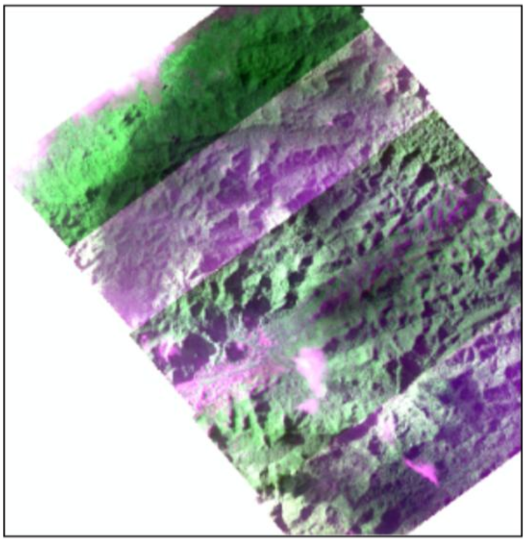
Planet’s satellites follow two different orbits namely International Space Station (ISS) and Sun Synchronous Orbit (SSO). The SSO is common to many earth-observing satellites which have a set equator crossing time and acquire images only on descending orbit. The planet satellites in SSO cross equator at 9:30-11:30 acquiring images of an area almost same time in every revisit. The satellites in ISS however have no fixed equatorial crossing time.

Data Characteristics of Planet Satellites

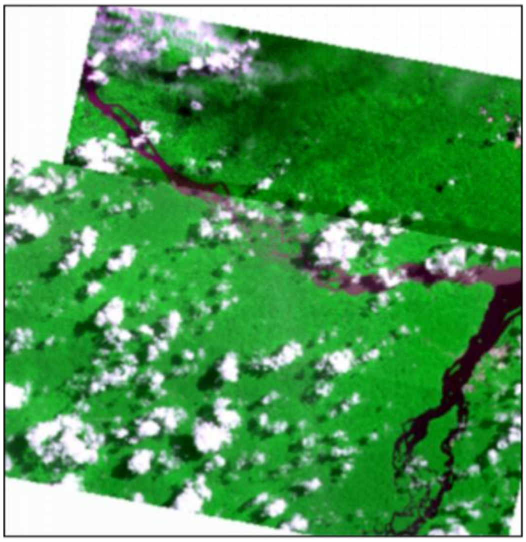
Mission Characteristic	International Space Station Orbit	Sun Synchronous Orbit
Orbit Altitude (reference)	400 km (51.6° inclination)	475 km (~98° inclination)
Max/Min Latitude Coverage	±52° (depending on season)	±81.5° (depending on season)
Equator Crossing Time	Variable	9:30 - 11:30 am (local solar time)
Sensor Type	Three-band frame Imager or four-band frame Imager with a split-frame NIR filter	Three-band frame Imager or four-band frame Imager with a split-frame NIR filter
Spectral Bands	Blue 455 - 515 nm Green 500 - 590 nm Red 590 - 670 nm NIR 780 - 860 nm	Blue 455 - 515 nm Green 500 - 590 nm Red 590 - 670 nm NIR 780 - 860 nm
Ground Sampling Distance (nadir)	3.0 m (approximate)	3.7 m (approximate)
Frame Size	20 km x 12 km (approximate)	24.6 km x 16.4 km (approximate)
Maximum Image Strip per orbit	8,100 km²	20,000 km²
Revisit Time	Variable	Daily at nadir (early 2017)
Image Capture Capacity	Variable	150 million km²/day (early 2017)
Camera Dynamic Range	12-bit	12-bit

The quality of the engineering grade 1 C imagery has been assessed against earlier releases of Planet Labs imagery and against Landsat. Results indicate that the data quality has continued to improve, however the radiometric quality and consistency of the latest 1C data is still variable. The characteristics of Flock 1C are that it images at 3 m spatial resolution which is resampled from an original pixel size of approximately 4.5 m.

Comparison Planet Images from ISS and SSO Orbits



ISS orbit with low sun angle (<20°)



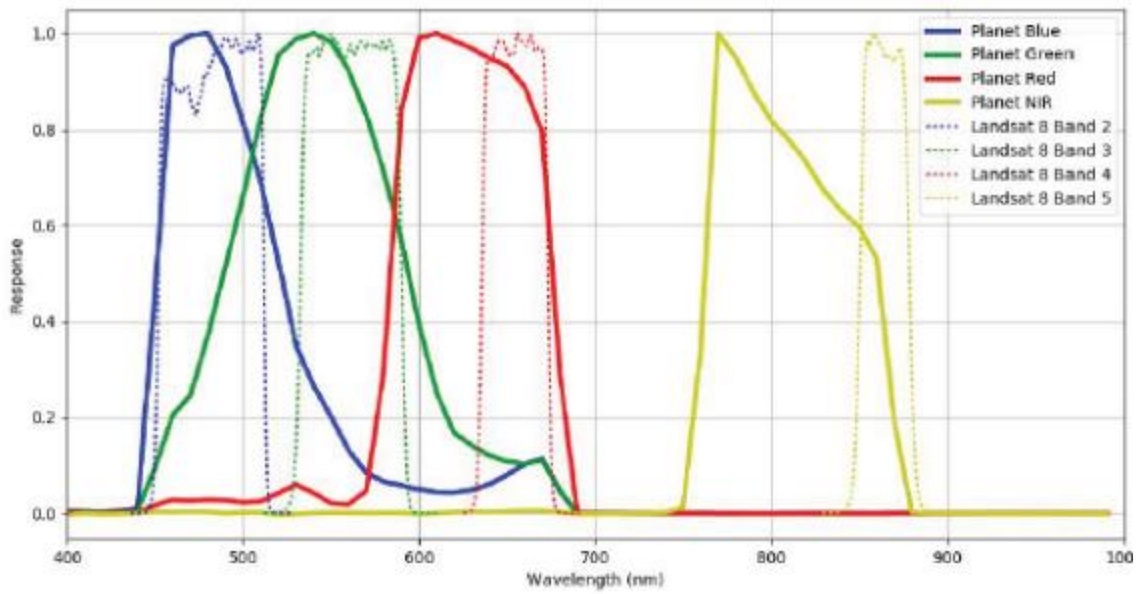
Sun synchronous orbit (Sun angle >50)

Spectral Characteristics

Planet has progressively added satellites to its constellation. Earlier satellites were equipped with three band cameras that recorded only blue, green, and red wavelengths. The more recent launches have included the near infrared band, referred to as 'AnalyticMS'. The inclusion of the NIR band enables the calculation of the common Normalised Vegetation Index (NDVI) which aids in the separation of forest and non-forest. This assists in automating the detection of deforestation events.

A feature of the Planet sensors which are essentially off-the-shelf cameras is that the wavelengths measured cover broader range than other satellites. As shown in Figure 6, Planet's blue band extends from 450 to 700 *nm* cf. Landsat 8 which captures and resolves a narrower range which better matches the spectral response of the blue wavelength.

Relative Spectral Response of Planet and Landsat 8 (Source: Planet Labs Inc.)

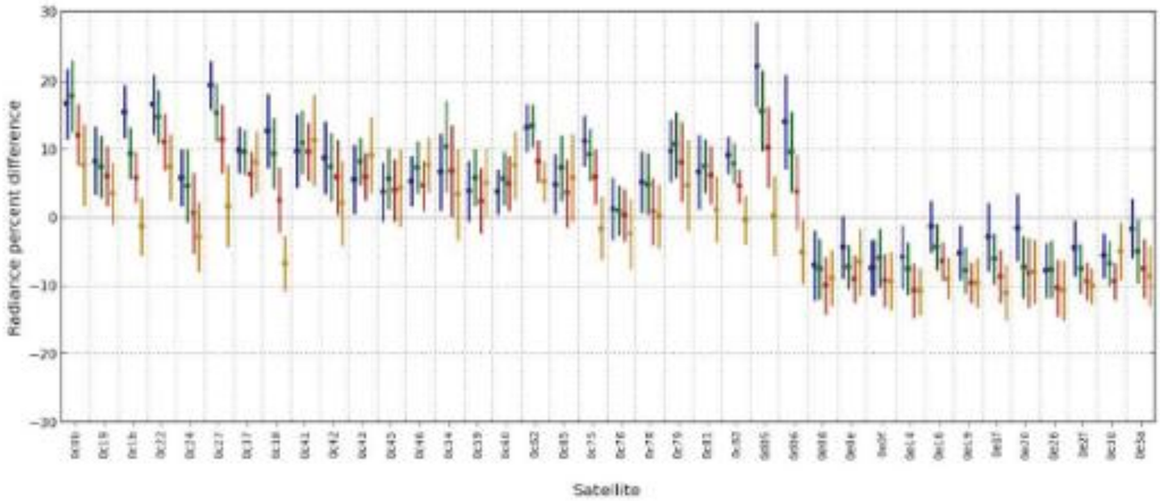


This has two impacts, it means automated processes need to be adapted to use Planet's NDVI values as the NDVI values are lower than other sensors which more precisely measure the position of the wavelengths. The second is that the wider span of the wavelengths and sensor filters used reduce the clarity of the images. This may reduce the usefulness of the planet images in areas where changes in forest cover are subtle (i.e. forest degradation activities), or the spectral characteristics of vegetation types are similar.

To reduce the impact of these differences Planet have recently applied Spectral Band Adjustment Factors (SBAF). The motivation for the correction comes from the need to compensate the spectral response differences of multispectral sensors (i.e. Landsat and RapidEye) to provide a more accurate cross-calibration between the sensors. For reference, the difference in band radiance values for 38 Dove satellites from Flock 2p (SSO) and Flock 2e (ISS).

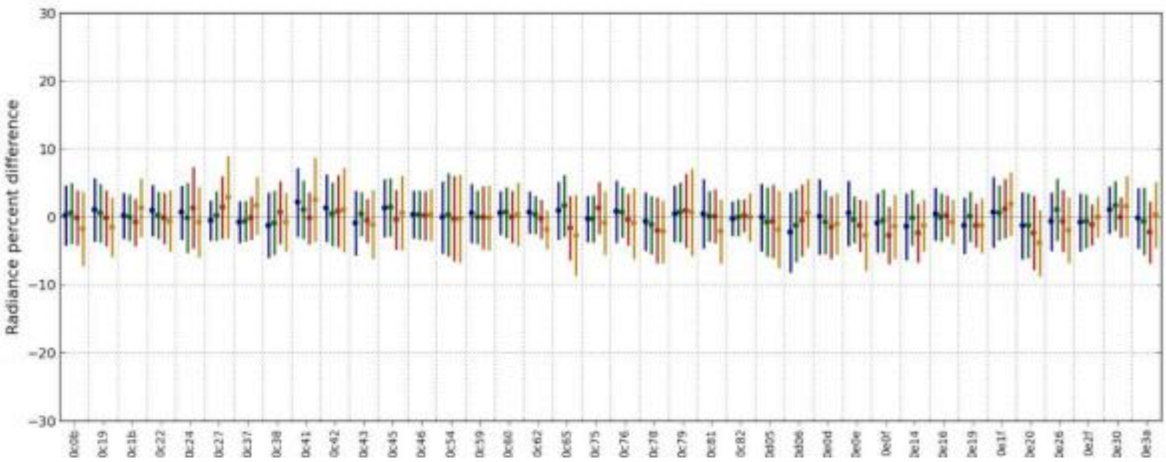
The measure uses the percentage difference for each satellite as compared against the response from RapidEye and Landsat over the same invariant calibration sites.

Before Correction F2E and F2P absolute accuracy vs. RapidEye and Landsat 8 (Source: Planet Labs Inc.)



The purpose of the calibration is to reduce the variation between satellites so that Planet's images better align with spectral bands measured by existing Earth observation satellites. According to Planet's technical documentation the calibration model reduces the radiometric uncertainty to around 5-6%. The distribution of the radiance differences by satellite and band

After Correction F2E and F2P Absolute Accuracy vs. RapidEye and Landsat 8



Change Detection

To effectively map forest change at a national scale efficiently a level of automation is desirable. Guyana's existing MRVS has been designed in a way that allows the inclusion of satellite images from various satellites.

The approach is semi-automated and detects forest to non-forest change by identifying new change. These changes are identified by transforming the images to represent the Normalised Vegetation Index (NDVI). The NDVI as an indicator of vegetation vigour and presence has been widely used to differentiate forest from non-forest.

The minimum mapping unit (MMU) threshold adopted for the MRVS is 1 ha. This means that all deforestation events equal to, or above this threshold are mapped and recorded in the MRVS. The exception to this guideline is the treatment of rotational shifting cultivation. In Guyana, these areas are often situated close to the forest / non-forest fringe. The areas cut are small and fragmented (≤0.5 ha) and move through a process of being cut, burnt, cropped and then abandoned.

The MRV has progressively added new indicators. In 2014 the annual area of shifting cultivation was first reported. The interim reporting measure includes shifting cultivation with other degradation sources and compares the annual change against an agreed benchmark value of 4 368 ha. Work on characterising Shifting Cultivation continues.

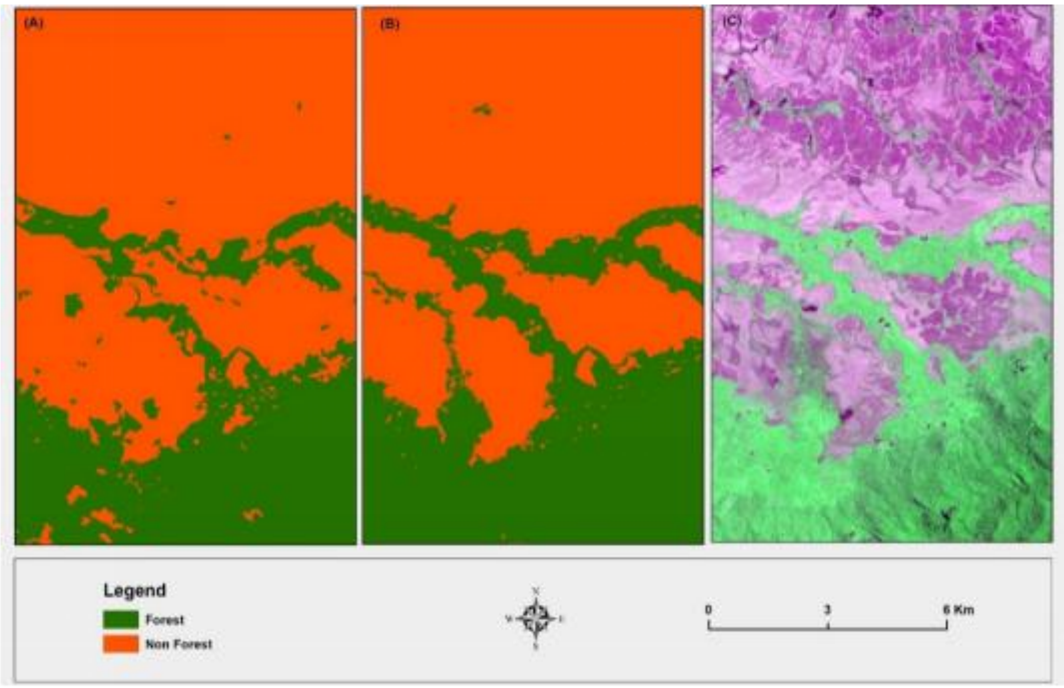
The results for the two sites are described as follow.

Site 1: Rotational Shifting Cultivation

The planet images were evaluated to ascertain if they could be used to identify the forest boundary and if the resolution was high enough to detect new areas of shifting cultivation. The number of scenes used was limited, so the analysis is only considered to provide first indication of the utility of the Planet datasets.

The figure below compares the automated forest and non-forest mapping from the MRVS (A), derived from the Planet image (B), referenced against the Planet image (C). The image resolution and scene quality were adequate to identify the forest/non-forest edge. This edge matches the existing boundary which was derived from interpretation of 5 m RapidEye imagery (A). Going forward the findings suggested the dataset is suitable for refining or monitoring changes within the forested extent.

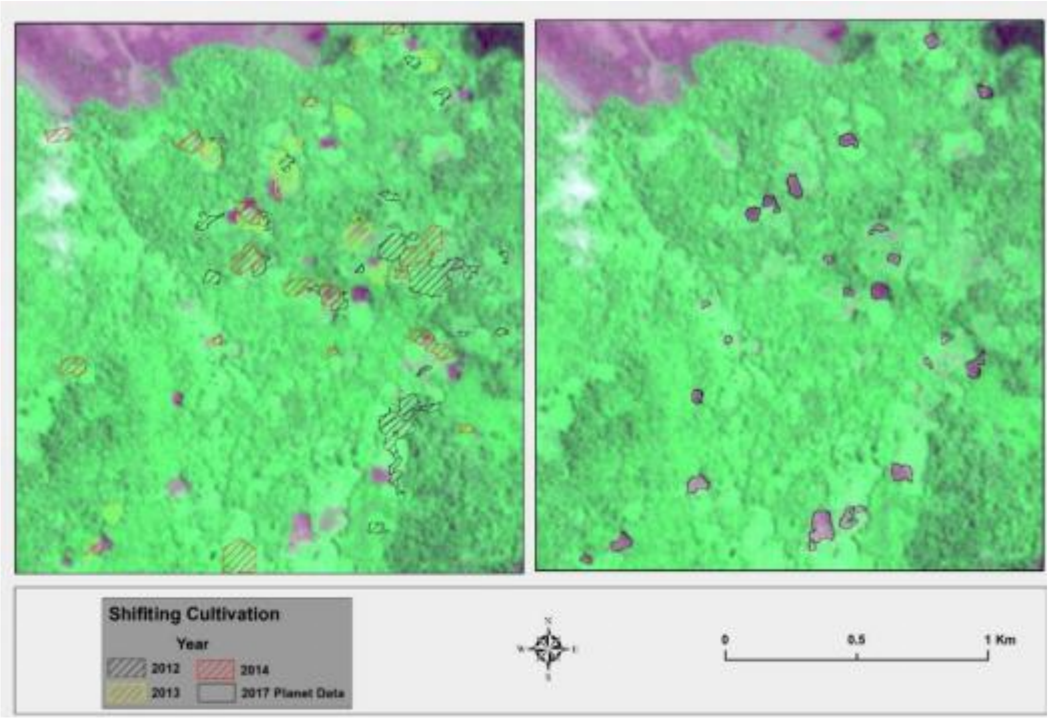
Forest Non-Forest Class comparison between MRVS and Planet derived datasets.



The second part of the assessment looked at an area of shifting cultivation that has been progressively monitored from 2012 to 2014. The areas detected were overlaid on the planet image and are relatively small (mean area of each patch 0.4 ha), but for completeness, any areas below the MMU threshold of 0.5 ha have are recorded.

No shifting cultivation was identified post 2014 due to the suspension of the national monitoring program. The new changes are evident on the 2017 Planet imagery. The extent of these areas is automatically extracted using the NDVI routine, assigned a change driver and added to the MRV.

Detection of new (post 2014) shifting cultivation areas

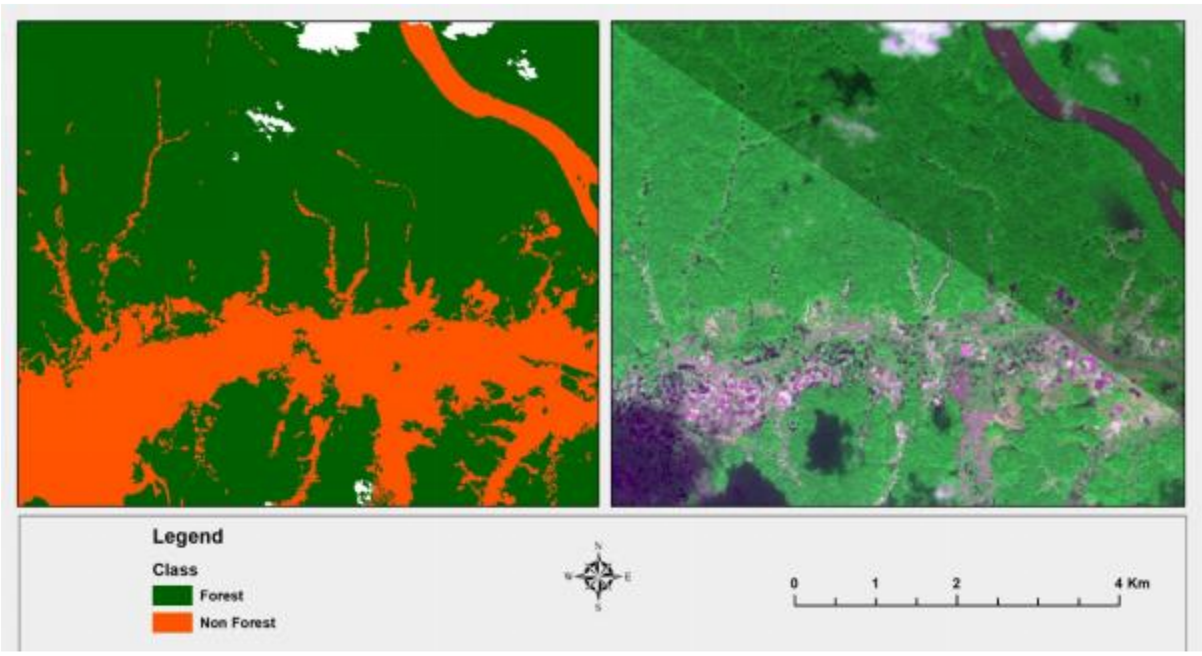


The results indicate that Planet images can be used to track shifting cultivation through time. Inclusion of Planet images into the MRVS effectively increases the temporal frequency which makes it easier to identify and track newly cut areas and monitor those areas that have been abandoned.

Site 2: Active Mining

Site two covers an area of active mining that continues to expand. The extent of the activity has been automatically extracted to identify newly mined areas. In this example, the level of change means the mined areas are clearly separable from the surrounding forest.

Delineation of forest change caused by mining activities.



The analysis shows that images can be incorporated within the framework of the existing MRVS and used to track new deforestation events.

Adoption of Real Time Monitoring

The current MRVS used by GFC is designed to report annual/biannual forest change. While this system provides a robust framework[27] and is suitable for this task, it is however not entirely compatible with operational requirements. For instance, it does not provide frequent and timely information in a format that can be readily distributed to GFC field stations, or other agencies involved in the management of resources.

The increased temporal resolution represents an important shift towards continuous monitoring of resources. The ability to monitor the same location repeatedly enables the detection of subtle changes in the forest canopy and identification of trends. The real analytical efficiencies are accomplished by leveraging off cloud computing architecture which hosts and serves petabytes of historical and recently acquired images on-demand. With data held in this environment there is no need to individually review, download, or process and analyse satellite imagery as was the norm in the recent past.

These developments represent a major change in the way data is analysed – allowing on-demand processing while simultaneously accessing an ever-increasing repository of global datasets, satellite images, topographic and climatic observations.

The proposed solution uses a cloud-based processing environment hosted by Google Earth Engine (available free). Satellite images are available in the cloud (optical, Landsat, Sentinel 2A/2B and radar Sentinel 1A).

The proposed system leverages off the high image cadence to produce a series of monitoring layers that support more effective resource monitoring. Key components include;

1. The use of cloud-based storage and image processing chain which reduces the need to invest and maintain computing software and hardware
2. The inclusion of per-pixel level processing routines that reduce the impact of cloud. The process is designed to select the best available pixel from multiple images to produce a cloud-free composite – this is relevant as parts of Guyana are frequently covered in cloud.

Cloud and Pixel Level Processing of Satellite Data

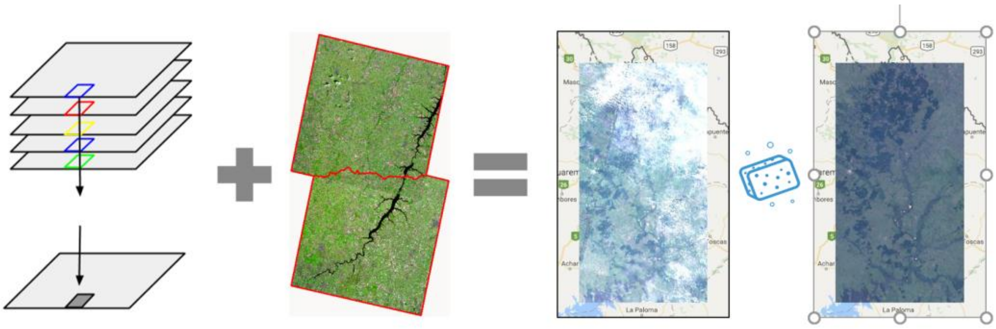


Image stack | Image mosaic | Image composite (raw) | Many Images composite (cleaned – replaced cloudy pixels)

3. Using the composites, the use of customised processing routines that automate the detection of forest change.
4. The inclusion of images from other data sources to increase the number of observations i.e. Sentinel 1A radar based on experienced gained with CORSAIR and GFOI.

[27] The MRV system has been subject to independent audits by DNV since 2009. The main purpose of the audits is to determine that the national forest change results are accurate.

5. Validation of change (as real) is a key element of users having confidence in new technologies. We will fully test algorithms and use results to a Bayesian model that continually improves the predictive power of the satellite-based change observations. A strength of Durham's Mathematical Sciences Department is Bayes linear methods and uncertainty quantification including imprecise probability.

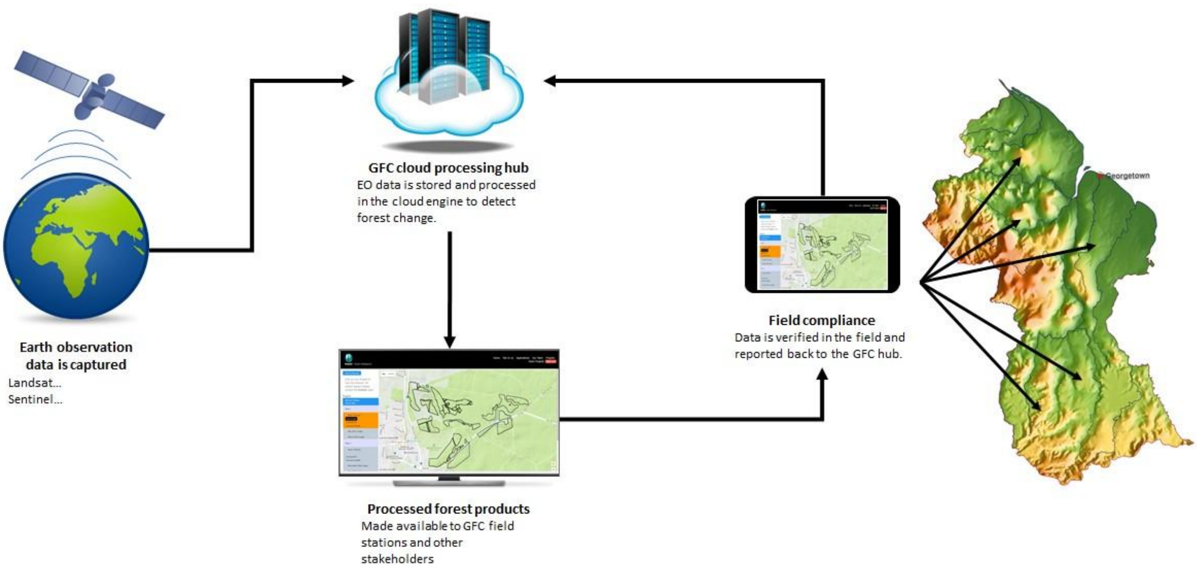
   Also, further operational research that tests the synergy and application of images sourced from other providers (Planet Labs / Cosmo Skymed and Tandem X) is also planned. The evaluation will be at a pilot scale to determine what the benefits are of, increased temporal resolution, inclusion of different sensors, and spatial resolutions. Equally important are the data costs versus potential benefits.

Task 3.1.13 Explore options for development of an information platform for access to MRVS results and data.

Several options are currently being considered and will be tested in 2018. These include development of an interagency solution (http://data.gim.gov.gy/), linkages with Forest Watcher which is a mobile app that allows offline display of forest change alerts generated by GFC or GFW (UMd maps).

The general process is illustrated below which shows the link between satellite imagery, which is held and processed in the cloud and the final output layers which are hosted on a web-based GIS. Potentially the system could be deployed to the field stations via the internet. Field stations user the data layers to focus their field activities and as an evidential data source from which to enforce legality and compliance. After the inspection updated information is relayed back to GFC.

Continuous Forest Monitoring Concept



Key features and advantages of the solution include:

1. A cloud-based environment that accesses and processes satellite images in a way that the user does not need to download imagery. Downloading of large images is time-consuming and slow due to the limited internet connectivity.
2. Image processing is completed in the cloud which increases processing efficiency and reduces the need for the GFC to invest in expensive remote sensing software, or image storage and back up.
3. All processing is accessible via a simple web-based GUI that allows multiple users to access the same set of algorithms and tools.
4. The process and methods used are documented and repeatable which allows consistency and an audit trial

5. The detection algorithms will be adapted and improved based on operational feedback and experience.
6. The final products are downloaded in a batch mode and divided into tiles which increases download efficiency and reduces redundancy.
7. These layers are distributed to field stations via a secure web-based platform managed by GFC. The platform allows the layers to be viewed relative to base layers (i.e. forest /mining concession boundaries or approved harvest/exploration areas). The different spatial layers – i.e. KML, common GIS formats, GPS format or images can be downloaded to check compliance in the field.
8. The layers also contain additional information such as the date the activity was detected the area (ha) and flags to signal if field inspections are necessary to ensure compliance.
9. Further functionality allows field offices to upload feedback from the field after inspections are complete.

The intention is that the system streamlines the monitoring and enforcement process. This will be achieved by embedding appropriate tools and technologies, so to provide an operational system that enables GFC to focus allocation of resources and improves the management of natural resources.

Appendix 2

2015 Follow up Actions

CARS and OBS	GFC Response	Update
CAR 4 – 2014 Minor **Status – Open** **Requirement**: Interim Measures 2.2 and 2.4 **Non-Compliance**: Biomass assessment plots of degraded forest within shifting cultivation areas are not adequately reflected within overall biomass calculation. **Objective evidence:** - Fieldwork evidence shows that most, if not all, SA mapped as pioneer actually is rotational. - Fieldwork evidence shows that the currently map identification of primary forest in shifting cultivation areas has led to the allocation of areas as primary forest where ground truthing of the same areas identified the area as rotational agriculture/degraded secondary forest.	The brief inspection conducted during the audit indicated that rotational shifting cultivation was classified as pioneer. It is worth noting that this the first year shifting cultivation has been reported. It is anticipated that as an approach 3 MRVS and with further repeat image coverages the attribution of both historical and new shifting cultivation areas will be improved. While the areas in question still fall within Guyana's definition of forest, it is recognised that this is secondary forest. It is expected that the historical extent of shifting cultivation areas will improve in line with annual coverages of high resolution imagery and area data continues to be collected that identifies and maps new shifting cultivation areasThe current work on Emission Factors by GFC will account for the differing carbon contents. It is planned for field assessments to be conducted to inform an emission factor for Shifting Agriculture. This will inform the impact that this activity has on biomass. This will remove the dependence of categorising shifting agriculture type using remove sensing methods only, which evidently has specific challenges. It is envisaged that an Emission Factor will be developed as part of the second phase of the MRVS 2017-2020 for Shifting Agriculture. It is likely that the emission factor will be a function of the forest-fallow cycle and local practices. The challenge will be how to count for the net emissions from this activity. It is still being assessed whether Shifting Cultivation mosaics are lengthening or shortening or stable. This determination will help to decide their role. Once an estimate of the average C stock is derived in different Shifting Cultivation mosaics then this can be used with pioneer shifting cultivation—i.e. first time cleared, as the net effect will not be the C stock of the application, that provisions need to be clearly outlined to address any eventuality – like a randomly selected area, already having undergone forest change. A section is proposed to be added to the SOP for Forest Carbon Monitoring, to address this. This will be included once the fieldwork and additional analysis of temporal forest changes have completed.	*The mapping of shifting cultivation has been reviewed and the section of the SOP specific to this has been updated to clarify mapping of pioneer and rotational shifting agriculture. Essentially the historical extent of Rotational shifting agriculture has been adjusted. Rotational shifting agriculture were extended using historical imagery as a guide whilst Pioneer shifting cultivation now has a more precise distinction in mapping boundaries that makes the separation of pioneer and rotational shifting agriculture more specific and thus, less likely to be misclassified. Further there has been additional effort directed towards a rigorous review of previously mapped areas of shifting cultivation to ensure that there is a precise and accurate mapping and attribution of this land use. Refer to new improvements ot eh SOP: sub section 7.4, Rotational shifting agriculture pg.34 and Pioneer shifting agriculture pg. 35 of the SOP.* *From the forest carbon aspect, this is also an item of focus for the current phase of the work. Guyana is seeking a cost effective means to attain accuracy in assessment of shifting cultivation while not incurring disproportionate costs. Active discussions are occurring on whether shifting cultivation areas should be considered forest or non-forest given Guyana's forest definition's exclusion of "lands that are predominantly under agriculture" as well as the fact that areas under shifting cultivation cycles will not be allowed to reach "maturity".* *Excluding shifting cultivation would lead to a focus on the limited areas converted from forest to shifting cultivation, while ongoing inclusion would require more work to demonstrate cycle length and emission factors associated with*

CARS and OBS	GFC Response	Update
		initial conversion as well as any shortening of cycles. *Guyana remains committed to accurate accounting. As such work over the next year will confirm the definition and will derive new procedures as necessary and will plan and where possible collect field data for new emission factors.*
CAR 2 - 2015 Minor **Status - Open** Requirement: 1.1, 2.1, 2.2, 2.3 and 2.4 Non-Compliance: Historical GIS layers not confirm the Y5 RapidEye images in some cases. Objective evidence: In some areas the GFC GIS layers show a significant shift (of up to 60 meters) (e.g. tile 214308, west side; tile 2140704) with the Y5 RapidEye images. The current mis-registration of GIS layers with the imagery could cause new deforestation or degradation to be missed, when it, due to these issues with registration, seems to coincide with already existing neighbouring deforestation/degradation and thus would be disregarded because of apparently no change. For Y5 RapidEye updated the positional accuracy for Guyana, resulting in an offset (compared to Y4) for some areas up to 30 meters (according to p. 12). This could be the root cause of this shift. However, whatever the cause, to ensure accurate mapping for Y6 the GIS layers of GFC should match the future RapidEye images.	It was recognized that when the base map was updated from Landsat to RapidEye full coverage, it would produce an offset/shift with the historical change mapped. To correct for this misalignment, each GFC Analyst was required to shift all historical change to fit the 2014 RapidEye imagery for each tile they were tasked with mapping before they started to digitize/map Year 5 change. We do recognize however that in identified areas, elements of the historical change remain misaligned with the 2014 RapidEye. To correct for this misalignment, the following is proposed and will be pursued in MRVS Year 6: Before the commencement of the year 6 mapping it is planned that each mapping analyst go through each RapidEye tile and manually correct for each misalignment found with the historical change and the 2014 RapidEye. The analyst would use the same approach for mapping new change (systematically go through tile by tile) except in this instance, they would be correcting the historical change and ensuring that it is properly aligned with the 2014 RapidEye imagery. As a secondary consideration there will be some exploration of the possibility of ordering the RapidEye 3B product which was used in 2013, as this aligns with historical change (this however would mean that GFC cannot use the updated base map and would need to align all change mapped for year 5 to the imagery (RapidEye 3B product) before GFC proceeds to do year 6 mapping). This is not the preferred option but will be explored to establish the pros and cons before a final decision is take on the next steps. Further the GFC would be assessing whether year 6 or future RapidEye would be referenced to the same coordinates as year 5; also that any other imagery would also fit with the Year 5 image and derived map data. The SOP & QC rules may benefit from an update where historic GIS could be updated to reflect any shift in the current year's satellite imagery. E.g. for Year 6 data (where applicable) historic GIS will be shifted to show consistency with Year 6 imagery. In terms of the SOP, this step will go in the preprocessing stage	*RapidEye has not been used as a source of imagery. Landsat and Sentinel 2A images were used. Only deforestation has been mapped using these images.*

CARS and OBS	GFC Response	Update
	(before digitising Year 6 change) so not to double count or misclassify any current changes. We also note that shifting is very common between different sensors and also from year to year as ground control points are updated. GFC has dealt with this issue in several examples over Phase 1 (Years 1 to 4 of the MRVS) and through consistent QC and results from the AA, image shifting has not been an issue where the reported figures are significantly inconsistent. We propose to continue using this approach moving forward as we are faced with similar challenges.	
CAR 3 - Minor **Status- Open** Requirement: 1.1 Non-Compliance: SOP are not followed in all events Objective evidence: During the audit it was found that as part of the rechecks SOP instructions on Page 62 of the SOP for Carbon Measurements were not followed i.e.: When the two measurements of DBH are with the allowable error range, the average of the two values is entered in the carbon calculator workbook (with notation made to indicate this was done) o Any error exceeding allowable limits will be used to calculate measurements error as described below and the identified errors should be corrected. No record of the errors found during the QA&QC were found as outlined in Page 68 of the SOP for Carbon measurements.	In improving the MRV system the SOP guiding the implementation has to be updated from time to time. One such improvement is the updating of the QA/QC section of the SOP which was added in August 2015. Important to note is that this modification was done after the data on the medium potential for change area was collected. The procedure will however, still be applied to this data and will be reported in the final report on the carbon stocks assessment after all biomass data is processed for the MRV Phase 1. Since the data for the low potential for change is still being processed including the rechecks, this modification to the SOP will be applied to this data set. A tab will be created in the tool itself to track the errors of data entry during the rechecks also applicable to the low potential for change stratum. We also plan on conducting a continuous programme of training of new and current staff to keep staff abreast of all relevant areas of the FCMS. We note that in some cases, these will need to be refresher courses, and in other cases, courses on new developments and areas. In general, we would like to note that in our assessment, field errors are minimal and do not affect in any substantial way, the results and analysis. CAR	*The steps to correct these actions were taken as indicated by the initial GFC response. As was mentioned at the time of the audit, data were still being collected while changes to the SOP were made. The SOPs have been edited further following discussion between GFC and partners to ensure there are no inconsistencies, errors and incongruences. The modified SOPs were applied for the ground data collection in the LPFC. This analysis produced an estimate of measurement error of just 0.05%.* *Going forward routine training will continue as the MRV enters into its second phase and QA/QC process will be standard.* *Further, the SOP has now been updated to reflect the revised approach.* *The second measurement is considered to be definitive as it is captured by the most experienced field staff.* *However, the remeasurement is just a sample and as such should not be used to selectively replace originally collected data.* *The purpose of the remeasurement is singularly to determine the measurement error in field measurement.*
CAR 4 - Minor **Status- Open** Requirement: 1.1, 2.1, 2.2, 2.3 and 2.4 Non-Compliance: RapidEye co-registration indicates misalignment leading to shifts between RapidEye images Objective evidence: For several RapidEye tiles,	The GFC has taken note of this issue and determines this matter to only prevail on a small scale and does not affect the main results and analysis. This is an important matter however, for the future improvement of the MRVS and to correct this issue we propose the following: Consult with RapidEye to inquire if it is possible for them to correct the	*RapidEye has not been used as a source of imagery. Landsat and Sentinel 2A images were used. Only deforestation has been mapped using these images.*

CARS and OBS	GFC Response	Update
images for one tile taken at different dates in Y5 don't exactly match. For example between 2140602_2014-1112_RE3_3A_298743 and 2140602_2014-1116_RE2_3A_298743, the latter is shifted approximately 3 pixels (15 meter) to the east.	misalignment between scenes of imagery obtained for the same tile. Use the Georeferencing tool present in ArcGis to align imagery. The approach would be to check for the RapidEye tile/image that is best aligned with both historical and Year 5 change and shift all other imagery collected for this area to align them with the selected image (this would be done by doing a point shift). The GFC will consider ordering RapidEye swaths and re co register imagery and forward the GCP's to RapidEye (this however does not guarantee that all images for the same area will line up, it is also time consuming). Thus, this is not the preferred option but will be examined nevertheless, as one alternative. In conclusion, the GFC notes that shifting of coincident tiles from the same year/delivery is an issue with the RE imagery provided to GFC. However, as a response for Year 6/Phase 2 development we will include an additional level of QC which will look at consistency of coincident tiles (mosaicked geo referenced products). Where tiles are offset we can apply a correction to align them correctly and/or inform RE of the misalignment should the number of tiles affected. The latter will likely be used should the issue be on a larger scale.	

Appendix 3

Joint Concept Note on REDD+ Cooperation between Guyana and Norway

Joint Concept Note

Background

On November 9th, 2009, Guyana and Norway signed a Memorandum of Understanding (MoU) regarding cooperation on issues related to the fight against climate change, in particular those concerning reducing emissions from deforestation and forest degradation in developing countries (REDD-plus[1]), the protection of biodiversity, and enhancement of sustainable, low carbon development.

An accompanying Joint Concept Note (JCN) sets out the framework for taking the Guyana-Norway co-operation forward. It sets out how Norway would provide Guyana with financial support for REDD-plus results, and formed the basis for the first payment from Norway to Guyana.

Since the first Joint Concept Note was published, considerable progress has been made in the Guyana-Norway cooperation. The JCN has been updated regularly to reflect this progress and sets out next steps for achieving the 2015 goals of the partnership:

- The first update of the Joint Concept Note was finalized in March 2011 and guided the partnership until December 2012.
- The second update was finalized in December 2012 and guided the partnership up until June 2013.
- For the period September 2013 to November 2014, Norway and Guyana agreed on performance targets for key Strategic Objectives of the partnership. These are available online[2] and will be reported on and assessed.

This current version of the Joint Concept Note is the third update and is intended to guide the partnership for the period from June 2014 to June 2015.

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[1] As defined in the Bali Action Plan (2/CP.13).

[2] https://www.regjeringen.no/globalassets/upload/kld/kl/klima-og-skogprosjektet/guyananorwayannouncement.pdf

Section 1: Introduction

This Joint Concept Note constitutes the overarching framework for taking the Guyana-Norway cooperation to its final year, 2015. Specifically, it addresses Paragraphs 2 (c), 3 and 4 of the MoU signed between Guyana and Norway on November 9^{th}, 2009. The Joint Concept Note sets out how Norway is providing, and will continue to provide, financial support to Guyana, based on Guyana's delivery of results as measured, and independently verified or assessed, against two sets of indicators:

- *REDD-plus Performance Indicators:* A set of forest-based greenhouse gas emissions-related indicators, as described in more detail in Section 3 and Table 2. Results against these indicators will be independently verified according to the established practice of the partnership. These indicators will gradually be substituted as a system for monitoring, reporting and verifying (MRV) emissions from deforestation and forest degradation in Guyana is established. The development of the MRV system is guided by the MRV roadmap.[3]

- *Indicators of Enabling Activities*: Indicators are identified that can be independently assessed through publicly available information on progress regarding a set of policies and safeguards to ensure that REDD-plus contributes to the achievement of the goals set out in Paragraph2(c) of the MoU signed between Guyana and Norway on November 9^{th}, 2009, namely *"that Guyana's LCDS Multi-Stakeholder Steering Committee and other arrangements to ensure systematic and transparent multi-stakeholder consultations will continue and evolve, and enable the participation of all affected and interested stakeholders at all stages of the REDD-plus/LCDS process; protect the rights of indigenous peoples; ensure environmental integrity and protect biodiversity; ensure continual improvements in forest governance; and provide transparent, accountable oversight and governance of the financial support received."* The enablers are described in more detail in Section 2 and Table 1 below.

Norwegian financial support is primarily being channeled through a multi-contributor financial mechanism – the Guyana REDD-plus Investment Fund (GRIF). The support is financing two sets of activities:

- The implementation of Guyana's Low Carbon Development Strategy (LCDS)

- Guyana's efforts in building capacity to improve overall REDD+ and LCDS efforts.

Section 4 sets out how the financial mechanism operates.

The previous concept note updated the longer term goals of the partnership – these goals are further updated in this concept note. The annual progress in developing the MRV system and in strengthening the quality of REDD-plus-related forest governance continues to be defined as steps towards reaching these goals. The Government of Guyana is responsible for making publicly available the necessary data for assessing performance against the given indicators.

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[3] http://www.forestry.gov.gy/Downloads/Terms_of_%20Reference_for_Guyana's_MRVS_Draft.pdf

Section 2: Enabling Activities

The continuation of result-based financial support from Norway to Guyana will depend on publicly observable progress on forest governance, as outlined below.

Section 2.1 Indicators of Enabling Activities

Performance in enabling activities will be measured against progress on six key categories of activities:

Strategic framework:

All aspects of Guyana's planned efforts to reduce deforestation and forest degradation, including forest conservation, sustainable management of forests and enhancement of forest carbon stocks ("REDD-plus"), are being developed in a consistent manner, through an internationally recognized framework for developing a REDD-plus programme, and will continue to evolve over time.

Guyana has chosen the Forest Carbon Partnership Facility (FCPF) as the strategic framework for its REDD+ efforts, with the Inter-American Development Bank (IDB) as the delivery partner. In 2014 Guyana concluded engagement with the IDB for the commencement of implementation of the FCPF with the signing of a Technical Co-operation Agreement between GoG and IDB. The focus will now be on the implementation of the FCPF and to commence the process of preparing the R-Package.

Guyana's REDD-plus efforts have been integrated within the Low Carbon Development Strategy (LCDS), which currently covers the period to 2015. The LCDS was originally launched in 2009, with an addendum in 2013. By June 2015, the LCDS will be updated to reflect progress in implementing REDD+ initiatives, lessons learnt from the Guyana-Norway Partnership and to set out in draft form the focus, initiatives and projects for the next phase of the LCDS (2015-2020).This draft document will then be subject to wide stakeholder consultations, including forest-dependent and Amerindian communities, and other members of civil society.

The contributions to Guyana's LCDS from Norway and other contributors, including the FCPF, will be administered in a transparent manner. Information concerning all expenditures, both planned and implemented, are publicly available on the relevant website of the Government of Guyana, and through national systems of public disclosure, including to the National Assembly.

Goal of the partnership

Guyana and Norway support the relevant decisions of the UNFCCC COPs in Cancun, Durban, Doha, Warsaw and Lima. In particular, the Governments welcome both (i) the Cancun decision to agree a new, global climate agreement by 2015, for implementation from 2020 at the latest and (ii) the Warsaw Framework for REDD+.

The Governments believe that the partnership between the two countries can provide many useful lessons for the crafting of the new global agreement, as well as influencing the effective functioning of other multilateral processes, e.g. the FCPF. This could include lessons on creating effective climate finance mechanisms, setting REDD+ reference levels, and providing practical lessons on the implementation of safeguards. The Government of Guyana's Readiness Package ("R-Package") was prepared and submitted to the FCPF in 2014. Guyana is considering to give an early idea presentation for the Carbon Fund in the April 2015 meeting with the intention of entering the fund´s second pipeline.

Improved Financial Intermediation

Goal of the partnership

It is hoped that by 2015, the financial mechanisms of the partnership can be used as examples of interim flexible climate financing instruments, which allow for rapid approval of projects and stronger national ownership, while at the same time applying internationally recognized standards for fiduciary, environmental and social safeguards.

Continuous multi-stakeholder consultation process:

The LCDS, including the REDD-plus strategy and prioritized LCDS funding needs, is subject to an institutionalized, systematic and transparent process of multi-stakeholder consultation, enabling the participation of all potentially affected and interested stakeholders at all stages of the REDD-plus/LCDS process. This process will continue to evolve over time. Particular attention is given to the full and effective participation of indigenous peoples and other forest-dependent communities.

Goals of the partnership

- Monthly meetings of the Multi Stakeholder Steering Committee (MSSC), with comprehensive minutes of every meeting made publicly available immediately upon approval from the following MSSC meeting. Enable participation of all relevant stakeholders through renewal of invitations to the MSSC,
- Information and consultation program which includes:
    - Keeping the GRIF and LCDS web pages updated with relevant information about the progress of ongoing processes.
    - Wide stakeholder engagement and inclusive consultations of the LCDS.
    - Establishing and operationalizing a Communications Team coordinated by the Office of Climate Change and responsible for communication, information and awareness sessions.
    - The establishment of information and awareness activities that are designed to meet the needs of Amerindian communities, including through the use of non-internet based channels of communication such as in-person meetings, information folders, and traditional media.
    - Coordinated information flows related to the different parts of LCDS implementation, including but not limited to LCDS progress, EITI, FLEGT, FCPF and GRIF projects. Collaboration with the National Toshaos Council (NTC) and MSSC members to function as agents of information sharing.

Governance:

A transparent, rules-based, inclusive governance, accountability and enforcement system for forests in Guyana is being progressively strengthened, in accordance with Guyana's outline REDD-plus Governance Development Plan (RGDP) as outlined in Table 1.

Goals of the partnership

- Execution of EITI Scoping Study along with the preparation of a fully costed Work Plan by February 2015; application for EITI Candidacy presented to the EITI Board by June 2015.

- Continuation of work towards a Voluntary Partnership Agreement (VPA) under the EU FLEGT Action Plan in accordance with the July 2013 Joint EU-GoG Road Map with the intent of signing the VPA by Guyana upon completion of the VPA negotiations, a process which is jointly conducted by the GoG and EU . This will be conditioned upon large consensus of all stakeholders involved and impacted by the VPA, that their inputs have been taken into account, sufficient time given for discussions and engagements at the stakeholder level, and subject to further updating of the Road Map, including that which may emanate from the scheduled April 2015 EU GoG negotiation session.
- Continued implementation of Independent Forest Monitoring (IFM), with the second IFM assessment done at the end April 2014. In keeping with Section 4 of the agreed Terms of Reference for IFM, the next IFM assessments will be conducted at 2 years intervals thereafter, the next one taking place in April 2016 unless other provisions are foreseen in the VPA.
- Ongoing implementation of activities by the Land Reclamation Committee in accordance with its ToR and Work Plan, such as site screening evaluation, backfilling, and stakeholder engagements, will continue and be communicated publicly by June 2015.
- Submission of Guyana's fifth national report by June 2015 to the CBD including to the extent possible a description of the synergies between the protection of biodiversity, REDD+ and the LCDS.
- Revision of the National Biodiversity Strategy and Action Plan and continuing to implement actions to meet the Aichi Targets and the UNCBD Strategic Plan publically communicated by June 2015.
- Implementation of a GoG (MNRE) programme of activities, with actions focused on specific efforts to manage degradation from extractive activities where this needs to be done, including, but not limited to: the operationalizing of a mining school, training and capacity development, applying technology for improved recovery and reduced environmental impact, recruitment of additional mines officers and enhanced enforcement, and continued dialogue with the sectors and relevant stakeholders towards ensuring that sectoral best practices are applied and sustained thereafter.
- Implement a project to mainstream biodiversity protection in the gold mining sector, including completion of ToRs for two (2) Consultancies - ongoing: (i) capacity building of EPA Officers, and (ii) prioritisation of hotspots for monitoring and enforcement of mining-related activities by June 2015.
- Exploration of the development of a GRIF project that focuses on expanding the current mercury free program in addition strengthening the Exploration and Prospecting Unit of the Guyana Geology and Mines Commission so as to help enable environmentally low-impact mining and prospecting for small and medium scale miners.

The rights of indigenous peoples and other local forest communities as regards REDD-plus:

The Constitution of Guyana guarantees the rights of indigenous peoples and other Guyanese to participation, engagement and decision making in all matters affecting their well-being. These rights will be respected and protected throughout Guyana's REDD-plus and LCDS efforts.
Guyana's policy is to enable indigenous communities to choose whether and how to opt in to the REDD+/LCDS process. This will take place only when communities wish to do so with their titled lands, in accordance with Guyana's policy of respecting the free, prior and informed consent of these communities.

Goals of the partnership

- GRIF funding made available to enable the achievement of the Government of Guyana's policy objective of completion of land titling for all eligible Amerindian communities, with progress measured relative to a publicly available timeline.
- GRIF funding made available for all Community Development Plans (CDPs) through the Amerindian Development Fund.
- Opt In mechanism strategy developed and the selection of a community to test the mechanism with a piloting of the mechanism in place by June 2015.
- Implementation of the part of the outreach program under the multi-stakeholder indicator which is tailored and targeted towards the needs of Amerindian communities by June 2015.

Integrated land-use planning and management:

Several aspects of REDD+ relate to the development of a system for environmentally sustainable and climate smart area planning and management.

Goals of the partnership

- By September 2015, Guyana has a formal system in place for holistic area planning and management.
- A key element of this system should be a publicly available map of area use (including, but not limited to, full transparency regarding existing and planned concession and reconnaissance areas for forestry and mining, titled lands for Amerindian communities, areas planned and concessioned for industrial agriculture etc.)
- The MNRE has recently launched a Geospatial Information Management Unit which has created a web-based application (Geonode) for the management and publication of spatial data inclusive of forestry concessions, mining concessions and Amerindian titled lands. The interface allows for non-specialized users to share data and create interactive maps which can all be publically accessed and viewed. By June 2015 the Geonode Server is to be publically available and operational.
- In the process of developing the system for area planning and management and the area use map, formal status of varying degrees of protection should be awarded to a significant part of the areas identified as Intact Forest Landscapes and priority areas for biodiversity. This will gradually replace the Intact Forest Landscapes interim performance indicator.The measures taken will as a whole be in line with Guyana's stated goal of maintaining 99.5 per cent of its forest for the duration of the partnership and stay on a similar trend after 2015,though the degree of forest protection will depend on various factors, including the availability of international climate finance.[4]

- [4] Whilst implementing the IFL Roadmap, it was apparent that there was an urgent need for a technical analysis required to determine priority areas for biodiversity. As such, the Protected Areas Commission (PAC) along with expertise solicited from the University of Kent and Conservation International, completed a Technical Report on the Priority Areas for Biodiversity through consultations with relevant stakeholders. The Report was submitted as a means of verification for JCN 2014. In an effort to progressively implement the IFL Roadmap with consideration given to the recently completed technical gap-analysis report, the PAC has commenced the development of its System Plan and Strategic Plan (2015-2020) which will both provide the framework for protecting and managing existing protected areas and priority areas for biodiversity. In addition, the road

Monitoring, Reporting and Verification:

Guyana has progressed far in developing a national MRV system. Guyana has established a deforestation baseline and performed four forest area assessments for the years 2009-10, 2010-11, 2012 and 2013. The fifth annual assessment for year 2014 is currently being conducted.

Goals of the partnership

- Guyana has implemented the MRV-roadmap and reached a reporting level incorporating several Tier 3 elements by the end of 2015. These Tier 3 elements include, but are not necessarily limited to, the use of high resolution data at national level that allows for disaggregation, the use of methods that provide estimates of greater certainty than lower tiers for key carbon pools, the use of comprehensive field sampling that is linked to GIS based systems which integrates land use and management activity data, and is subject to quality checks, and validations. Further, other areas relevant to Tier 3 reporting, will be explored as stated in the MRV Roadmap.
- Guyana will conclude technical analyses that inform a national reference level that is to be submitted to the UNFCCC. The reference level will reflect the core elements of the reference level agreed by the GoG and the GoN, and also make provisions that the reference level be reassessed at regular intervals as/if global rates decrease. Guyana submitted the reference level to the UNFCCC by December 2014 in accordance with timelines provided by the UNFCCC secretariat – and was one of the first countries in the world to do so.
- Establish mechanisms for data sharing between governmental agencies, so that the MRV data generated can inform policy development in the broader land use sector, e.g. for land use planning, enforcement in the mining sector etc. The Geospatial Information Management Unit under the Ministry of Natural Resources and the Environment will coordinate this work.

Section 2.2 Assessing Progress Against Enabling Indicators

Table 1 below sets out how progress will be measured regarding enabling indicators going forward. These indicators are informed by the long term goals of the partnership as agreed in section 2.1 above, and thereafter updated in accordance with the long term goals.

Guyana and Norway have agreed that the necessary information to assess Guyana's delivery on these indicators will be easily accessible in the public space. Independent assessment of the information thus accessible determines to what degree, the REDD-plus enablers have been met.

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map makes reference to site-level management plans for which the PAC is currently drafting through a number of stakeholder consultations for three (3) existing protected areas – Shell Beach, Kanuku Mountains and Kaieteur National Park. In doing so, the management plans will serve as a template for piloting site specific priority areas for biodiversity.

Section3: REDD-plus performance indicators

Guyana is being paid for its performance through an incentive structure which rewards keeping deforestation below an agreed reference level, as well as avoiding increased forest degradation.

The Governments of Guyana and Norway strongly endorse the establishment of such an incentive structure under the United Nations Framework Convention on Climate Change (UNFCCC). To help facilitate such an agreement, the Governments have decided to pilot this incentive structure on a national scale and in a pragmatic, gradually evolving, workable and hopefully replicable manner. Once an international regime is in place, the Guyana-Norway partnership will be adjusted accordingly. Section 3.1 sets out the incentive structure, while Section 3.2 outlines how performance is to be assessed.

Section 3.1 REDD+ incentive structure

The payments due to Guyana for a given year are paid post facto. They are calculated as follows:

1. Measure avoided deforestation by subtracting Guyana's observed deforestation rate against the agreed *reference level*. See Section 3.1.1

2. Determine avoided greenhouse gas emissions by applying a set of *carbon-density proxies* to:
   (i) convert the observed avoided deforestation rate into avoided greenhouse gas emissions;
   (ii) subtract increased emissions from forest degradation based on agreed indicators and their reference levels as set out in table 2.
   See Section 3.1.2.

3. Apply an interim carbon price of US$5 per tonne of avoided emissions, providing Guyana does not exceed an agreed level of deforestation within the context of the Guyana-Norway partnership – see Section 3.1.3. If the deforestation rate is above the levels stipulated in section 3.1.3, payments will be reduced and ultimately cease.

Section 3.1.1 – Measuring Avoided Deforestation and Forest Degradation

Setting a Deforestation Reference Level

For a global REDD+ mechanism to be effective it must incentivize both (i) reductions in deforestation in countries with high levels of deforestation and (ii) maintenance of low deforestation rates in countries that have maintained their forest cover. If only countries with high deforestation rates are compensated for improving their forest protection under an international climate regime, deforestation pressures will move to countries with currently low deforestation, like Guyana, and the overall emissions reduction effect will be diluted or lost.

On the other hand, if a global incentive structure does not ensure global additionality, the international community will be paying for "hot air" and there will be no mitigation impact.

This point is broadly accepted within the UNFCCC negotiations, and there is general agreement that a REDD-mechanism must provide genuine incentives for forest conservation in low deforestation countries, as well as ensure global additionality.

Therefore, Norway and Guyana have – pending the finalization of a UNFCCC reference level methodology – decided to use the "combined reference level" methodology to set a provisional reference level, based on an equal weighting of Guyana's mean 2000 - 2009 deforestation rate and the mean 2005 – 2009 rate in developing countries with deforestation. The "combined reference level" methodology provides incentives for all categories of forest countries, and ensures that emissions from deforestation and forest degradation are reduced cumulatively at a global level.

In setting a historical deforestation baseline for Guyana under the Guyana-Norway REDD+ partnership, the mean value for the 2000-2009 period is used; 0.03% (see Box 1 below for background).

This estimate included all forest to non-forest change i.e. detected mining, road infrastructure, agricultural conversion and fire events that result in deforestation. It does not include forest degradation caused by selective harvesting, fire or shifting agriculture. The same approach and criteria was applied to calculate the area of deforestation from 2009 to 2010 (Year 1 period). The total area of deforestation for this period was calculated at 10 287 ha. In year 2 the change figure was similar and reported as 9 891 ha. For Year 3 the total area of deforestation over the 12 month period is calculated at 14 655 ha. There have been significant improvements in Year 3 in the development of methods of reporting on forest degradation.

This adheres to the principles used for setting the historical deforestation baseline in the Brazilian Amazon Fund.

The "global average deforestation rate" is calculated[5] across 85 developing forested countries by dividing the sum of reported forest area loss in only those countries which lost forest by the starting area of forest across all countries, Data on forest loss is taken from FAOs Forest Resources Assessment 2010 (FRA 2010). For the period 2005-2010 the "global average deforestation rate" was 0.52%. This figure will be subject to revision given new data from e.g. future FAO FRA's or from the IPCC.

The reference level for Guyana is the mean value of these two measures, that is, 0.275%.

Setting Reference Levels for forest degradation indicators.

In the first two years of the partnership, Guyana's MRVS was not sufficiently developed to enable an analysis of forest degradation in Guyana that would enable a facts- based reference level to be established for all degradation indicators. Guyana has made substantial progress in improving the knowledge base for degradation indicators, and the current set of indicators and their associated reference levels are described in Table 2.

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[5]The open source Osiris database was used for these calculations (www.conservation.org/osiris). Note that this is an underestimate because it does not include deforestation that occurred within countries that had a net gain in forest, nor does it account for all deforestation in countries that lost forest as some countries' reported forest area loss are net values.

Box 1:

To improve knowledge in historical deforestation rates in Guyana, an analysis of forest area change since 1990 to September 2009 was undertaken using archived Landsat type satellite data that met the IPCC Good Practice Guidelines for Land Use, Land use Change and Forestry (LULUCF). The analysis was conducted by Poyry and subsequently by Indufor upon assignment by the Guyana Forestry Commission. Assessments were conducted for three periods: Year 1 (01 October, 2009 to 30 September, 2010); Year 2 (01 October, 2010 to 31 December, 2011) Year 3 (1 January 2012 to December 31 2012) and Year 4 (1 January 2013 to December 31 2014) with findings subject to independent verification by Det Norske Veritas (DNV GL). The reports are available at www.regjeringen.no/guyana and www.forestry.gov.gy.

Forest Change Area by Period & Driver from 1990 to 2013

Driver	Historical Period			Year 1	Year 2 2010-11 (15 months)		Year 3 2012		Year 4 2013	
	1990 to 2000	2001 to 2005	2006 to 2009	2009-10	Deforestation	Degradation	Deforestation	Degradation	Deforestation	Degradation
	Area (ha)									
Forestry (includes forestry infrastructure)	6 094	8 420	4 784	294	233	147	240	113	330	85
Agriculture (permanent)	2 030	2 852	1 797	513	52	N/A	440	0	424	N/A
Mining (includes mining infrastructure)	10 843	21 438	12 624	9 384	9 175	5 287	13 516	1 629	**11 251	2 955
Infrastructure	590	1 304	195	64	148	5	127	13	278	112
Fire (deforestation)	1 708	235		32	58	28	184	208	96	395
Settlements									23	20
Year 4 Shifting Agriculture										765
Year 2 forest degradation converted to deforestation							148		67	N/A
Year 3 forest degradation converted to deforestation									200	N/A
Amaila Falls development (Infrastructure Roads)					225				64	20
Area Change	**21 267**	**34 249**	**19 400**	**10 287**	**9 891**	**5 467**	**14 655**	**1 963**	**12 733**	**4 352**
Area Change for Year 4 without Shifting Agriculture										3 587
Total Forest Area of Guyana	18 473 394	18 452 127	18 417 878	18 398 478	18 388 190		**18 502 531**		18 487 876	
Total Forest Area of Guyana Remaining	18 452 127	18 417 878	18 398 478	18 388 190	18 378 299		18 487876		18 475 143	
Period Deforestation (%)	0.01%	0.04%	0.02%	0.056%	0.054%		0.079%		0.068%	

**Forestry infrastructure accounts for the full total of deforestation from forestry activities.

**Mining Infrastructure accounts for 918 ha in 2013 out of the total deforestation driven by mining of 11 518 ha, when Year 2 & 3 transitional areas are taken into account.

***Amalia Falls Development has been split from other infrastructure driven change for reporting purposes.

Section 3.1.2 Converting to Avoided Greenhouse Gas Emissions

Guyana is working to implement an IPCC-compliant MRV-system for emissions or removals of carbon from Guyana's forest sector. Until such a system is in place, a set of basic interim (proxy) indicators will be used to assess Guyana's performance. As a more sophisticated forest carbon accounting-system is implemented, these basic indicators will be gradually phased out. The set of interim performance indicators is based on the following assumptions:

- They provide justification and prioritization for near-term implementation of REDD-plus efforts.
- They are based on conservative estimates while encouraging the development of a more accurate MRV system over time through building national capacities.
- They will contribute towards the development of a national MRV-system, based on internationally accepted methodologies and following the IPCC reporting principles of completeness, consistency, transparency, uncertainty, comparability, and encourage independent international review of results.

When calculating reduced emissions from avoided deforestation, an interim default value of 100 tons of Carbon is applied. This interim carbon figure corresponds to 367 tons of CO2. When calculating emissions caused by forest degradation, a default value of 400 tons per hectare is applied, this corresponds to 1468 tons of CO2. These conservative carbon values help to ensure that emission reductions from deforestation are not over-estimated and emissions from forest degradation are not under-estimated.

The interim indicators are described in table 2 below.

Section 3.1.3 Calculating Payment

Payments due to Guyana will be calculated by applying an interim carbon price of US$5/ton CO2, as established in Brazil's Amazon Fund.

However, this price will only be applied if Guyana's observed deforestation rate is below the agreed level. This is explained in the following section.

Agreed maximum level of Deforestation

If designed for maximum effectiveness and efficiency, a future global incentive system could allow for significant variations in individual countries' deforestation rates while still ensuring global additionality.

However, in the absence of a global system, such an approach alone would imply that Guyana would be eligible for significant payments even if it were to increase its deforestation along a business-as-usual trajectory towards the agreed reference level of 0.275%.

However, neither Norway nor Guyana wishes to see such an increase in deforestation, and in November 2009 the Joint Concept Note clearly stated that:

"(…) the Participants agree that Norwegian financial support from 2011 onwards is also dependent on no national-level increase in deforestation over an agreed level that should be as close to historical levels as is reasonable in light of expanded knowledge of these historical rates and the quality of that knowledge. Such a level can only be set when more robust data is available concerning current and historic deforestation."

Box 2:

Mechanism for reducing results based payments if deforestation rate exceeds the agreed maximum level (0,056%)

Deforestation rates (%)	Up to 0.056	0.057-0.062	0.063-0.080	0.081-0.090	0.091-0.1
Reduced compensation (% per 0.0015 increased deforestation)	0	1,5	2,0	2,5	3,0

At the same time, Guyana's national development requires limited but strategic use of forest assets to enable (i) a limited amount of economic activity to take place within the forest, where the economic value to the nation of such activity is very valuable; (ii) a limited amount of essential national infrastructure to be constructed where this is in line with critical development goals; (iii) support for the sustainable development of forest villages. Guyana is reaching a stage of economic development where experience from other countries suggests that enabling these objectives brings further deforestation pressures.

Therefore, pending the introduction of a global incentive system, it would defeat the purpose of making REDD+ an attractive development option for forest countries if this REDD+ agreement meant that no increases at all be allowed in Guyana's historically low deforestation rates. First, the rates are so small that the margin of error of measurements in itself could yield significant annual variations (as measured in per cent). Second, insisting on such strict limitations would probably yield an insufficient incentive structure for the people of Guyana to stick to a low-deforestation development path, as the economic downsides would be disproportionate to the incentive offered.Third, the relevance of historical trends when deforestation rates are extremely low is not as useful a predictor of future pressures on the forest as it is in countries with higher historic rates of deforestation.

There is no given mathematically correct answer to how these concerns should best be balanced. Guyana and Norway have chosen a model that on the one hand enables Guyana to exercise careful, strategic use of limited forest areas for high value economic activity, the construction of essential national infrastructure and sustainable development of forest villages. On the other hand, the model puts in place incentives that would quickly penalize an upward trend in deforestation, see Box 2.

The essence of this approach has two implications:

(i) One-off predictable and controllable deforestation events will be allowed for critical national infrastructure that is part of Guyana's transition to a low carbon development path.[6] During the duration of the current Guyana-Norway partnership, the only such event will be the construction of the Amaila Falls hydro-electricity plant. This plant is the flagship of Guyana's Low Carbon Development Strategy, and is expected to eliminate over 92% of the country's energy-related emissions, after the emissions associated with its construction are accounted for[7]. It will only go ahead after Guyana and Norway have agreed that the necessary Environmental and Social safeguards have been met, and an independent verification agreed by Guyana and Norway confirms the overall beneficial effects of the project from a climate change perspective.

(ii) Economic activities will be permitted within the forest, within a ceiling on deforestation of 0.056 per annum, without any financial penalty apart from the reduction in compensation caused by a smaller margin between the reference level and the verified deforestation level. For any deforestation rate up to this level, Guyana will be eligible for payments equaling the full margin between the reference level and the verified deforestation level. For deforestation rates between 0,056 per cent and 0,1 per cent (unless they relate to the Amaila Falls project as described above), eligibility for payments would be calculated as a gradually decreasing percentage of the payments that would be due if only the margin between the reference level and the verified deforestation level were taken into account, as set out below. At deforestation rates at or above 0,1 per cent, no payments would be due to Guyana for that given year.

This approach is compatible with the Government of Guyana's declared long-term strategy to maintain the maximum amount of forest cover in Guyana, if an appropriate incentive structure is in place to make this strategy viable. This is being done through a balanced mix of maintaining forests under full protection (areas where only small-scale subsistence farming by forest dependent communities is allowed) and sustainable commercial forest management (where existing forestry concessions can operate within the terms of their licenses and the GFC's sustainable forest management guidelines).

In sum, this means:

a) that a ceiling on the level of deforestation that can take place before 2015 with any incentives still flowing, has been set at only around 35 per cent of the level of deforestation that the reference level would imply;
b) the accommodation of limited annual upward variations to ensure that the incentive structure still makes REDD+ a positive development choice for Guyana; and
c) that Guyana is incentivized to maintain more than 99.5 per cent of its forest cover for the duration of the partnership.

See Box 3 for a summary description of how performance based payments will be calculated.

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[6] The exception is only from the 'agreed maximum level of deforestation' provision. The emissions resulting from such activities would still be part of the total deducted from the reference level to determine total payments due to Guyana. I.e., emissions from Amaila would still count as deduction in total amount due to Guyana in the years when Amaila was established.

[7] The January 2011 ESIA for the Amaila Falls project can be found at http://amailahydropower.com/latest-news/key-project-documents. Section 5 details how a 92% reduction in net greenhouse gas emissions is calculated.

Norwegian support to GRIF – alone or in combination with other contributors – will not exceed the sum calculated on the basis of the above described methodology.

It is also likely that while support from Norway will provide majority funding for results delivered by Guyana, in a given year, it is unlikely to equal the total sum owed to Guyana. Therefore, to ensure that the incentives which underpin the partnership are fully in place, Guyana and Norway will work together to seek to get other Participants to join the partnership.

Once other Participants are in place with sufficient commitments to the Partnership, this will enable Norwegian (and other Participants') contributions to vary directly with performance, i.e. a reduction in estimated emissions will lead to relatively higher contributions, increases to relatively lower contributions.

Section 3.2 Monitoring Progress Against Reducing Emissions and Enhancing Removals of Carbon in Guyana's Forests

Progress against reducing emissions and enhancing removals of carbon in Guyana's forests will in time be measured through the MRV system that is being put in place as set out in the MRV-system Road-map, which was recently updated with a new version[8].

Pending the implementation of the MRV-system, Table 2 sets out the interim REDD+ performance indicators described above. Guyana and Norway 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. In 2014, a system of parallel reporting will be conducted to pilot reporting on forest carbon emissions for main drivers of deforestation.

Reporting on forest carbon emissions will be done in addition to reporting on the Interim Indicators in Table 2 of the JCN.

A roadmap for the establishment of a national MRV system and accompanying Terms of Reference for the system have been developed to provide a framework for verifiable, performance monitoring, set against international best practice and nationally appropriate circumstances. In years 1, 2 and 3 (2009-2012), implementation has also commenced in a number of administrative and technical areas. Broad based MRV-system Steering and Technical Committees have been established and initial technical work has commenced and advanced in forest area and forest carbon stock assessment and monitoring. The framework has been created for annual reporting on deforestation and forest degradation in accordance with interim REDD+ Performance Indicator that will evolve into a full MRV system. The first product has been the completion of historic reporting on forest/non forest cover and deforestation by driver, over the period 1990 to 2009, accompanied by annual reporting of forest/non forest cover and deforestation and forest degradation results in accordance with REDD+ Interim indicators set out in the JCN. Concurrently, work is also proceeding for field based assessments of forest carbon stock assessment and monitoring, the establishment of demonstration activities, and detailed technical studies on reference level setting and forest degradation, as well as other areas.

During 2009-2013, significant improvements to Guyana's ability to measure deforestation indicators were made. In particular, it was determined (and independently verified) that deforestation rates were extremely low.

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[8] http://www.forestry.gov.gy/Downloads/Terms_of_%20Reference_for_Guyana's_MRVS_Draft.pdf

Box 3:
How will results based payments be calculated?

To calculate the results based payments due to Guyana based on the results in any given year, the following steps will be followed:

1. Subtracting Guyana's reported and verified deforestation rate from the agreed interim reference level of 0.275%;

2. Calculating the carbon emission reductions achieved through avoided deforestation (as compared to the agreed reference level) by applying an interim and conservatively set estimate of carbon loss of 100tC/ha. This value will be replaced once a functional MRV system is in place. The interim carbon loss figure corresponds to 367tCO_2/ha.

3. Subtracting from that number changes in emissions – on a ton-by-ton basis – from forest degradation as measured against agreed indicators and their reference levels, as specified in Table 2.

4. In calculating the carbon effects of forest degradation, an interim and conservatively set carbon density of 400 tC/ha will be applied. Upon agreement under the UNFCCC on how to estimate and account for emissions from degradation, this approach will be adjusted accordingly;

5. The tons of "avoided emissions" is then multiplied with an interim carbon price of US$ 5/ton CO2, as established in Brazil's Amazon Fund.

6. If the deforestation rate in a given rate exceeds 0,0056, the payments will be gradually reduced as a proportion of the sum derived through step 1-4 above, or cease (if at or exceeding 0,1 per cent), as stipulated in section 3.1.3, box 2.

Progress has also been made to gain a greater understanding of how degradation is to be measured, and is leading to further work that is expected to enable progress on refining the reporting on indicators to assess degradation, including that from mining and infrastructure (currently the dominant drivers of degradation).

Guyana and Norway have agreed that annual independent verification of REDD+ performance indicators will be conducted by one or more neutral expert organizations, to be appointed jointly by the Participants. The assessment determines what results Guyana has delivered according to the established indicators for REDD-plus performance. For the first, second and third reporting periods, the measurement of progress was carried out by Poyry and Indufor in collaboration with the Guyana Forestry Commission, and independent verification was carried out by DNV GL. DNV GL was selected on the basis of an international tender process in accordance with Norwegian procurement regulations.

Section 4: Financial Mechanism:

The Guyana REDD+ Investment Fund (GRIF) is channeling REDD-plus financial support from Norway and other potential contributors to the implementation of Guyana's LCDS.

Pending the creation of an international REDD+ mechanism, the Guyana REDD+ Investment Fund (GRIF) represents an effort to create an innovative climate finance mechanism which balances national sovereignty over investment priorities with ensuring that REDD+ funds adhere to globally accepted financial, environmental and social safeguards.

The GRIF is an interim solution for channelling climate finance to Guyana - designed for the Guyana-Norway Partnership up to 2015 - pending the transfer of payment intermediation, and associated processes, to Guyana's national systems. This will be done when it is possible to specify how independent verification of Guyana's adherence globally accepted financial, environmental and social safeguards can be implemented. This will draw on UNFCCC and other relevant guidance.

Until such time as national systems can be used, the World Bank's International Development Association (IDA) was invited by Guyana and Norway to act as Trustee and is responsible for providing financial intermediary services to the GRIF.

The Trustee (i) receives payments for forest climate services provided by Guyana; and (ii) transfers these payments and any investment income earned on these payments, net of any administrative costs, to Partner Entities, for projects and activities that support the implementation of Guyana's LCDS. Transfer of funds takes place on approval by the GRIF Steering Committee, which consists of Guyana and Norway, with observers from Partner Entities, as well as Guyanese and Norwegian civil society.

Partner Entities provide operational services for the approved LCDS investments, and apply their own globally accepted operational procedures and safeguards. As of March 2015, Guyana and Norway have approved as Partner Entities the Inter-American Development Bank (IDB), the World Bank and the United Nations Development Group.

More information on the operation of the GRIF is set out in the Administration Agreement between the Government of Norway and the World Bank.[9]

Improved Financial Intermediation
Improved Financial Intermediation is one of the key objectives of the Guyana-Norway partnership, in order to ensure effective flow of finances to GRIF projects. The lessons learned will be of global relevance. During the period of this JCN, steps to improve financial intermediation will see the Governments of Guyana and Norway:

(i) The GRIF Steering Committee will amend the GRIF Governance Framework document to allow for partner entities to use any instrument they deem appropriate under the GRIF.

(ii) The Governments of Guyana and Norway will encourage the Partner Entities to use the financing instruments they are comfortable with.

(iii) Acknowledging the need for optimizing financing mechanisms to streamline development of GRIF projects and accessing other climate funds, the PMO will be equipped with the resources and provided with the flexibility to fast track project development.

[9] http://lcds.gov.gy/guyana-redd-investment-fund-grif.html

Table 1 –Key REDD+ Enabling Efforts in 2014/15 (from June 15th 2014 to June 19th 2015):

Goal of Partnership	Description of annual indicators for Years 5 of the Partnership outlining Actions to June 19th 2015	
	ANNUAL INDICATOR	VERIFICATION/EVIDENCE
STRATEGIC FRAMEWORK		
Ongoing National Strategy	By June 2015, the LCDS will be updated to reflect progress in implementing REDD+ initiatives, lessons learnt from the Guyana-Norway Partnership and to set out in draft form the focus, initiatives and projects for the next phase of the LCDS (2015-2020).This draft document will later be subject to wide stakeholder consultations, including with Amerindian and forest-dependent communities, as well as other members of civil society.	Draft updated LCDS document available. Public announcement of wide stakeholder consultations for the LCDS update.
	Continued engagement between IDB and GFC for implementation of the FCPF. R Package prepared	Documentation on the implementation of the FCPF (copies of progress report, deliverables etc) R Package prepared and publicly available
CONTINUOUS MULTI-STAKEHOLDER CONSULTATION		
	Monthly meetings of the MSSC with comprehensive minutes made publically available immediately upon approval from the MSSC meeting	Minutes of meetings available on LCDS web site
	Coordinated approach to outreach and communications with support from the MSSC. Information flow will include climate change, LCDS and technical areas on REDD+ including MRVS, FLEGT, IFM, EITI, and FCPF across various sectors and stakeholder groups.	Annual Stakeholder Engagement Plan approved by MSSC and publically communicated. Copy of renewed invitation to the MSSC and list of invitees. Copies of awareness and communications materials Reports from outreach sessions

	Regular updates of the GRIF and LCDS websites. Update with relevant information about progress of on-going processes. All documents, I including deforestation reports, relevant for the Guyana-Norway partnership are available on one web page.	Matrix of information updates provided. Link to web page with all relevant documents, including, but not limited to the LCDS with its addendum, deforestation reports, accuracy assessment reports, verification reports, independent forest monitoring reports, enabling activities self assessment, enabling activities independent assessment, GRIF-projects, etc. Simplified summary of the MRVS interim measures report adapted to non-experts publicly available.
GOVERNANCE		
Application for EITI Candidacy by June 2015		
	Candidacy application submission to EITI Secretariat	Copy of EITI Candidacy Application.
Signing of the VPA	Continue to work towards a VPA in accordance with the joint GoG-EU Road Map with intent to sign the VPA upon completion of negotiations.	Updates on joint GoG-EU Road Map, widely circulated among stakeholders. Concrete steps are taken to ensure the genuine consultation and participation of all stakeholders involved and impacted by the legality definition and minutes of meetings available and widely circulated among stakeholders. Draft sections of VPA including drafts of the Product Scope, LAS and Transparency Annex, are developed in a participatory way and made available to all stakeholders and agreed with EU.
SLUC/Extractive Industries		

Implementation of a GoG programme with actions focused on specific efforts to manage degradation from extractive activities where this needs to be done	Mining School fully operational and conducting training courses for miners and operators in the sector	Curriculum for the Mining School available and records on number of persons completing courses
	Recruitment of additional field personnel and enhanced monitoring and enforcement	Report on recruitment of additional mines officers by GGMC Completion of 3 new Mining Stations
	Land Reclamation Committee functional and supporting efforts to restore and rehabilitate areas subjected to mining with publically communicated goal for area restored by June 2015.	Minutes of meeting of the Committee 3 Site Specific Action Plan and Progress Reports, publically available
	Continue training and capacity building for new entrants and existing small and medium scale operators	Training reports and materials
GRIF support to sustainable mining	Explore the development of a GRIF project that focuses on strengthening the Exploration and Prospecting Unit of the Guyana Geology and Mines Commission- so as to help enable environmentally low-impact mining and prospecting for small and medium scale miners.	Draft PCN developed and presented to partner entity for consideration.
IFM		
Conduct IFM assessments at 2 year intervals	Preparations in accordance with IFM ToR for next assessment scheduled for April 2016	Communication with European Forest Institute on synergies and transitioning of IFM audits to Independent Monitoring under EU FLEGT. Guyana's presentation at third Negotiation session of the EU and GoG on a FLEGT VPA, (scheduled for April 2015) on role of IFM in EU FLEGT process so far and possibilities of synergies and linkages Evidence of IFM Audits taking place every 2nd year, the last in April 2014 and the next planned for April 2016
CBD		

Prepare Fifth National Report to the CBD, including to the extent possible a description of the synergies between the protection of biodiversity, REDD+ and the LCDS	Submit 5th national report to the CBD	Copy of 5th National Report (including description of stakeholder consultation process and comments compilation) and submission.
Revise the National Biodiversity Strategy and Action Plan (NBSAP)	NBSAP revised to through a process of stakeholder involvement and takes on board recent REDD+ initiatives as well as outlines actions to meet the Aichi Targets and CBD Strategic Objectives	Revised NBSAP publicly available
The rights of indigenous peoples and other forest communities as regards REDD+		
Provision of GRIF resources to enable the achievement of the Government of Guyana's policy objective of completion of land titling for all eligible Amerindian communities, with progress measured relative to a publicly available timeline (ALT project timeline 2012-2016)	Continuation of activities under the titling and demarcation activities under ALT project.	Copies of Absolute Grants and Certificates of Title issued Copies of investigation reports from MoAA and work orders for demarcation from GLSC
Opt In mechanism pilot started by June 2015	Opt In Mechanism Strategy prepared and piloted in one community	Copy of the Strategy Initial report on the piloting of the Opt In Mechanism
GRIF funding made available for all CDPs through the Amerindian Development Fund	Documentation of lessons learned from Initiation Phase in the project document and operations manual for Phase II.	Phase II Project Document and Operations Manual with lessons learnt, publically available on GRIF webpages. Signed project document for Phase II publicly available
	Commencement of funding and implementation of Phase II of the ADF, which will fund 160 CDPs.	List of villages which have received funding under phase II-
FINANCIAL MECHANISM		
Create maximum flexibility for project funding within the current GRIF framework.	Propose change to GRIF Governance Framework allowing for budget support. Conditioned on the GRIF SC decision on changing the Governance Framework; encourage partner entities to use all financing instruments they are comfortable using in Guyana.	Copy of proposal to GRIF Steering Committee on changes to the Governance Framewok. Copy of letter to Partner Entities.

Optimizing project development	Acknowledging the need for optimizing financing mechanisms to streamline development of GRIF projects and accessing other climate funds, the PMO will be equipped with the resources and provided with the flexibility to fast track project development.	Institutional Strengthening Phase II project document submitted to IDB describing the strengthening of the PMO
INTEGRATED LAND USE PLANNING AND MANAGEMENT		
Implementation of a formal system for holistic area planning and management	Present the NLUP to Minister of MNRE and Cabinet for consideration and approval.	Copy of submission of NLUP publically available.
	Continuous public awareness on the NLUP.	Public Awareness materials available.
	Update GIS layer to include forest concession information and available information on mining concessions, agriculture leases and protected areas	Updated GIS dataset available. Written confirmation from affected agencies that the land use plan and related GIS layer are agreed to, and that the plan indeed forms the basis of land use planning in Guyana. Beta version of web-based application (Geonode) for management and publication of spatial data.
	Continually update GIS layer of allocated forest concessions but also including additional information on mining, agriculture and protected areas	Updated GIS dataset available. Annual production of written confirmation from affected agencies that the land use plan and related GIS layer updates are agreed to.
	Revise the IFL layer based on the available data	Updated GIS dataset available. Any revision of the IFL layer should be confirmed by both GoG and GoN.
	Finalize the definition of priority areas for biodiversity	Definition of priority areas for biodiversity established and publically communicated.

	Commence implementation of roadmap to codify formal status of protection for areas identified as IFL and priority areas for biodiversity.	Identification of parameters to map key biodiversity areas. Public communication of the timeline for establishment of the areas of varying degrees of protection. The roadmap will be made publically available. Develop site specific management plans for the National Protected Area System in 2015. The drafting of site-specific management plans will include public consultation. 3 Site Specific Management Plans for Protected Areas. Technical Report on the Priority Areas for Biodiversity publically communicated. (**Parameters & Definition included)

Table 2: Interim Indicators for REDD+ performance in Guyana[10]

Source of emissions or removals	Justification	Interim performance indicator	Monitoring and estimation	IPCC LULUCF reporting
Deforestation indicator:				
Gross deforestation	Emissions from the loss of forests are among the	Rate of conversion of forest area as compared to	Forest cover as of September 2009 will be used as baseline for monitoring gross	Activity data on change in forest land

10The 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. Based on experiences from the first and second reporting and verification exercise, some adjustments have been made in this table. However, the process has identified a need to develop further detail on the operationalisation of the indicators. Significant improved ability to operationalise the indicators has already been achieved, and this process will continue over the duration of the partnership.

	largest per unit emissions from terrestrial carbon loss.	agreed reference level. Forest area as defined by Guyana in accordance with the Marrakech accords: • Minimum 30% tree cover • At a minimum height of 5 meter • Over a minimum area of 1 ha. Conversion of natural forests to tree plantations shall count as deforestation with full carbon loss. Forest area converted to new infrastructure including logging roads, shall count as full carbon loss, unless otherwise informed by field study that identifies an alternative carbon loss level.	deforestation. Reporting to be based on medium and high resolution satellite imagery and in-situ observations where necessary. Monitoring shall detect and report on expansion of human infrastructure (eg. new roads, settlements, pipelines, mining/agriculture activities etc.)	
Degradation indicators:				
Loss of intact forest landscapes[11]. This indicator will be phased out of reporting on forest degradation under	Degradation of intact forest through human activities will produce a net loss of carbon and is often the	The total area of intact forest landscapes within the country should remain constant.	Using similar methods as for forest area change estimation.	Changes in carbon stocks in forests remaining as forests

[11] Intact Forest Landscape (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)." (See www.intactforests.org)

the MRVS subject to fulfillment of provisions laid out in the JCN on IFL	pre-cursor to further processes causing long-term decreases in carbon stocks. Furthermore, preserving intact forests will contribute to the protection of biodiversity.	Any loss of intact forest landscapes area[12] shall be accounted as deforestation with full carbon loss. The IFL Baseline map developed in the first reporting period will be used to assess changes. Note that this indicator will be subject to review as stipulated in section 2.1.		
Forest management (i.e. selective logging) activities in natural or semi-natural forests	Forest management should work towards sustainable management of forest with net zero emissions or positive carbon balance in the long-term.	All areas under forest management should be rigorously monitored and activities documented (i.e. concession activities, harvest estimates, timber imports/exports). Increases in total extracted volume,expressed in tons of CO_2, (as compared to mean volume 2003 – 2008) will be accounted as	Data on extracted volumes is collected by the Forestry Commission. Independent forest monitoring will act as an additional data source on forest management to complement this information. Accounting of this indicator should be done in terms of carbon units referred as close as possible to extraction of biomass from the	Changes in carbon stocks in forests remaining as forests

[12]When assessing loss of IFL, the established elimination criteria will be applied:

- Settlements (including a buffer of 1 km);
- Infrastructure used for transportation between settlements or for industrial development of natural resources, including roads (except unpaved trails), railways, navigable waterways (including seashore), pipelines and power transmission lines (including a buffer of 1 km on each side);
- Areas used for agriculture and timber production;
- Areas affected by industrial activities during the last 30-70 years, such as logging, mining, oil and gas exploration and extraction, peat extraction, etc.
- Amerindian titles and extentions granted (the footprint of such areas, i.e. without applying a 1 km buffer)

The threshold values for IFL-patches (500 km2, min. width 10 kms) will not be applied in assessing IFL loss.

		increased forest carbon emissions[13] unless otherwise can be documented using the gain-loss or stock difference methods as described by the IPCC for forests remaining as forests. In addition to the harvested volume, an appropriate expansion factor of 25 % (applied to the whole population of trees under forest management, i.e. harvested + remnant trees) shall be used to take account of carbon loss caused by collateral damage, etc, unless it is documented that this has already been reflected in the recorded extracted volume.	above ground carbon pool.	
Carbon loss as indirect effect of new infrastructure.	The establishment of new infrastructure in forest areas often contributes to forest carbon loss outside the areas directly affected by constructions.	High resolution satellite imagery and/or field observations shall be used to detect degradation in a 100m buffer surrounding new infrastructure (incl. mining sites, roads, pipelines, reservoirs etc.).	Medium and high resolution satellite to be used for detecting human infrastructure (i.e. small scale mining) and related degradation.	Changes in carbon stocks in forests remaining as forests

[13] The participants agree on the need to create incentives for net-zero or carbon positive forest management practices in Guyana. This will require a sophisticated MRV system to assess the carbon effects of forestry activities. This will be an objective of the MRV system under development. In the interim period, focus will be on incentives for avoiding increased emissions from forest management activities.

		As the benchmark for this indicator, the annualized number of the mapped degraded area from the second reporting period will be used (4368 ha)[14]. Any degradation above this benchmark in subsequent reporting years will result in reduced compensation. Unless other emission factors can be documented through the MRVS, these areas shall be accounted with a 50 % annual carbon loss, i.e. areas mapped in one year will be accounted with a further 50 % carbon loss in subsequent reporting periods.		
Emissions resulting from subsistence forestry, land use and shifting	Emissions resulting from communities to meet their local	Not considered relevant in the interim period before a proper		Changes in carbon stocks in forests

[14]For the second reporting period, Guyana made use of a new and significantly improved method for mapping infrastructure related degradation. A historical proxy analysis of areas affected by degradation from infrastructure was conducted for the period 2000-2010. The total area of a 100m buffer surrounding all new infrastructure was calculated for the historical period, as well as for the for the year 2 reporting period. This analysis indicated that the area affected by new infrastructure in the year 2 reporting period was comparable to the historical period.

As a benchmark for infrastructure related degradation in future reporting periods, the area mapped as degraded in the second reporting period will be used. This area equaled 5460 ha, but as the second reporting period had a length of 15 months, and subsequent reporting periods will be 12 months, this number was annualized. The benchmark is therefore 4368 ha.

cultivation lands (i.e. slash and burn agriculture).	needs may increase as result of *inter alia* shorter fallow cycle or area expansion.	MRV-system is in place.		remaining as forests
Emissions resulting from illegal logging activities	Illegal logging results in unsustainable use of forest resources while undermining national and international climate change mitigation policies	Areas and processes of illegal logging should be monitored and documented as far as practicable.	The monitoring of illegal logging is within the main objectives of the GFC's forest monitoring system, and is informed by an illegal logging database. In addition to reporting on illegal logging via the database, Independent Forest Monitoring will support performance monitoring of forest legality through the IFM framework. Should IFM detect potentially significant challenges with the established forest monitoring system, this indicator will be reassessed. In the absence of hard data on volumes of illegally harvested wood, a default factor of 15% (as compared to the legally harvested volume) will be used. This factor can be adjusted up and downwards pending documentation on illegally harvested volumes, inter alia from Independent Forest Monitoring. Medium resolution satellite to be used for detecting human infrastructure and	Changes in carbon stocks in forests remaining as forests

			targeted sampling of high-resolution satellite for selected sites. Accounting of this indicator should be done in terms of carbon units referred as close as possible to extraction of biomass from the above ground carbon pool.	
Emissions resulting from anthropogenically caused forest fires	Forest fires result in direct emissions of several greenhouse gases	Area of forest burnt each year should decrease compared to current amount	Coarse-resolution satellite active fire and burnt area data products in combination with medium and high resolution satellite data used for forest area changes	Emissions from biomass burning
Indicator on increased carbon removals:				
Encouragement of increasing carbon sink capacity of non-forest and forest land	Changes from non-forest land to forest (i.e. through plantations, land use change) or within forest land (sustainable forest management, enrichment planting) can increase the sequestration of atmospheric carbon.	Not considered relevant in the interim period before a proper MRV-system is in place but any dedicated activities should be documented as far as practicable. In accordance with Guyanese policy, an environmental impact assessment will be conducted where appropriate as basis for any decision on initiation of afforestation, reforestation and carbon stock enhancement projects.		Activity data on change to forest land and changes in carbon stocks in forests remaining as forests

Appendix 3

Year 6 & 7 Satellite Image Catalogue

All new imagery that is available has been added to the existing archive at GFC. The following table describes the naming conventions and column headings for the image catalogue shown in Table 2. This archive is dynamic and will be continually added to over time.

Table 1: Image Catalogue Naming Conventions

Image Stack Name	Image name in the following format: Satellite (2-3), Path (4), Row (1-3) _ Image Date (YYMMDD)_Image Provider (1)_Processing level (1-2)
Acquisition Month	The month of 2014 when image was taken
Mapping Stream	The mapping stream that the imagery is for.
Data Provider	The name of the data provider.
Satellite Instrument	The satellite or instrument of origin

Table 2: Summaryof 2015 & 2016 Satellite Images

All new imagery that is available has been added to the existing archive at GFC. The following table describes the naming conventions and column headings for the image catalogue as below. This archive is dynamic and will be continually added to over time.

Image Naming Conventions

Landsat Image Stack Name	Image name in the following format: Satellite (2-3), Path (4), Row (1-3) _ Image Date (YYMMDD)_Image Provider (1)_Processing level (1-2)
Sentinel Image Stack Name	Image name in the following format: datatake sensing start time_data take sensing stop time_tile ID
Acquisition Month	The month when image was taken
Mapping Stream	The mapping analysis that the imagery is for.
Data Provider	The name of the data provider/source of data
Satellite Instrument	The satellite or instrument of origin

Summary of 2015 Satellite Images

Stack Name	Satellite/Instrument	Data Provider	Resolution(m)	Acquistion Year	Acquistion Month
L7P230R57_150827_U_O.tif	Landsat 7 DCM	USGS Glovis	30	2015	August
L7P230R58_150827_U_O.tif	Landsat 7 DCM	USGS Glovis	30	2015	August
L7P232R54_150825_U_O.tif	Landsat 7 DCM	USGS Glovis	30	2015	August
L7P232R55_150825_U_O.tif	Landsat 7 DCM	USGS Glovis	30	2015	August
L7P230R56_150827_U_O.tif	Landsat 7 DCM	USGS Glovis	30	2015	August
L7P229R59_150921_U_O.tif	Landsat 7 DCM	USGS Glovis	30	2015	September
L7P230R57_150921_U_O.tif	Landsat 7 DCM	USGS Glovis	30	2015	September
L7P230R59_150912_U_O.tif	Landsat 7 DCM	USGS Glovis	30	2015	September
L7P229R58_150921_U_O.tif	Landsat 7 DCM	USGS Glovis	30	2015	September
L7P231R55_150919_U_O.tif	Landsat 7 DCM	USGS Glovis	30	2015	September
L7P231R56_150919_U_O.tif	Landsat 7 DCM	USGS Glovis	30	2015	September
L7P231R58_150919_U_O.tif	Landsat 7 DCM	USGS Glovis	30	2015	September
L7P232R55_150926_U_O.tif	Landsat 7 DCM	USGS Glovis	30	2015	September

L7P231R59_150919_U_O.tif	Landsat 7 DCM	USGS Glovis	30	2015	September
L7P232R56_150926_U_O.tif	Landsat 7 DCM	USGS Glovis	30	2015	September
L7P232R56_150910_U_O.tif	Landsat 7 DCM	USGS Glovis	30	2015	September
L7P233R55_150901_U_O.tif	Landsat 7 DCM	USGS Glovis	30	2015	September
L7P232R54_150926_U_O.tif	Landsat 7 DCM	USGS Glovis	30	2015	September
L7P232R57_150926_U_O.tif	Landsat 7 DCM	USGS Glovis	30	2015	September
L7P233R56_150901_U_O.tif	Landsat 7 DCM	USGS Glovis	30	2015	September
L7P230R59_150928_U_O.tif	Landsat 7 DCM	USGS Glovis	30	2015	September
L7P229R58_151023_U_O.tif	Landsat 7 DCM	USGS Glovis	30	2015	October
L7P229R59_151023_U_O.tif	Landsat 7 DCM	USGS Glovis	30	2015	October
L7P230R56_151014_U_O.tif	Landsat 7 DCM	USGS Glovis	30	2015	October
L7P230R57_151014_U_O.tif	Landsat 7 DCM	USGS Glovis	30	2015	October
L7P230R58_151014_U_O.tif	Landsat 7 DCM	USGS Glovis	30	2015	October
L7P231R55_151005_U_O.tif	Landsat 7 DCM	USGS Glovis	30	2015	October
L7P231R56_151005_U_O.tif	Landsat 7 DCM	USGS Glovis	30	2015	October
L7P231R57_151005_U_O.tif	Landsat 7 DCM	USGS Glovis	30	2015	October
L7P231R57_151021_U_O.tif	Landsat 7 DCM	USGS Glovis	30	2015	October
L7P231R58_151005_U_O.tif	Landsat 7 DCM	USGS Glovis	30	2015	October
L7P231R59_151005_U_O.tif	Landsat 7 DCM	USGS Glovis	30	2015	October
L7P232R57_151028_U_O.tif	Landsat 7 DCM	USGS Glovis	30	2015	October
L7P233R55_151019_U_O.tif	Landsat 7 DCM	USGS Glovis	30	2015	October
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L7P229R58_160923_U_O.tif	Landsat 7 DCM	USGS Glovis	30	2016	September
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L7P232R57_160928_U_O.tif	Landsat 7 DCM	USGS Glovis	30	2016	September
L7P231R56_160921_U_O.tif	Landsat 7 DCM	USGS Glovis	30	2016	September
L7P233R56_160903_U_O.tif	Landsat 7 DCM	USGS Glovis	30	2016	September
L7P233R55_160903_U_O.tif	Landsat 7 DCM	USGS Glovis	30	2016	September
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L7P230R58_161016_U_O.tif	Landsat 7 DCM	USGS Glovis	30	2016	October
L7P230R59_161016_U_O.tif	Landsat 7 DCM	USGS Glovis	30	2016	October
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L7P231R57_161007_U_O.tif	Landsat 7 DCM	USGS Glovis	30	2016	October
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L7P233R55_161005_U_O.tif	Landsat 7 DCM	USGS Glovis	30	2016	October
L7P232R56_161014_U_O.tif	Landsat 7 DCM	USGS Glovis	30	2016	October
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L8P231R58_161202_U_O.tif	Landsat 8 DCM	USGS Glovis	30	2016	December

20160806T142041_20160806T192619_T21NUD.tif	Sentinel 2B	ESA	10	2016	August
20160806T142041_20160806T192619_T21NUE.tif	Sentinel 2B	ESA	10	2016	August
20160806T142041_20160806T192619_T21NVC.tif	Sentinel 2B	ESA	10	2016	August
20160806T142041_20160806T192619_T21NVF.tif	Sentinel 2B	ESA	10	2016	August
20160819T142752_20160819T193247_T20NRJ.tif	Sentinel 2B	ESA	10	2016	August
20160819T142752_20160819T193247_T20NRK.tif	Sentinel 2B	ESA	10	2016	August
20160819T142752_20160819T193247_T20NRM.tif	Sentinel 2B	ESA	10	2016	August
20160819T142752_20160819T193247_T20NRN.tif	Sentinel 2B	ESA	10	2016	August
20160819T142752_20160819T193247_T20NRP.tif	Sentinel 2B	ESA	10	2016	August
20160819T142752_20160819T193247_T20PRQ.tif	Sentinel 2B	ESA	10	2016	August
20160819T142752_20160819T193247_T21NTC.tif	Sentinel 2B	ESA	10	2016	August
20160819T142752_20160819T193247_T21NTD.tif	Sentinel 2B	ESA	10	2016	August
20160819T142752_20160819T193247_T21NTF.tif	Sentinel 2B	ESA	10	2016	August
20160819T142752_20160819T193247_T21NTG.tif	Sentinel 2B	ESA	10	2016	August
20160819T142752_20160819T193247_T20NRG.tif	Sentinel 2B	ESA	10	2016	August
20160819T142752_20160819T193247_T21NTJ.tif	Sentinel 2B	ESA	10	2016	August
20160819T142752_20160819T193247_T21NUG.tif	Sentinel 2B	ESA	10	2016	August
20160819T142752_20160819T193247_T21PTK.tif	Sentinel 2B	ESA	10	2016	August
20160826T142042_20160826T192652_T21NVG.tif	Sentinel 2B	ESA	10	2016	August
20160826T142042_20160826T192652_T21NVH.tif	Sentinel 2B	ESA	10	2016	August
20160901T143752_20160901T194127_T20NQN.tif	Sentinel 2B	ESA	10	2016	September
20160901T143752_20160901T194127_T20NQP.tif	Sentinel 2B	ESA	10	2016	September
20160915T142032_20160915T192940_T21NUC.tif	Sentinel 2B	ESA	10	2016	September
20160928T142752_20160928T192805_T20NQN.tif	Sentinel 2B	ESA	10	2016	September
20160921T143742_20160921T194028_T20NQN.tif	Sentinel 2B	ESA	10	2016	September
20160915T142032_20160915T192940_T21NVC.tif	Sentinel 2B	ESA	10	2016	September
20160915T142032_20160915T192940_T21NVG.tif	Sentinel 2B	ESA	10	2016	September
20160921T143742_20160921T194028_T20NQM.tif	Sentinel 2B	ESA	10	2016	September
20160921T143742_20160921T194028_T20NQN.tif	Sentinel 2B	ESA	10	2016	September
20160921T143742_20160921T194028_T20NQP.tif	Sentinel 2B	ESA	10	2016	September
20160915T142032_20160915T192940_T21NUB.tif	Sentinel 2B	ESA	10	2016	September
20160928T142752_20160928T192805_T20NQL.tif	Sentinel 2B	ESA	10	2016	September
20160928T142752_20160928T192805_T20NQM.tif	Sentinel 2B	ESA	10	2016	September
20160928T142752_20160928T192805_T20NRJ.tif	Sentinel 2B	ESA	10	2016	September
20160928T142752_20160928T192805_T20NRK.tif	Sentinel 2B	ESA	10	2016	September
20160928T142752_20160928T192805_T20NRM.tif	Sentinel 2B	ESA	10	2016	September
20160921T143742_20160921T194028_T20NPN.tif	Sentinel 2B	ESA	10	2016	September
20160921T143742_20160921T194028_T20NPM.tif	Sentinel 2B	ESA	10	2016	September
20160928T142752_20160928T192805_T20NRN.tif	Sentinel 2B	ESA	10	2016	September
20160928T142752_20160928T192805_T20NRP.tif	Sentinel 2B	ESA	10	2016	September
20160928T142752_20160928T192805_T20PRQ.tif	Sentinel 2B	ESA	10	2016	September
20160928T142752_20160928T192805_T21NTC.tif	Sentinel 2B	ESA	10	2016	September

20160928T142752_20160928T192805_T21NTD.tif	Sentinel 2B	ESA	10	2016	September
20160928T142752_20160928T192805_T21NTE.tif	Sentinel 2B	ESA	10	2016	September
20160928T142752_20160928T192805_T21NTF.tif	Sentinel 2B	ESA	10	2016	September
20160928T142752_20160928T192805_T21NTG.tif	Sentinel 2B	ESA	10	2016	September
20160928T142752_20160928T192805_T21NTH.tif	Sentinel 2B	ESA	10	2016	September
20160928T142752_20160928T192805_T21NTJ.tif	Sentinel 2B	ESA	10	2016	September
20160928T142752_20160928T192805_T21NUJ.tif	Sentinel 2B	ESA	10	2016	September
20160928T142752_20160928T192805_T21PTK.tif	Sentinel 2B	ESA	10	2016	September
20161005T142032_20161005T192453_T21NUC.tif	Sentinel 2B	ESA	10	2016	October
20161005T142032_20161005T192453_T21NUD.tif	Sentinel 2B	ESA	10	2016	October
20161005T142032_20161005T192453_T21NUE.tif	Sentinel 2B	ESA	10	2016	October
20161018T143002_20161018T205657_T20NRG.tif	Sentinel 2B	ESA	10	2016	October
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20161028T143042_20161028T193404_T20NQN.tif	Sentinel 2B	ESA	10	2016	October
20161005T142032_20161005T192453_T21NVC.tif	Sentinel 2B	ESA	10	2016	October
20161005T142032_20161005T192453_T21NVE.tif	Sentinel 2B	ESA	10	2016	October
20161018T143002_20161018T193233_T20PRQ.tif	Sentinel 2B	ESA	10	2016	October
20161018T143002_20161018T193233_T21PTK.tif	Sentinel 2B	ESA	10	2016	October
20161018T143002_20161018T205657_T20NRP.tif	Sentinel 2B	ESA	10	2016	October
20161018T143002_20161018T205657_T21NTC.tif	Sentinel 2B	ESA	10	2016	October
20161018T143002_20161018T205657_T21NTD.tif	Sentinel 2B	ESA	10	2016	October
20161018T143002_20161018T205657_T21NTF.tif	Sentinel 2B	ESA	10	2016	October
20161018T143002_20161018T205657_T21NTG.tif	Sentinel 2B	ESA	10	2016	October
20161018T143002_20161018T205657_T21NTJ.tif	Sentinel 2B	ESA	10	2016	October
20161018T143002_20161018T205657_T21NUG.tif	Sentinel 2B	ESA	10	2016	October
20161018T143002_20161018T205657_T21NUH.tif	Sentinel 2B	ESA	10	2016	October
20161025T142032_20161025T192558_T21NUD.tif	Sentinel 2B	ESA	10	2016	October
20161025T142032_20161025T192558_T21NUE.tif	Sentinel 2B	ESA	10	2016	October
20161025T142032_20161025T192558_T21NVF.tif	Sentinel 2B	ESA	10	2016	October
20161025T142032_20161025T192558_T21NVG.tif	Sentinel 2B	ESA	10	2016	October
20161028T143042_20161028T193404_T20NQM.tif	Sentinel 2B	ESA	10	2016	October
20161107T142852_20161107T193822_T20NQL.tif	Sentinel 2B	ESA	10	2016	November
20161107T142852_20161107T193822_T20NRJ.tif	Sentinel 2B	ESA	10	2016	November
20161107T142852_20161107T193822_T20NRK.tif	Sentinel 2B	ESA	10	2016	November
20161107T142852_20161107T193822_T21NTE.tif	Sentinel 2B	ESA	10	2016	November
20161110T143752_20161110T181731_T20NPM.tif	Sentinel 2B	ESA	10	2016	November
20161117T142852_20161117T193606_T20NQL.tif	Sentinel 2B	ESA	10	2016	November
20161124T142032_20161124T192519_T21NVF.tif	Sentinel 2B	ESA	10	2016	November
20161210T143752_20161210T143748_T20NPN.tif	Sentinel 2B	ESA	10	2016	December

Appendix 5

Land Use Class Description

IPCC Land Use Categories

The following land use classes will be used as the MRVS is developed. These are briefly introduced below and currently are based on the default categories as defined by IPCC guidelines.

1. **Forest land**

- This category includes all land with woody vegetation consistent with thresholds used to define forest land in the national GHG inventory, sub-divided into managed and unmanaged, and also by ecosystem type as specified in the *IPCC Guidelines*3. It also includes systems with vegetation that currently fall below, but are expected to exceed, the threshold of the forest land category.
- During the MRVS development a stratification map will be produced. This builds on existing work undertaken at GFC in 2001 by consolidating the existing forest strata into six classes (see below).

2. **Grassland**

- This category includes rangelands and pasture land that is not considered as cropland. It also includes systems with vegetation that fall below the threshold used for the forest land category that are not expected to exceed, without human intervention, the threshold used in the forest land category. The category also includes all grassland from wild lands to recreational areas as well as agricultural and silvi-pastural systems, subdivided into managed and unmanaged consistent with national definitions.

3. **Cropland**

- This category includes arable and tillage land, and agro-forestry systems where vegetation falls below the thresholds used for the forest land category, consistent with the selection of national definitions

4. **Wetland**

- This category includes land that is covered or saturated by water for all or part of the year (e.g., peatland) and that does not fall into the forest land, cropland, grassland or settlements categories. The category can be subdivided into managed and unmanaged according to national definitions. It includes reservoirs as a managed sub-division and natural rivers and lakes as unmanaged sub-divisions.

5. **Settlements**

- This category includes all developed land, including transportation infrastructure and human settlements of any size, unless they are already included under other categories. This should be consistent with the selection of national definitions

6. **Other land**

- This category includes bare soil, rock, ice, and all unmanaged land areas that do not fall into any of the other five categories. It allows the total of identified land areas to match the national area, where data are available.
- The following table provides an overview of the preliminary land use classification for Guyana.

Guyana Land Use Classes

Land Use	Land Use Type	2001 Classes	Map Classes
Forest Land	Mixed forest	1 to 1.4 & 1.8	Class 1
	Wallaba/Dakama/Muri Shrub Forest	2 to 2.6	Class 2
	Swamp/Marsh forest	3.1 to 3.3	Class 3
	Mangrove	4.1	Class 4

	Savannah >30% cover	5, 6	Class 5
	Montane & steep forest	1.5 -1.7[28], 7.1, 7.2. 8.1	Class 6
	Plantations	Locations in GFC's GIS	Area insignificant
Grassland	Savannah <30% cover	Grouped as non-forest	Class 15
	Grassland		
Cropland	Cropland		Class 17
	Shifting Agriculture		Class 22
Wetland	Wetland open water		Classes 18 and 19
	Herbaceous wetland		
Settlements	Settlements		Class 20
Other land	Other land		Class 18 and 30

Forest Type Mapping by GFC

- In 2001 a series of detailed forest vegetation maps was produced for the entire State Forest Area. These combine various existing vegetation maps with new interpretations of aerial photographs and satellite radar imagery (JERS-1), coupled with analysis of field data collected during the Commission's forest inventories. The resulting maps are to be made available to forest concession holders to assist with their forest management planning activities.
- Secondly, a less detailed map has been produced for the entire country, based mainly on national soil survey data made available by the National Agricultural Research Institute (NARI). This map will be available to all of the Commission's stakeholders.
- To complete this work GFC's Forest Resource Information Unit drew on the skills and experience of former Tropenbos Program Manager, Dr Hans ter Steege. Dr ter Steege has extensive knowledge of Guyana's diverse forest vegetation types and specialist skills in digital cartography.

National Vegetation Map of Guyana

- Produced for the Guyana Forestry Commission and Dr Hans ter Steege, University of Utrecht, Netherlands, in collaboration with the GFC Forest Resources Information Unit 2001.

Methods

- The following provides a summary of the process used to create these maps.
- The National Vegetation Map is based on the GINRIS soil map (1:1 000 000) which was kindly provided for this purpose by the NRMP. Although problems were encountered with the accuracy of the National Map, it was felt that at the 1:1 000 000 scale they were of less importance and that using the GINRIS basemap would ensure compatibility among National Theme Maps.
- In making the National Map, use was made of the usually strong correspondence between major forest and soil types, realizing that the soil map is in fact an interpretation of vegetation cover. Based on the strong correspondence a first forest type was assigned to each of the soil classes. Problems then arose in a few areas.

[28] This class (1.7) has also been identified as potentially threatened by fire.

- For instance, white sands are covered by Wallaba forest, Dakama forest, Muri scrub, or grass, and peat soils may have palm swamp, broadleaved swamp forest, or open swamps.
- To improve the interpretation of the forests on white sand first a digital combination of low forest of Vinks NE-Guyana map (Vink 1957) with the white sands of the soil map was created. Low forest on white sand was classified as Dakama. Then a combination of the new 'Vegetation map' was made with the dry and wet savannah themes of Vink. Dry savannah on white sand was classified as Muri scrub/grassland, dry savannah on other soil as (intermediate) savannah, wet savannah on peat was classified as open coastal swamp, on white sand as wet savannah/muri scrub on white sand, the other as open swamp. Because in the two maps that were intersected edges of similar vegetations are not identical, a great number of small 'stray' polygons were created that had to be manually removed.
- For central and North West Guyana, FIDS maps were used to classify the various white sand areas. In a few cases white sand polygons were split into the different types of forest, especially in central Guyana. Large stretches of wet forest exist in south Guyana. These were digitized into the National Map on the basis of the regional FIDS maps. In other cases large forest areas classified as wet forest were reclassified into mixed forest in accordance with FIDS coverage.
- In the southwest savannah cover from the FIDS maps was superimposed. However, the level of detail was much greater than the other parts of the map and it was decided to use the savannah interpretation of Huber et al (1995) for this vegetation type, which is nearly identical. In the Pakaraimas, also the interpretation of Huber et al. (1995) was used for the open non-forest vegetation types. The forests in this area were not classified on the basis of soil but rather on altitude. Submontane forest from 500-1500 m and montane forest above 1500 m. These areas were obtained by intersecting the vegetation map with altitudes obtained from a digital elevation model of Guyana.
- Several draft versions were produced and discussed. At close inspection it became clear that even at the 1:1 000 000 scale there were inconsistencies between the vegetation map and the river base map[29]. However, as the vegetation map appeared to be correct in most instances no further changes were made.
- A descriptive legend of the map was produced based on ter Steege and Zondervan (2000), Fanshawe 1952, Huber et al 1995 and FIDS reports (de Milde and de Groot 1970 a-g) (see below).
- The map was finally produced in three sizes, A4 (letter), A3 (tabloid) and A0 (1:1 000 000). TIFF & JPG versions for the GFC web page were also produced (See The Map in Appendix 4).

Provisional Forest Types

- The following forest types have been grouped into 1 of 6 forest classes. This classification will form the basis of the forest carbon stratification map. This map groups forest types according to their carbon storage potential and identifies those forest areas under threat of degradation or deforestation. The intention is to use the map to assist with the design of the carbon monitoring plot network.

Class 1: Mixed rainforest

The following mixed forest classes have been merged to form a single class

1. **Mixed rainforests on Pleistocene brown sands in central to NW Guyana**

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[29]The rivers base layer has subsequently been improved as part of the MRVS implementation

Forests on the brown sands of the Berbice formation are almost invariably characterised by species of *Eschweilera* and *Licania*. Species, which may be locally dominant are *Eschweilera sagotiana, E. decolorans, E. confertiflora, Licania alba, L. majuscula, L. laxiflora, Chlorocardium rodiei, Mora gonggrijpii, Alexa imperatricis, Swartzia schomburgkii, S. leiocalycina, Catostemma commune, Eperua falcata, Pouteria guianensis, P. cladantha, Aspidosperma excelsum* and *Pentaclethra macroloba*. Mono-dominance is common in forests on brown sands in central Guyana and tends to get less in an eastward direction. Towards the east in Guyana and across the border in Suriname the species mix changes slightly and the more common species are *Goupia glabra, Swartzia leiocalycina, Aspidosperma excelsum, Manilkara bidentata, Terminalia amazonica, Parinari campestris, Vochysia surinamensis, Emmotum fagifolium, Humiria balsamifera, Catostemma fragrans, Hymenaea courbaril, Licania densiflora* and *Eperuafalcata.* The latter forest on light brown sands extends south towards the Kanuku mountains, where it grades into semi-evergreen mixed forest of the Rupununi district (1.4).

2. Mixed rainforests of the Northwest District

The dry land forests of the Northwest District of Guyana and eastern Venezuela are characterised by a high abundance of *Eschweilera sagotiana, Alexa imperatricis, Catostemma commune, Licania* spp. and *Protium decandrum*. These species are found abundantly in almost every dry land forest type in this region. Poor mono-dominant stands of *M. gonggrijpii* are found on the (probably) more clayey soils between the Cuyuni and Mazaruni.

3. Mixed rainforest in the Pakaraimas

Dicymbe altsonii (endemic to Guyana) is the main characteristic and one of the most common canopy species in the 'mixed forests' of the lowland eastern Pakaraima Mountains. *Dicymbe* may be absolutely dominant over large areas. Co-dominants are *Eperua falcata, Eschweilera sagotiana, E. potaroensis, Mora gonggrijpii, Alexa imperatricis, Licania laxiflora, Swartzia leiocalycina, Vouacapoua macropetala* and *Chlorocardium rodiei*. *Eschweilera potaroensis,* an endemic of this region, may be co-dominant in forests around the confluence of the Potaro and Essequibo Rivers.

4. Mixed rainforest in south Guyana

Dry (deciduous) forest types fringe the savannahs in south Guyana. Most of the dry forest stands show high presence of *Goupia glabra, Couratari, Sclerolobium, Parinari, Apeiba, Peltogyne, Catostemma, Spondias mombin* and *Anacardium giganteum.* South of the Cuyuwini river to east of the New River the forest is characterised by a high presence of *Geissospermum sericeum*, *Eschweilera* cf. *pedicellata, Lecythis corrugata, Pouteria coriacea* and *Pourouma* spp. Several other taxa, characteristic of late secondary forest, have fairly high presence this region: *Parkia, Ficus, Sclerolobium, Trichilia, Parkia, Parinari* and *Goupia*. *Eperua falcata(rugiginosa?), Pterocarpus* and *Macrolobium acaciifolium* are common in forests along the rivers in this area.

5. Complex of mixed forest and swamp forest in south Guyana

Large stretches of this type occur in SW Guyana between the upper reaches of the Oronoque and New Rivers. The forest is characterised by high occurrence of *Geissospermum, Pterocarpus* and *Eperua*.

Class 2: Wallaba/Dakama/Muri Scrub Forest

These are forests located on excessively drained white sands and include the following classes;

1. Clump wallaba forest

Clump wallaba forest, dominated by *Dicymbe altsonii* and *D. corymbosa* with co-dominance of *Eperua, Catostemma* and *Hyeronima* is found on excessively drained white sand ridges in the Mazaruni basin.

2. Clump wallaba/wallaba forest

In the upper Mazaruni basin *Dicymbe corymbosa* and *Eperua* spp. dominate nearly all forests on white sand. *Chamaecrista* and *Micrandra* are common co-dominants.

3. Wallaba forests (dry evergreen forest)

Dry evergreen forest on bleached white sands (albic Arenosols) occurs from the Pakaraima escarpment, through central Guyana and northern Suriname into a small narrow portion of French Guiana. *Eperuafalcata* and *E. grandiflora* are strongly dominant and may form, alone or together, more than 60% of the canopy individuals. Common other species in the canopy layer are *Catostemma fragrans, C. altsonii, Licania buxifolia, Talisia squarrosa, Formosacousinhood, Eschweilera corrugata, Aspidosperma excelsum, Terminalia Amazonia, Chamaecrista adiantifolia, Chamaecrista apocouita, Swartzia* spp., *Dicymbe altsonii* (west Guyana only), *D. corymbosa* (ibid.), *Manilkara bidentata* (Pomeroon-Waini water divide) and *Pouteria*.

4. Forests on white sands in south Guyana

Very small patches of forests on white sand are found in south Guyana. In SW. Guyana *Eperua* is the most commonly found tree genus.

5. Dakama forest

Forest dominated by *Dimorphandra conjugata* (Dakama forest) is common on the higher parts of waterdivides from central Guyana to western Suriname. This forest type is characterised by very high standing litter crop (up to 800 ton/ha, Cooper 1982) and is very fire prone. Other species, characteristic for Dakama forests, are *Eperua falcata, Talisia squarrosa, Emmotum fagifolium* and *Swartzia bannia*. *Humiria balsamifera* (Muri) co-dominates the degraded Dakama forest and Dakama-Muri scrub with *Dimorphandra*.

6. Muri scrub/white sand savannah

In areas where fires are very regular or in flood-prone areas Dakama forest degrades into Muri-scrub, dominated by *Humiria* balsamifera. Other common species in this scrub are *Swartzia bannia, Clusia fockeana, Licania incana, Bombax flaviflorum, Ocotea schomburgkiana, Trattinickia burserifolia, Ternstroemia punctata* and *Byrsonima crassifolia*.

Class 3: Swamp/Marsh forest

This class combines Swamps, swamp and marsh forests

1. Open swamps

Herbaceaous and grass swamps in brackish and sweet water with *Cyperus, Montrichardia, Commelina,* Paspalum and *Panicum.*

2. Marsh Forest

Mora excelsa forms extensive stands along the rivers on alluvial silt up to the confluence of Rupununi and Rewa rivers. Canopy associates of the *Mora* forest are *Carapa guianensis, Pterocarpus officinalis, Macrolobium bifolium, Eschweilera wachenheimii, E. sagotiana, Clathrotropis brachypetala, C. macrostachya, Eperua falcata, E. rubiginosa, Catostemma commune, C. fragrans, Pentaclethra macroloba, Vatairea guianensis, Symphonia globulifera, Terminalia dichotoma* and *Tabebuia insigni*.

The rivers in the savannah area are bordered by gallery forest, which is inundated during part of the year. Trees species such as *Caryocar microcarpum*, *Macrolobiumacaciifolium*, *Senna latifolia*, *Zygia cataractae* and *Genipa spruceana* occur along all the rivers in S-Guyana. In the open savannah *Mauritia* is a dominating element in the landscape.

3. Coastal swamp forest

In permanently flooded, flat plains in the present coastal zone a low swamp forest is found. Characteristic species are *Symphonia globulifera, Tabebuia insignis/fluviatilis, Pterocarpus officinalis* and *Euterpe oleracea*. Species that can become locally dominant in this forest type in Guyana are *Pentaclethra macroloba, Vatairea guianensis, Pterocarpus officinalis* and *Virola surinamensis*. *Manicaria saccifera* is commonly found as a narrow belt along rivers. More inland the duration of flooding is less pronounced and forest composition is slightly different. Common species here are *Symphonia globulifera, Virola surinamensis, Iryanthera* spp., *Pterocarpus officinalis, Mora excelsa, Pachira aquatica, Manicaria saccifera* and *Euterpe oleracea*.

Class 4: Mangrove forest

1 Mangrove forests

Mangrove forests occur in a narrow belt of a few kilometres wide along the coast and along the banks of the lower reaches of rivers. The mangrove forest along the coast consists mainly of *Avicennia germinans*, with occasional undergrowth of the salt fern, *Acrostichum aureum*. *Rhizophora* occupies the more exposed, soft silts in river mouths and shores. Where the water is distinctively brackish a third mangrove species can be found, *Laguncularia racemosa*. Further inland mangrove species mix with *Euterpe oleracea* palms and such trees as *Pterocarpus officinalis.*

Class 5 Savannah >30% forest cover

This class contains forest with lower volume that still meets the national definition of forest. Those areas that do not have been excluded and are treated as non-forest

1. **Lowland shrub and grass savannah**

   Lowland grass savannahs

   Lowland savannahs, dominated by the grasses *Trachypogon* and *Axonopus* and the shrubs *Curatella* and *Byrsonima* are found mainly in the southern parts where the Pakaraima Mts. border the Rupununi and Rio Branco savannahs and are also scattered throughout the western part of the region. At slightly higher altitude *Echinolaena* and *Bulbostylis* are also typical. Savannahs on white sands have more sedges and also include more genera typical of the alpine meadows.

   Lowland shrub savannah

   Fire-climax savannah vegetation, which contains characteristic species such as: *Curatella americana, Byrsonima crassifolia, Byrsonima coccolobifolia, Antonia ovata, Palicourearigida*, *Tibouchina aspera* and *Amasonia campestris*. The main grasses belong to the genera *Trachypogon, Paspalum, Axonopus* and *Andropogon* and the main sedges to the genera *Rhynchospora* and *Bulbostylis*

   Highland open vegetation types

2. **Xeromorphic scrub**

   Xeromorphic scrub is found throughout the Pakaraimas. *Humiria, Dicymbe, Clusia* and *Dimorphandra* are typical genera of this vegetation type.

3. **Tepui scrub**

   At high altitudes tepui scrub is found - in Guyana only on Mts. Roraima and Ayanganna. Most characteristic genera are *Bonnetia, Schefflera, Clusia,* and *Ilex*.

4. **Upland savannah**

   Uplands savannahs are very similar in composition to lowland savannahs. The upland savannahs on white sands have more sedges and also include more genera typical of the alpine meadows.

5. **Alpine meadows**

   The alpine meadows are also a very rich and distinct formation within the Guyana Highlands. In Guyana it is only found in the upper reaches of the Kamarang R., Mt. Holitipu and Lamotai Mt., both along the lower Kamarang R. Grasses are usually not dominant but are replaced by *Stegolepis*spp.. Other common genera include *Abolboda, Xyris, Orectanthe, Chalepophyllum, Lagenocarpus* and *Brocchinia*.

Class 6: Montane & steep forest

This class groups forests found at higher altitudes and on steep slopes.

1. **Submontane forest of south Guyana**

   Submontane forest is found in the Acarai Mts from 600-800 m. The forest is quite similar to the forest in the Kanuku Mts. with *Centrolobium, Cordia, Peltogyne, Vitex, Inga, Protium, Tetragastris, Parkia, Pseudopiptadenia, Spondias* and *Genipa.* Forests on the mountain tops are dominated by Myrtaceae and *Clusia* on Sierra do Acarai.

2. **Rain forest and evergreen forest on steep hills**

   Throughout the central and North West Guyana dolerite dykes penetrate through the sediments. These dykes are often covered with lateritic soils that are rocky, gravelly or clayey. There is little quantitative information available on the forest composition on these soils, except for central Guyana. Common trees are *Eschweilera* spp., *Licania* spp., *Swartzia* spp., *Mora gonggrijpii*, *Chlorocardium rodiei*. On lateritic soils in central Guyana a local endemic, *Vouacapoua macropetala*, forms extensive stands with *Eschweilera sagotiana, Licania laxiflora, Sterculia rugosa, Poecilanthe hostmanii* and *Pentaclethra macroloba*. On the rocky phase of laterite, a low shrubby forest is found. Myrtaceae (*Eugenia* spp., *Calycolpes, Marlierea*) and Sapotaceae (*Ecclinusa, Manilkara*) dominate here. Because of the occurrence of steep slopes landslides are not uncommon on laterite ridges. Often liana forest is encountered on such landslides. Pioneers, such as *Cecropia* spp., *Schefflera morototonii, Jacaranda copaia* and *Pentaclethra macroloba* are also abundantly present on such sites in central Guyana.

3. **Forest on steep hills in Pakaraimas**

   Not much is known about specific composition of this forest. The composition, though, is quite similar to mixed rain forest (1.3), with *Dicymbe altsonii, Mora gongrijppii* and *M. excelsa*. In the forests along the foothills of the southern Pakaraima Mts., *Cordia/Centrolobium* forest is found (see 1.7).

4. **Forest on steep hills in south Guyana**

   Forests along the foothills and middle slopes of the Kanuku Mts. are characterised by *Cordia alliodora, Centrolobium paraense, Apeiba schomburgkii, Acacia polyphylla, Pithecellobium* s.l., *Peltogyne pubescens, Manilkara* spp., *Cassia multijuga* and *Vitex* spp. *Manikara* dominates the higher areas. Low forest/woodland with *Erythroxylum* and *Clusia* are on slopes with bare rock.

   The South Rupununi Savannah, in particular, has rock outcrops with a typical 'rock vegetation'. The species present on the smallest rock plates are: *Cereushexagonus, Melocactus smithii, Cnidoscolus urens, Cyrtopodium glutiniferum* and *Portulacasedifolia*.

5. **Submontane forests of the Pakaraima uplands**

   Submontane forests, from 500 – 1500m, are fairly similar in composition to the lowland forests surrounding them, with species from *Dicymbe, Licania, Eschweilera, Mora, Alexa* being common to dominant. On white sands *Dicymbe, Dimorpandra, Eperua* and *Micrandra* are the most characteristic genera. Dry submontane forest is characterised by *Dicymbe jenmanii* (endemic to the Kaieteur region), *Moronobea jenmanii, Humiria balsamifera, Chrysophyllum beardii, Tabebuia* spp., *Anthodiscus obovatus, Saccoglottis, Dimorphandra cuprea* and *Clusia* spp.

6. **Upper montane forests of the Pakaraima highlands**

   Upper montane forests (1500-2000m) are only found on the high table mountains, such as Mts. Roraima, Ayanganna and Wokomung. Typical highland genera such as *Bonnetia tepuiensis, Schefflera, Podocarpus, Magnolia* and *Weinmannia* are found here. Low scrubs with Melastomataceae, Rubiaceae, *Ilex* and *Podocarpus steyermarkii* are also expected.

Non-forest Classes

In 2014 the non-forest areas were mapped from high resolution satellite images and further divided into the following IPCC classes.

- Cropland

- Grassland
- Wetland and open water
- Settlements
- Other land

Literature cited and/or used:

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Appendix 6

IPCC Common Reporting Format Tables

In the year 6 report, Guyana has included the reporting of LULUCF activity in the Common Reporting Tables (CRF) format of the IPCC. The CRF tables report land use area by:

- land use categories/sub-categories in year 5 “remaining” in the same category in year 6
- land use categories/sub-categories in year 5 “converted to” other land use categories/sub-categories in year 6.

The six land use categories used in the IPCC reporting are[30]:

1. **Forest land**: All land with woody vegetation consistent with the country thresholds used to define forest land, including vegetation structure that currently is below the threshold, but *in situ* could potentially reach the threshold values.
2. **Cropland**: Cropped land, including rice fields, and agro-forestry systems where the vegetation structure falls below the thresholds used for the forest land category.
3. **Grassland**: Including rangelands and pasture land that are not considered cropland. It also includes systems with woody vegetation and other non-grass vegetation such as herbs and brushes that fall below the threshold values used in the forest land category.
4. **Wetlands**: Areas of peat extraction and land that are covered or saturated by water for all or part of the year and that do not fall into the categories above or into the settlements category. It also includes reservoirs as a managed sub-division and natural rivers and lakes as unmanaged sub-divisions.
5. **Settlements**: All developed land, including transportation infrastructure and human settlements of any size, unless they are already included under other categories. This should be consistent with national definitions.
6. **Other land**: This category includes bare soil, rock, ice, and all land areas that do not fall into any of the other five categories. It allows the total of identified land areas to match the national area, where data are available.

The stratification into land use subcategories is country specific and depends on national circumstances.

For the forest land category, Guyana defined the subcategories by the forest stratification approach used in the Forest Carbon Monitoring System developed and implemented by GFC and Winrock International. This is based on the Potential for Future Change (PfC) which results in three strata: high (HPfC), medium (MPfC), and low (LPfC) potential for change. In addition to stratifying by potential for change, the forests are also stratified by accessibility: More or Less accessible[31] (Figure 1). Work is still ongoing to determine the appropriate emission factors land use change drivers across the different strata. These include forest degradation and afforestation – as appropriate

For non-forest areas, Guyana classified these into the relevant IPCC land categories. Indufor notes that the MRVS work mainly focuses in monitoring the changes to and from forest land. Thus, the area remaining and land use changes occurring within non-forest classes (i.e. cropland remaining cropland, conversion from grassland to cropland, etc.) are not part of the MRVS. In this report, the total area for non-forest land categories were estimated for end of year 5 and end of year 6. No area changes have been monitored or calculated between non-forest classes from year 5 to year 6 (“Not estimated” (NE) Notation Key used).

[30] IPCC. 2006. Volume 4: Agriculture, Forestry, and Other Land Use. Eggleston, H. S., L. Buendia, K. Miwa, T. Ngara and K. Tanabe. Eds. In: Penman, J., M. Gytarsky, T. Hiraishi, T. Krug, D. Kruger, R. Pipatti, L. Buendia, K. Miwa, T. Ngara, K. Tanabe and F. Wagner. Eds. 2006 IPCC Guidelines for National Greenhouse Gas Inventories. Prepared by the National Greenhouse Gas Inventories Programme. IGES, Japan.

[31] Petrova S., K. Goslee, N. Harris, and S. Brown. 2013 Spatial Analysis for Forest Carbon Stratification and Sample Design for Guyana’s FCMS: Version 2. Submitted by Winrock International to the Guyana Forestry Commission.

Figure 1: Year 5 Stratification of Guyana's Forest Area by Potential for Change

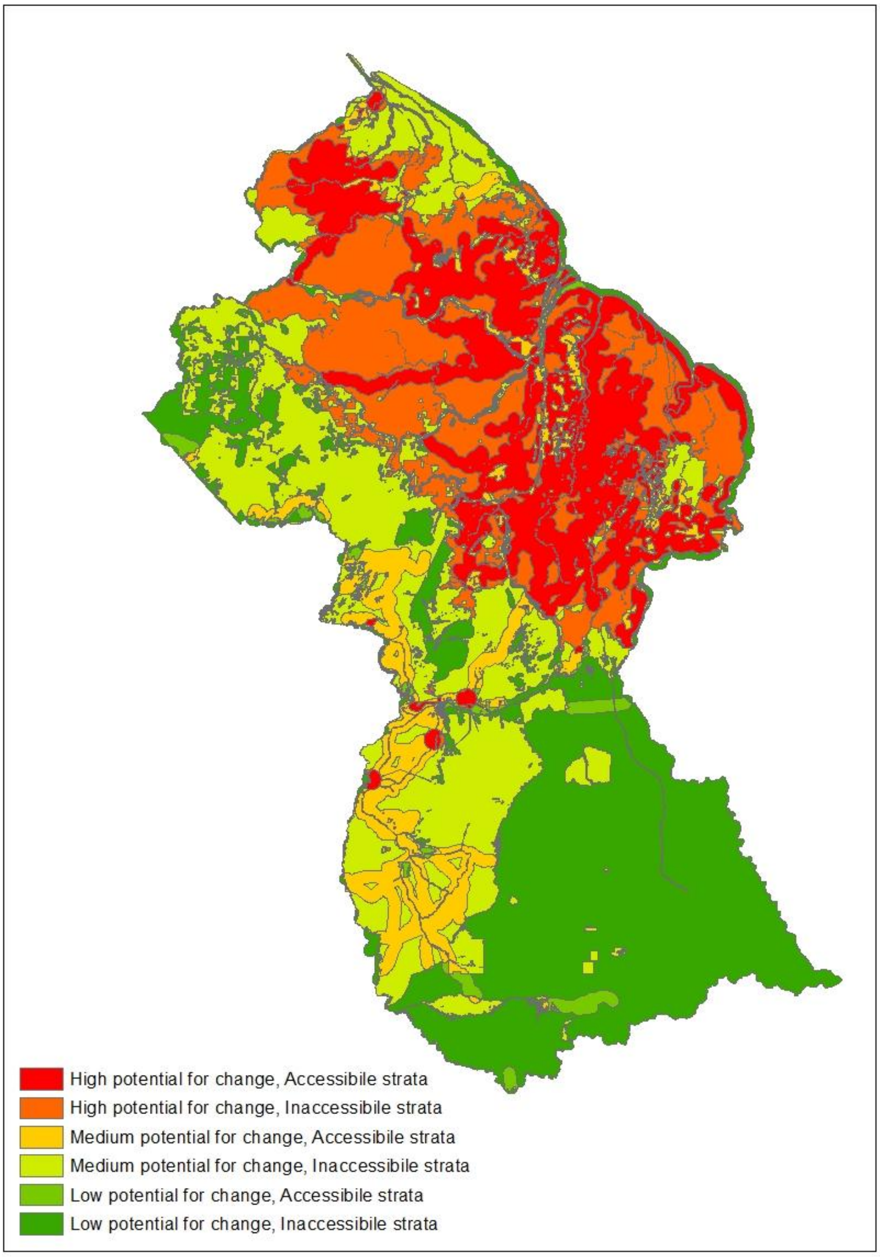


Table 4.1. LAND TRANSITION MATRIX | **Inventory 2017**

Areas and changes in areas between the previous and the current inventory year | **Submission 2017 v1**

GUYANA

FROM: 2013 (Year 4) / TO: 2014 (Year 5)	Forest land	Cropland (managed)	Grassland (unmanaged)	Wetlands (unmanaged)	Settlements	Other land	Final area at Y6
	(kha)						
Forest land (HPfC MA)[2]	6,533.1	0.27	NO	NO	0.04	0.14	6,534
Forest land (HPfC LA)[2]	5,154.3	0.11	NO	NO	0.04	0.23	5,155
Forest land (MPfC MA)[2]	2,166.9	0.01	NO	NO	NO	0.05	2,167
Forest land (MPfC LA)[2]	3,526.5	0.07	NO	NO	0.10	0.08	3,527
Forest land (LPfC MA)[2]	115.8	0.001	NO	NO	NO	0.02	116
Forest land (LPfC LA)[2]	954.3	0.03	NO	NO	0.02	0.03	954
Cropland (managed)[4]	0.76	NE	NE	NE	NE	NE	222
Grassland (unmanaged)[5]	NO	NE	NE	NE	NE	NE	2,073
Wetland (unmanaged)[6]	NO	NE	NE	NE	NE	NE	252
Settlements[7]	1.94	NE	NE	NE	NE	NE	58
Other land [8]	15.71	NE	NE	NE	NE	NE	62
Final area at Y5 (Initial at Y6)	18,470.6	220.3	2058.7	250.4	57.7	61.7	21,119
Net change [9]	-18.42	1.53	14.31	1.74	0.40	0.43	0.00

Documentation for Notation keys used:

Afforestation/reforestation activity in Guyana occurs through regeneration of abandoned mining sites primarily. These areas are monitored at present and reported when detected, or as not occurring if the value is nil (NO).
There is no human induced conversion from forest to grasslands or forest to wetlands in Guyana (NO).
Area remaining in non-forest land uses and land use changes between non-forest land uses were not estimated in this reporting period (NE).

TABLE 4.A SECTORAL BACKGROUND DATA FOR LAND USE, LAND-USE CHANGE AND FORESTRY

Forest Land

GREENHOUSE GAS SOURCE & SINK CATEGORIES		ACTIVITY DATA		IMPLIED CARBON-STOCK-CHANGE FACTORS						CHANGES IN CARBON STOCK						Net CO_2 emissions/ removals [8] [9]
Land-Use Category	Subdivision[1]	Total area[2] (kha)	Area of organic soil[2] (kha)	Carbon stock change in living biomass per area [3] [4]			Net carbon stock change in dead organic matter per area[4]	Net carbon stock change in soils per area [4]		Carbon stock change in living biomass[3] [4]			Net carbon stock change in dead organic matter[4]	Net carbon stock change in soils [4] [6]		
				Gains	Losses	Net change		Mineral soils[5]	Organic soils	Gains	Losses	Net change		Mineral soils	Organic soils[7]	
				(t C/ha)						(kt C)						(kt)
A. Total Forest Land		18,452.2														
1. Forest Land remaining Forest Land	Forest HPfC MA remaining Forest HPfC MA	6,533.1														
	Forest HPfC LA remaining Forest HPfC LA	5,154.3														
	Forest MPfC MA remaining Forest MPfC MA	2,166.9														
	Forest MPfC LA remaining Forest MPfC LA	3,526.5														
	Forest LPfC MA remaining Forest LPfC MA	115.8														
	Forest LPfC LA remaining Forest LPfC LA	954.3														
2. Land converted to Forest Land[10]																
2.1 Cropland converted to Forest Land	Cropland to High Potential for Change/More Accessible Forest	0.2683														
	Cropland to High Potential for Change/Less Accessible Forest	0.1126														
	Cropland to Medium Potential for Change Forest/More Accessible Forest	0.0069														
	Cropland to Medium Potential for Change Forest/Less Accessible Forest	0.0672														
	Cropland to Low Potential for Change Forest/More Accessible Forest	0.0009														
	Cropland to Low Potential for Change Forest/Less Accessible Forest	0.0289														
2.2 Grassland converted to Forest Land	Grassland to High Potential for Change/More Accessible Forest	NO														
	Grassland to High Potential for Change/Less Accessible Forest	NO														
	Grassland to Medium Potential for Change Forest/More Accessible Forest	NO														

GREENHOUSE GAS SOURCE & SINK CATEGORIES		ACTIVITY DATA		IMPLIED CARBON-STOCK-CHANGE FACTORS						CHANGES IN CARBON STOCK						Net CO_2 emissions/ removals [8] [9]
Land-Use Category	Subdivision[1]	Total area[2] (kha)	Area of organic soil[2] (kha)	Carbon stock change in living biomass per area [3] [4]			Net carbon stock change in dead organic matter per area[4]	Net carbon stock change in soils per area [4]		Carbon stock change in living biomass[3] [4]			Net carbon stock change in dead organic matter[4]	Net carbon stock change in soils [4] [6]		
				Gains	Losses	Net change		Mineral soils[5]	Organic soils	Gains	Losses	Net change		Mineral soils	Organic soils[7]	
				(t C/ha)						(kt C)						(kt)
	Grassland to Medium Potential for Change Forest/LessAccessible Forest	NO														
	Grassland to Low Potential for Change Forest/More Accessible Forest	NO														
	Grassland to Low Potential for Change Forest/Less Accessible Forest	NO														
2.3 Wetlands converted to Forest Land	Wetlands to High Potential for Change/More Accessible Forest	NO														
	Wetlands to High Potential for Change/Less Accessible Forest	NO														
	Wetlands to Medium Potential for Change Forest/More Accessible Forest	NO														
	Wetlands to Medium Potential for Change Forest/Less Accessible Forest	NO														
	Wetlands to Low Potential for Change Forest/More Accessible Forest	NO														
	Wetlands to Low Potential for Change Forest/Less Accessible Forest	NO														
2.4 Settlements converted to Forest Land	Settlements to High Potential for Change/More Accessible Forest	0.0429														
	Settlements to High Potential for Change/Less Accessible Forest	0.0430														
	Settlements to Medium Potential for Change Forest/More Accessible Forest	NO														
	Settlements to Medium Potential for Change Forest/Less Accessible Forest	0.1041														
	Settlements to Low Potential for Change Forest/More Accessible Forest	NO														
	Settlements to Low Potential for Change Forest/Less Accessible Forest	0.0159														
2.5 Other Land	Other Land to High Potential for Change/More Accessible Forest	0.1378														

GREENHOUSE GAS SOURCE & SINK CATEGORIES		ACTIVITY DATA		IMPLIED CARBON-STOCK-CHANGE FACTORS						CHANGES IN CARBON STOCK						Net CO_2 emissions/ removals (8) (9)
Land-Use Category	Subdivision(1)	Total area(2) (kha)	Area of organic soil(2) (kha)	Carbon stock change in living biomass per area (3) (4)			Net carbon stock change in dead organic matter per area(4)	Net carbon stock change in soils per area (4)		Carbon stock change in living biomass(3) (4)			Net carbon stock change in dead organic matter(4)	Net carbon stock change in soils (4) (6)		
				Gains	Losses	Net change		Mineral soils(5)	Organic soils	Gains	Losses	Net change		Mineral soils	Organic soils(7)	
				(t C/ha)						(kt C)						(kt)
converted to Forest Land	Other Land to High Potential for Change/Less Accessible Forest	0.2313														
	Other Land to Medium Potential for Change Forest/More Accessible Forest	0.0486														
	Other Land to Medium Potential for Change Forest/Less Accessible Forest	0.0776														
	Other Land to Low Potential for Change Forest/More Accessible Forest	0.0177														
	Other Land to Low Potential for Change Forest/Less Accessible Forest	0.0304														

Documentation box:

Afforestation/reforestation activity in Guyana occurs through regeneration of abandoned mining sites primarily. These areas are monitored at present and reported when detected, or as not occurring if the value is nil (NO).

TABLE 4.B SECTORAL BACKGROUND DATA FOR LAND USE, LAND-USE CHANGE AND FORESTRY

Cropland

(Sheet 1 of 1)

GREENHOUSE GAS SOURCE AND SINK CATEGORIES		ACTIVITY DATA		IMPLIED CARBON-STOCK-CHANGE FACTORS						CHANGES IN CARBON STOCK						Net CO_2 emissions/ removals (10) (11)
Land-Use Category	Subdivision (1)	Total area(2) (kha)	Area of organic soil(2) (kha)	Carbon stock change in living biomass per area (3) (4)			Net carbon stock change in dead organic matter per area(4)	Net carbon stock change in soils per area (4)		Carbon stock change in living biomass(3), (4), (6)			Net carbon stock change in dead organic matter(4) (7)	Net carbon stock change in soils (4) (8)		
				Gains	Losses	Net change		Mineral soils(5)	Organic soils	Gains	Losses	Net change		Mineral soils	Organic soils(9)	
				(t C/ha)						(kt C)						(kt)
B. Total Cropland		221.9														
1. Cropland remaining Cropland		NE														
2. Land converted to Cropland(12)																
2.1 Forest Land converted to Cropland		0.8														
2.2 Grassland converted to Cropland		NE														
2.3 Wetlands converted to Cropland		NE														
2.4 Settlements converted to Cropland		NE														
2.5 Other Land converted to Cropland		NE														

Documentation box:

Non-forest area remaining and land use changes between non-forest land uses were not estimated in this reporting period (NE).

TABLE 4.C SECTORAL BACKGROUND DATA FOR LAND USE, LAND-USE CHANGE AND FORESTRY

Grassland

(Sheet 1 of 1)

GREENHOUSE GAS SOURCE AND SINK CATEGORIES		ACTIVITY DATA		IMPLIED CARBON-STOCK-CHANGE FACTORS						CHANGES IN CARBON STOCK						Net CO_2 emissions/ removals [10] [11]
Land-Use Category	Subdivision [1]	Total area[2] (kha)	Area of organic soil[2] (kha)	Carbon stock change in living biomass per area [3] [4]			Net carbon stock change in dead organic matter per area[4]	Net carbon stock change in soils per area [4]		Carbon stock change in living biomass[3], [4], [6]			Net carbon stock change in dead organic matter[4] [7]	Net carbon stock change in soils [4] [8]		
				Gains	Losses	Net change		Mineral soils[5]	Organic soils	Gains	Losses	Net change		Mineral soils	Organic soils[9]	
				(t C/ha)						(kt C)						(kt)
B. Total Grassland		2,073.0														
1. Cropland remaining Cropland		NE														
2. Land converted to Grassland[12]																
2.1 Forest Land converted to Grassland		NO														
2.2 Cropland converted to Grassland		NE														
2.3 Wetlands converted to Grassland		NE														
2.4 Settlements converted to Grassland		NE														
2.5 Other Land converted to Grassland		NE														

Documentation box:

Non-forest area remaining and land use changes between non-forest land uses were not estimated in this reporting period (NE).

There is currently no human induced conversion from Forest to grasslands in Guyana (NO)

TABLE 4.D SECTORAL BACKGROUND DATA FOR LAND USE, LAND-USE CHANGE AND FORESTRY

Wetlands

(Sheet 1 of 1)

GREENHOUSE GAS SOURCE AND SINK CATEGORIES		ACTIVITY DATA		IMPLIED CARBON-STOCK-CHANGE FACTORS						CHANGES IN CARBON STOCK						
Land-Use Category	Subdivision [1]	Total area[2] (kha)	Area of organic soil[2] (kha)	Carbon stock change in living biomass per area [3] [4]			Net carbon stock change in dead organic matter per area[4]	Net carbon stock change in soils per area [4]		Carbon stock change in living biomass[3], [4], [6]			Net carbon stock change in dead organic matter[4] [7]	Net carbon stock change in soils [4] [8]		Net CO_2 emissions/ removals [10] [11]
				Gains	Losses	Net change		Mineral soils[5]	Organic soils	Gains	Losses	Net change		Mineral soils	Organic soils[9]	
				(t C/ha)						(kt C)						(kt)
B. Total Wetlands		252.1														
1. Wetlands remaining Wetlands		NE														
1.1 Peat extraction		NE														
1.2 Flooded land remaining flooded land		NE														
2. Land converted to Wetlands		NE														
2.1 Land converted for Peat extraction		NE														
2.2 Land converted to flooded land		NE														
2.3 Land converted to other wetlands		NE														

Documentation box:

Non-forest area remaining and land use changes between non-forest land uses were not estimated in this reporting period (NE).
The Wetlands category was not subdivided (NE)

TABLE 4.E SECTORAL BACKGROUND DATA FOR LAND USE, LAND-USE CHANGE AND FORESTRY

Settlements

(Sheet 1 of 1)

GREENHOUSE GAS SOURCE AND SINK CATEGORIES		ACTIVITY DATA		IMPLIED CARBON-STOCK-CHANGE FACTORS						CHANGES IN CARBON STOCK						
Land-Use Category	Subdivision (1)	Total area(2) (kha)	Area of organic soil(2) (kha)	Carbon stock change in living biomass per area (3) (4)			Net carbon stock change in dead organic matter per area(4)	Net carbon stock change in soils per area (4)		Carbon stock change in living biomass(3), (4), (6)			Net carbon stock change in dead organic matter(4)) (7)	Net carbon stock change in soils (4) (8)		Net CO_2 emissions/ removals (10) (11)
				Gains	Losses	Net change		Mineral soils(5)	Organic soils	Gains	Losses	Net change		Mineral soils	Organic soils	
				(t C/ha)						(kt C)						(kt)
B. Total Settlements		58.1														
1. Settlements remaining settlements		NE														
2. Land converted to Settlements																
2.1 Forest Land converted to Settlements		1.9														
2.2 Cropland converted to Settlements		NE														
2.3 Grassland converted to Settlements		NE														
2.4 Wetland converted to Settlements		NE														
2.5 Other Land converted to Settlements		NE														

Documentation box:

Non-forest area remaining and land use changes between non-forest land uses were not estimated in this reporting period (NE).

TABLE 4.F SECTORAL BACKGROUND DATA FOR LAND USE, LAND-USE CHANGE AND FORESTRY

Other land

(Sheet 1 of 1)

GREENHOUSE GAS SOURCE AND SINK CATEGORIES		ACTIVITY DATA		IMPLIED CARBON-STOCK-CHANGE FACTORS						CHANGES IN CARBON STOCK						Net CO_2 emissions/ removals (10) (11)
Land-Use Category	Subdivision (1)	Total area(2) (kha)	Area of organic soil(2) (kha)	Carbon stock change in living biomass per area (3) (4)			Net carbon stock change in dead organic matter per area(4)	Net carbon stock change in soils per area (4)		Carbon stock change in living biomass(3), (4), (6)			Net carbon stock change in dead organic matter(4) (7)	Net carbon stock change in soils (4) (8)		
				Gains	Losses	Net change		Mineral soils(5)	Organic soils	Gains	Losses	Net change		Mineral soils	Organic soils(9)	
				(t C/ha)						(kt C)						(kt)
B. Total Other Land		62.1														
1. Other land remaining Other land		NE														
2. Land converted to Other land(12)																
2.1 Forest Land converted to Other land		15.7														
2.2 Cropland converted to Other land		NE														
2.3 Grassland converted to Other land		NE														
2.4 Wetlands converted to Other land		NE														
2.5 Settlements converted to Other land		NE														

Documentation box:

Non-forest area remaining and land use changes between non-forest land uses were not estimated in this reporting period (NE).

Appendix 7

Independent Accuracy Assessment Report

Guyana Forestry Commission

Guyana REDD+ Monitoring Reporting and Verification System (MRVS)

Accuracy Assessment Report

Year 6

Daniel Donoghue, Ruusa David, Saidur Rahman, Department of Geography, Durham University; Nikolaos Galiatsatos, Royal School of Military Survey

December 2017

EXECUTIVE SUMMARY

1. This report was commissioned by Indufor Asia Pacific Ltd for the Guyana Forestry Commission (GFC) in support of a system to Monitor, Report and Verify (MRVS) for forest resources and carbon stock changes as part of Guyana's engagement in the UN Collaborative Programme on Reducing Emissions from Deforestation and Forest Degradation Plus (REDD+). The scope of the work was to conduct an independent assessment of deforestation, forest degradation and forest area change estimates for the period January 2015–December 2016. Specifically, the terms of reference asked that confidence limits be attached to forest area estimates.

2. The methods used in this report follow the recommendations set out in the GOFC-GOLD guidelines to help identify and quantify uncertainty in the level and rate of deforestation and the amount of degraded forest area in Guyana over the period 01 January 2015 to 31 December 2016 (Interim Measures Period – Year 6). High resolution ESA Sentinel-2 and Planet-PlanetScope imagery was used to assess change.

3. A change analysis using two-stage stratified sampling design was conducted to provide precise estimates of forest change. Three strata were selected according to "risk of deforestation"; and, the remaining areas were designated as non-forested. The drivers (cause) of change were made from expert image interpretation of high spatial resolution satellite imagery.

4. The estimate of the total area of change in the 24-month Year 6 period - Forest to Non-forest and Degraded forest to Non-forest is 16,239 ha with a standard error of 1,940 ha and a 95% confidence interval (12,436 ha; 20,041 ha)

5. The estimate of the annualised rate of deforestation that occurred over the Year 6 two-year period is 0.0548% with a standard error of 0.0064% and a 95% confidence interval (0.0423%, 0.0673%).

6. The estimate the total area of change in the 24-month Year 6 period from Forest to Degraded forest is 14,672 ha with a standard error of 1,850 ha and a 95% confidence interval (11,046 ha, 18,297 ha).

7. No changes were detected with samples located within the boundary of the Intact Forest Landscape.

8. The sample-based estimates for land cover class areas for December 2016 are as follows:
    a. Forest = 16,860,331 ha
    b. Degraded forest = 185,550 ha
    c. Non-forest = 2,095,654 ha + 990,000 ha (in the zero risk stratum) = 3,085,654 ha
    d. Note that the total area of Guyana in the sample-based estimates is 1.5% different from the GIS-based area because the samples use a 5 km by 15 km grid that intersects with the national boundary polygon.

1. AREAS OF ACTIVITY

1. To assess Year 6 deforestation, taking note of IPCC Good Practice Guidelines and GOFC/GOLD recommendations.

2. To outline a methodology for accuracy assessment including an outline of the (1) sample design, (2) response design, and (3) analysis design.[32] For the design component, reference data to be used should be identified, and literature cited for methods proposed. The design must ensure representativeness of the scenes selected for analysis. The sampling specifications used must be stated.

3. To support independent verification of the REDD+ interim measures and national estimates (Gross Deforestation, Intact Forest Landscape, Extent of Degradation associated with new infrastructure, and emissions from forest fires – referred to in the context of the Joint Concept Note between the Governments of Guyana and the Kingdom of Norway, including initial interim results, with a priority being on gross deforestation and the associated deforestation rate (i.e. change over time) and assessing their error margins/confidence bands, and providing verification of the deforestation rate figure for Year 6 as an area change total and by driver.

4. To conduct an independent assessment on the area changes (deforestation, degradation), an assessment on the attribution of types of changes (agriculture, mining, forestry and fire). Make recommendations that can be used to improve efforts in the future. This assessment should be done with the recognition that "best efforts" will have to be applied in situations where there is a challenge in terms of availability of reference data. The error analysis should highlight areas of improvement for future years to decrease uncertainties and maintain consistency. Additionally, the assessment should also consider the quality on how missing data were treated for national estimation (if this is observed to be the case). It is required that real reference data is used either from the ground, ancillary data (e.g. for concessions), and/or high resolution imagery.

5. This assessment is done with the recognition that "best efforts" will have to be applied in situations where there is a challenge in terms of availability of reference data. The error analysis highlights areas of improvement for future years to decrease uncertainties and maintain consistency. Additionally, the assessment considers the effect of missing data for national estimation. It is required that real reference data are used either from the ancillary map data (e.g. for concessions), and the data acquired specifically for accuracy assessment including high spatial resolution imagery.

[32]GOFC GOLD Sourcebook (2016) Section 2.7.

2. AREA REPRESENTATION

The total land area for Guyana is 21,127,762 hectares, calculated from the national boundary Shapefile provided by GFC in 2014. The digital maps contained in the report were obtained from the Guyana Forestry Commission (GFC), and the Guyana Land and Surveys Commission (GL&SC). All maps use the WGS 84 datum and are projected to UTM Zone 21N.

a. Forest Area

Land classified as **forest** by GFC follows the definition from the Marrakech Accords (UNFCCC, 2001). Under this agreement forest is defined as: a minimum area of land of 1.0 hectare (ha) with tree crown cover (or equivalent stocking level) of more than 10-30% with trees with the potential to reach a minimum height of 2-5 m at maturity in situ.

In accordance with the Marrakech Accords, Guyana has elected to classify land as forest if it meets the following criteria:

- Tree cover of minimum 30%
- At a minimum height of 5 m
- Over a minimum area of 1 ha.

The forest area was mapped by GFC / IAP by excluding non-forest land cover types, including water bodies, infrastructure, mining and non-forest vegetation. The first epoch for mapping is 1990, and from that point forward land cover change from forest to non-forest has been mapped and labelled with the new land cover class and the change driver. GFC have conducted field inspections and measurements over a number of non-forest sites to verify the land cover type, the degree of canopy closure, the height of the vegetation and its potential to regenerate back to forest.

The assessment in this report does not look at the GFC / IAP mapping, it is an independent analysis. For reference we note that the Y6 mapping process involves a systematic review of Landsat and Sentinel data. Details of the GFC / IAP Y6 mapping are explained in the Standard Operating Procedure for Forest Changes Assessment. Areas mapped as deforested during the period 1990-2009 are used to establish the *deforestation rate* for the benchmark reporting period.

The purpose of this report is to build upon the estimates of deforestation established for Years 1-5 of the Norway-Guyana agreement and to quantify the precision of the estimate of deforestation and forest degradation observed in the Year 6 period. A second task is to identify the processes (drivers) that are responsible for deforestation and degradation, and where possible to estimate the precision of area estimates.

3. SAMPLING DESIGN FOR VERIFYING YEAR 5 TO YEAR 6 FOREST CHANGE

a. Change sample design

The Year 6 assessment for gross deforestation and forest degradation in Guyana used a two-stage stratified random sampling design. Stratification was based on past patterns of deforestation from Period 1 (1990) though to Year 4 (Dec 2013), where the primary drivers of land cover change are alluvial gold mining, logging, anthropogenic fire, agriculture and associated infrastructure including roads.

The assessment is guided by established principles of statistical sampling for area estimation and by good practice guidelines (GOFC-GOLD, 2016, UNFCCC Good Practice Guidance (GPG) and Guidelines (GL)). The purpose of the sampling strategy for the Guyana MRV was to determine the status of the forest resource by checking the accuracy of the wall-to-wall mapping based on satellite observations. The purpose of stratification is to calculate the within-stratum means and variances and then calculate a weighted average of within-stratum estimates where the weights are proportional to the stratum size. Stratification will reduce the variance of the population parameter estimate and provide a more precise estimate of forest change area than a simple random sample.

The sampling design and the associated response design are influenced by the quality and availability of suitable reference data to verify interpretations of the GFC Forest Area Assessment Unit (FAAU). In Year 3, 4 and 5 the GFC Forest Area Assessment Unit (FAAU) used RapidEye as the primary mapping tool and so the whole country is mapped from multiple looks of orthorectified RapidEye resampled data to 5 m pixel size. For Y6 the GFC Forest Area Assessment Unit (FAAU) used Landsat and Sentinel 2 data as the primary mapping tool. The Y6 response design used Planet PlanetScope and Sentinel 2 imagery as an appropriate fine-resolution source of data to validate land cover changes in all but the low risk of change areas where assessment was based on interpreted of Sentinel-2 and Landsat data.

For Guyana, the established MRV protocol is for the entire country to be remapped on an annual basis, and so a forest change map will be generated from wall-to-wall coverage of satellite data. To assess the accuracy of land cover change statistics an independent reference sample is needed. The focus of the independent assessment places emphasis on inference, that is optimising the precision of the change estimates. Therefore, we generate an *attribute change sample* as the reference data to estimate gross deforestation and forest degradation area.

A change sample for reference data will:

1. have a smaller variance than an estimate of change derived from two equivalently sized sets of independent observations provided the correlation coefficient is positive;
2. increase the precision of the change estimate by virtue of the reduction of the variance of estimated change;
3. despite its obvious advantage, encounter practical and inferential problems if resampling the same areas proves difficult, or if, as time passes, the sample or the stratification of the sampling scheme, is no longer representative of the target population (Cochran 1963; Schmid-Haas, 1983);
4. for the same sample size, require no additional resource but allow both map accuracy and area estimation to be performed;
5. be an alternative to wall-to-wall mapping and may be preferred because of lower costs, normally smaller classification error, and rapid reporting of results;
6. have value when assessing any additional forest change map product such as the University of Maryland Global Change map 2000-2014 or any annual updates published by Maryland.

The desired goal of this validation is to derive a statistically robust and quantitative assessment of the uncertainties associated with the forest area and area change estimates.
Several factors potentially impact on the quality of forest mapping (GOFC GOLD, 2016), namely

- The spatial, spectral and temporal resolution of the imagery
- The radiometric and geometric pre-processing of the imagery

- The procedures used to interpret deforestation, degradation and respective drivers
- Cartographic and thematic standards (i.e. minimum mapping unit and land use definitions)
- The availability of reference data of suitable quality for evaluation of the mapping

The Standard Operating Procedure for Forest Change Assessment (GFC and Indufor Ap Ltd, 2015) outlines approaches used to minimize sources of error following IPCC and GOFC-GOLD good practice guidelines as appropriate.

The verification process used follows recognised design considerations in which three distinctive and integral phases are identified: response design, sampling design, and analysis and estimation (Stehman and Czaplewski, 1998).

b. Response Design

Table 3.1 summarises the data available to validate the deforestation and forest degradation change estimates for Years 5 and 6. It also specifies the areas covered by the imagery used for accuracy assessment.

Table 3.1: Data sources used for Validation (Application: Forest Change Assessment)

Dataset used	Provider	Sensor	Spectral Range	Date of Acquisition	Pixel size (m)	Area (ha)	% of Guyana
RGB and CIR aerial photography	GeoVantage	Four channel multi-spectral sensor	Visible and NIR	June–July 15	0.25-0.60	732,698	3.47
RapidEye	BlackBridge	Five channel multi-spectral sensor	Visible and NIR	Aug-Dec 14	5	21,127,762	100
Sentinel-2	ESA	Four channel multispectral sensor (at 10m)	Visible and NIR	Aug-Nov 16	10	19,347,200	91.5
PlanetScope	Planet	Four channel multispectral sensor	Visible and NIR	Aug-Dec 16	3	3,898,900	18.4
Landsat	USGS	ETM+ and ALI	Visible and NIR	Aug-Dec 16	30	21,127,762	100

A critical component of any accuracy assessment is the need for appropriate reference data (Herold et al, 2006; Powell et al 2004). It is often the case that reference data itself contains errors and is not a gold standard and at least one study reports large differences of the order of 5-10% between field-based and remotely sensed reference data (Foody, 2010; Powell et al. 2004). Therefore, a key aspect of the response design is to use reference data that allow forest / non- forest land cover to be classified with certainty. Year 6 deforestation and degradation was mapped by the IAP/GFC team from Sentinel-2 and Landsat imagery, while the accuracy assessment primarily used PlanetScope swarm imagery supplemented by the detailed reinterpretation of Sentinel-2 satellite imagery in parts of Guyana that were within the Low Risk stratum, and occasionally Landsat where there were clouds in Sentinel.

The accuracy assessment was carried out in Durham by a small team (four persons) using a rules-based approach. Any misinterpretation or miscalculation of change is most likely to arise from human-error or interpretation using poor quality imagery or areas partially obscured by cloud or cloud shadow.

The Interim Measures for Year 6 includes an assessment of the mapping of areas of forest degradation. Noting exclusions as detailed in Table 3.2.

Table 3.2 Year 6 Deforestation/Degradation Assessment Exclusions	
Reference	Criteria
1	Land use change that occurred prior to 1 January 2015 or after 31 December 2016
2	Roads less than a 10 m width.
3	Naturally occurring areas – i.e. water bodies
4	Cloud and cloud shadow

The following sections provide a summary of the datasets available and the way they were used for the accuracy assessment.

1.1.1 GEOVANTAGE PHOTOGRAPHY

GeoVantage is an aerial imaging camera system mounted externally to a Cessna 172. The camera uses a multi spectral sensor, capturing red, green, blue, and near infrared spectral bands. The spatial resolution of the imagery depends on the altitude that the data is captured. For this project the operating altitude ranged from 2000 to 5000 ft and the resultant imagery ranged from 25 to 60 cm pixel size. Deriving a change sample based of aerial imagery over tropical forests is a challenging task given the constraints of weather, cloud cover and navigating the exact same flight path as the previous year. To preserve an optimal ratio of imagery coverage and flight time, GeoVantage imagery was acquired in June-July 2015 over approximately 70 sample areas in the High and Medium Risk strata. These data are helpful for confirming the status of sample area at the start of the assessment period. The high resolution aerial imagery is particularly helpful for identifying areas of forest degradation.

1.1.2 RAPIDEYE

RapidEye is a constellation of five high-resolution visible and near infrared satellites. These acquire five-band multispectral imagery at 6.5 m (resampled to 5 m) nominal ground pixel size. These data were provided to GFC as a Level 3A orthorectified image product using a Landsat orthorectified mosaic for horizontal control and SRTM v4.1 for height control (total accuracy 30m CE90 at worst; February 2011 Product Guide; www.rapideye.de). The imagery was resampled to 5m spatial resolution by cubic convolution. The RapidEye data contain clouds and so a proportion of these data are unusable for accuracy assessment purposes. However the majority of these data are of good quality and remain useful for validation purposes. The RapidEye imagery was acquired Nov-Dec 2014 and so is a key dataset in assessing the land cover status of sample area at the start of the assessment period. RapidEye imagery is available for the whole country.

1.1.3 PLANETSCOPE

PlanetScope data were acquired from the Planet Explorer Beta GUI tool that can be used to search Planet's catalog of imagery, view metadata, and download full-resolution images[33].

[33] http://www.planet.com/explorer (last accessed: December 2017)

PlanetScope is a swarm of 120 micro (10cm x 10cm x 30cm) satellites orbiting the Earth at 475 km altitude, and offering the capability of daily revisit. The first three generations of Planet's optical systems are referred to as PlanetScope 0, PlanetScope 1, and PlanetScope 2.PlanetScope 2 has a 4-band multispectral imager (blue, green, red, near-infrared) with a Ground Sample Distance of 3.7 m. The radiometrically-corrected orthorectified product (that was used in this project) is resampled to 3m.

The radiometric resolution is 12-bit and sensor-related effects are corrected using sensor telemetry and a sensor model. The bands are co-registered, and spacecraft-related effects are corrected using attitude telemetry and best available ephemeris data. Data are Orthorectified using GCPs and fine DEMs (30 m to 90 m posting).

The PlanetScope imagery was found to be of varied quality with different radiometric integrity displayed by different sensors. On some occasions the imagery was offset, and in one occasion the imagery was hundreds of metres off position.

1.1.4 **SENTINEL-2**

The Sentinel satellites are launched by ESA in support of the EU Copernicus programme. Sentinel-2 carries an innovative wide swath high-resolution multispectral imager with 13 spectral bands primarily intended for the study of land and vegetation. The bands vary in spatial resolution, with four bands (Blue, Green, Red, and NIR) at 10m, six bands (four in NIR and two in SWIR) at 20m, and three bands (Blue, NIR and SWIR) at 60m. Although data are processed to different levels, only Level-1C (orthorectified product) is provided to users. The Sentinel Toolbox[34] can then be used to generate a Level-2A (Bottom of Atmosphere reflectance product). Although the pixel size of 10m is not as fine as PlanetScope, the Sentinel-2 radiometric resolution was found to be superior, thus providing a clearer (but not finer) land cover image.

c. Sampling Design for Change Analysis

The sampling design refers to the methods used to select the locations at which the reference data are obtained. To assess the area and rate of deforestation a two stage sampling strategy with stratification of the primary units was adopted. First a rectangular grid of 5 km by 15 km in size was created within the spatial extent of the country's national boundary[35]. The shape was selected to assist with the collection of North-South orientated strips of aerial GeoVantage imagery as this shape minimises the cost of acquisition of the imagery. Gridding resulted in 2837 rectangles; note that only rectangles with a centroid within the Guyana national boundary were selected.

As the area of the country is large, and deforestation is observed to be clustered around relatively small areas of human activity, it is efficient to adopt a stratified sampling framework rather than use simple random or systematic sampling (Gallego, 2000; Foody, 2004; Stehman, 2001). For each stratum, sample means and variances can be calculated; a weighted average of the within stratum estimates is then derived, where weights are proportional to stratum size. In this case, the goal is to improve the precision of the forest (or deforestation) area using a stratum-based estimate of variance that will be more precise that using simple random sampling (Stehman and Czaplewski, 1998; Stehman, 2009; Potapov et al., 2014).

Strata are based on actual observations of deforestation (particularly Years 1 to 4). The method first selected the grid rectangles that intersected deforestation events. For every year of deforestation the value 1 (one) was given. If no event was recorded then the value 0 (zero) was given. For example, the

[34] https://earth.esa.int/web/sentinel/toolboxes/sentinel-2 (last accessed: December 2017)
[35] According to the Interim Measures Report October 2013, the national boundary was defined by following information received from the GL&SC and with the aid of RapidEye imagery.

rectangle with value 0011 intersects deforestation events that were recorded for Years 3 and 4. When there have been more than two deforestation events, or deforestation events for the last two years, then the rectangle was assigned to High Risk (HR) stratum. All other rectangles were assigned to LR (Low Risk) stratum.

After this, and based on geographical data provided by GFC, MR (Medium Risk) grid rectangles were selected from the LR stratum and stratified according to factors closely associated with risk of deforestation and forest degradation. In particular, data about the location of logging camps, mining dredges, settlements, and the existing road network were used (see Table 3.3 and Figure 3.4). This way, all grid rectangles that satisfied the following criteria were selected to be included in the MR stratum.

Contain at least one of: logging camps, mining dredges, or settlements,
<OR>
Intersect with at least one road.

Last but not least, we used the non-forest map of 1990 to identify rectangles that are almost completely deforested, and so no further deforestation event is expected within. When more than 90% of the rectangle contained non-forest in 1990, then this rectangle was assigned to 0R (Zero Risk) stratum.

This resulted in the classification of grid rectangles into four strata: 435 HR, 794 MR, 1476 LR, and 132 0R. (see Figure 3.2).

To assess the Year 6 deforestation and forest degradation a two stage sampling strategy with stratification of the primary units was adopted. At the first stage, a rectangular grid of 5 km by 15 km in size was created within the spatial extent of the country's national boundary. This resulted in 2837 rectangles; note that only rectangles that their centroid was within the national boundary were selected.

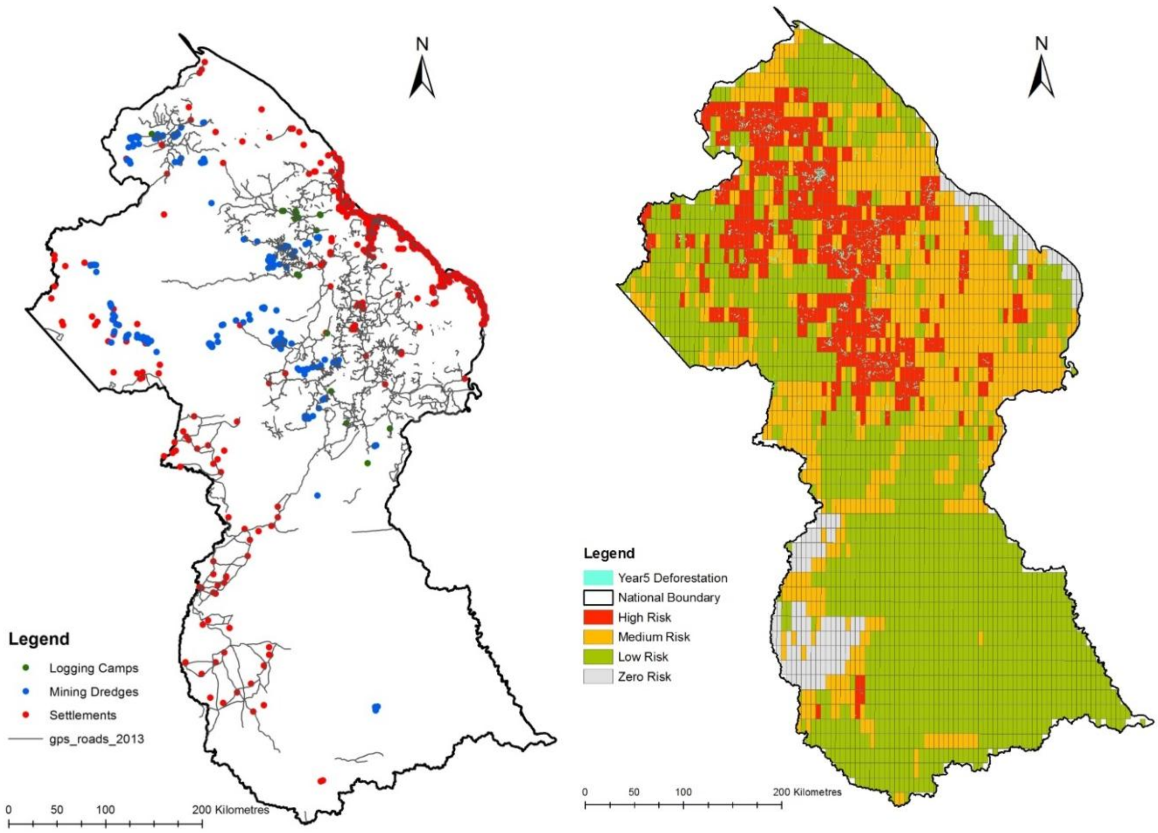


Figure 3.1 Left **-** Criteria for sampling stratification. Right – Strata with Y5 deforestation map.

Table 3.4 Spatial data used to assist with defining risk strata			
Data Group	Layer Name	Created/ Update Frequency	Description
Admin	guyana_boundary	Received August 2013	Updated country boundary for Guyana.
Managed Forest Areas	logging_camps	N/A	Point location of logging camp sites, based on the Annual Operating plan.
Roads	gps roads_dd	3-6 months	All GPS roads and trails as at August 2013.
Mining Areas	mining_dredges	Upon granting of mining permit/licence/claim	Mining Dredge sites normally found in/around rivers
Population	Settlements	N/A	An extraction of a number of larger settlements from the place names point feature class.

The map in Figure 3.2 suggests that there is lower probability of sampling deforestation in the Low Risk stratum than the High and Medium Risk strata and so, in order not to under sample and miss deforestation events in this stratum, a weighting was applied when randomly selecting rectangles to analyse in detail. This resulted in 58 HR rectangles, 51 MR rectangles and 204 LR rectangles (see right).

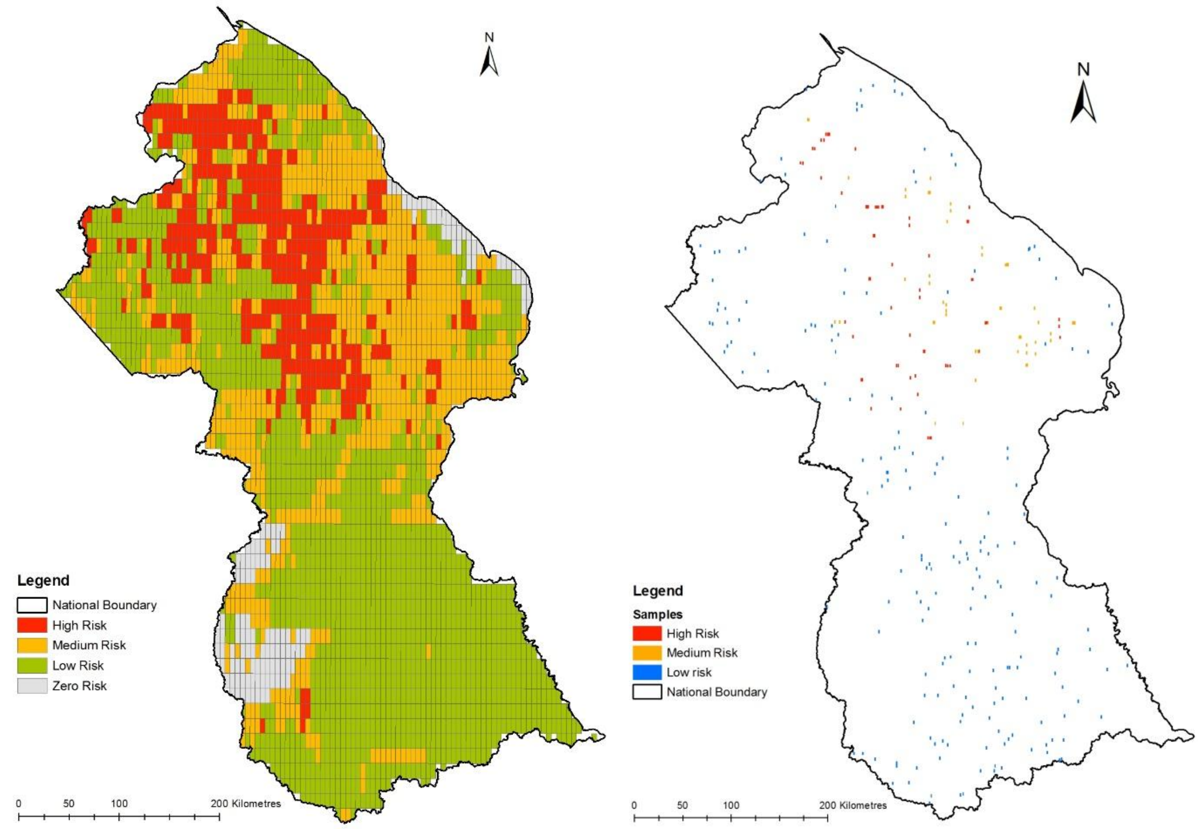


Figure 3.2 High, Medium, Low, and Zero Risk strata (left) and final random sampling of the strata (right image).

Within each first-stage sample, a systematic grid of 300 hectares was generated. The centre point of the each of the first-stage samples was generated randomly. In total 93,900 one-hectare samples became available for accuracy assessment.

For each primary sampling unit, the initial land cover class (e.g. Forest or Non-Forest, Degradation or Non-Degradation) is determined for the Year 5 deforestation and degradation map. The assessment follows a systematic procedure where the GIS table for the samples is populated using a GIS toolbar.

Specifically the tools used to interpret and validate Year 6 land cover change included high resolution satellite imagery (see Table 3.1). Also available were GIS data indicating mining, forestry and agricultural concessions.

Year 6 Change Assessment involved the collection of 313 equally-sized primary sample units (each with 300 ha) with a direct correspondence with Year 5. The reference data selected for the change assessment in Year 6 was a combination of PlanetScope and Sentinel 2 imagery for the High and Medium Risk strata and Sentinel 2 and Landsat for the Low Risk stratum. GeoVantage aerial imagery was available to assist with the interpretation of land cover status for some HR and MR samples for the Y5 start point in the change assessment.

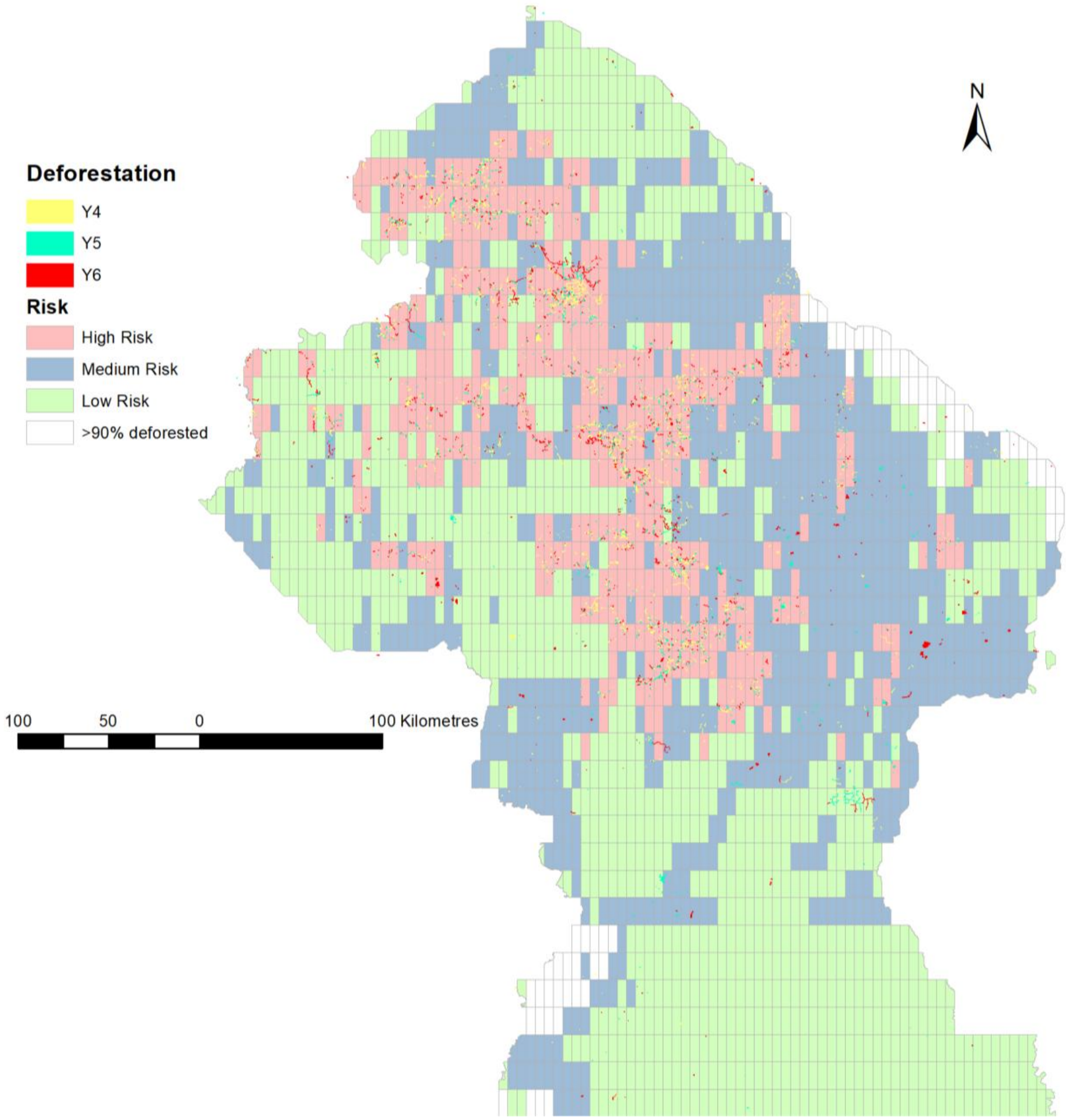
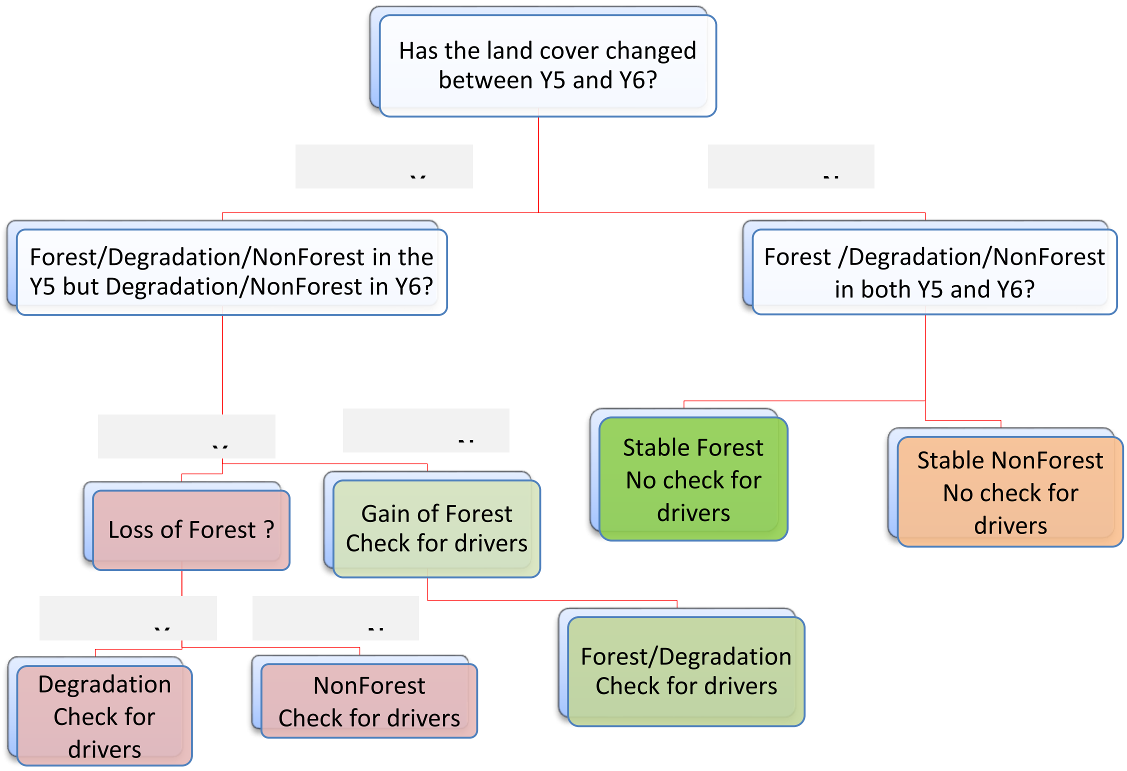


Figure 3.3 Pattern of deforestation overlain on Risk Strata for North part of Guyana

d. Decision Tree for Year 5 – Year 6 Change Analysis

Change for each Land-Cover / Land-use Class. The analysis will report a gross deforestation change estimate based on a stratified random change estimator. This will provide confidence interval information on the deforestation estimate (i.e. the amount of change). Put another way, there is no sub-sampling other than to break down the measurement into a hectare-sized grid to make the assessment manageable. Figure 3.4.1 illustrates a change decision tree where the Y5 land cover is forest. There will be equivalent decisions changes from forest to degraded forest and for forest to non-forest land cover types. These statistics allow change in major land cover categories to be reported and areas estimated.



	Y6 Reference Class			
Y5 Reference Class	Y6 Forest	Y6 Degradation	Y6 NonForest	**Total**
Y5 Forest	Stable Forest	Loss	Loss	
Y5 Degradation	Gain	Stable Degradation	Loss	
Y5 NonForest	Gain	Gain	Stable NonForest	
Total				Change reference samples

Figure 3.4.1. Decision tree for change sample analysis

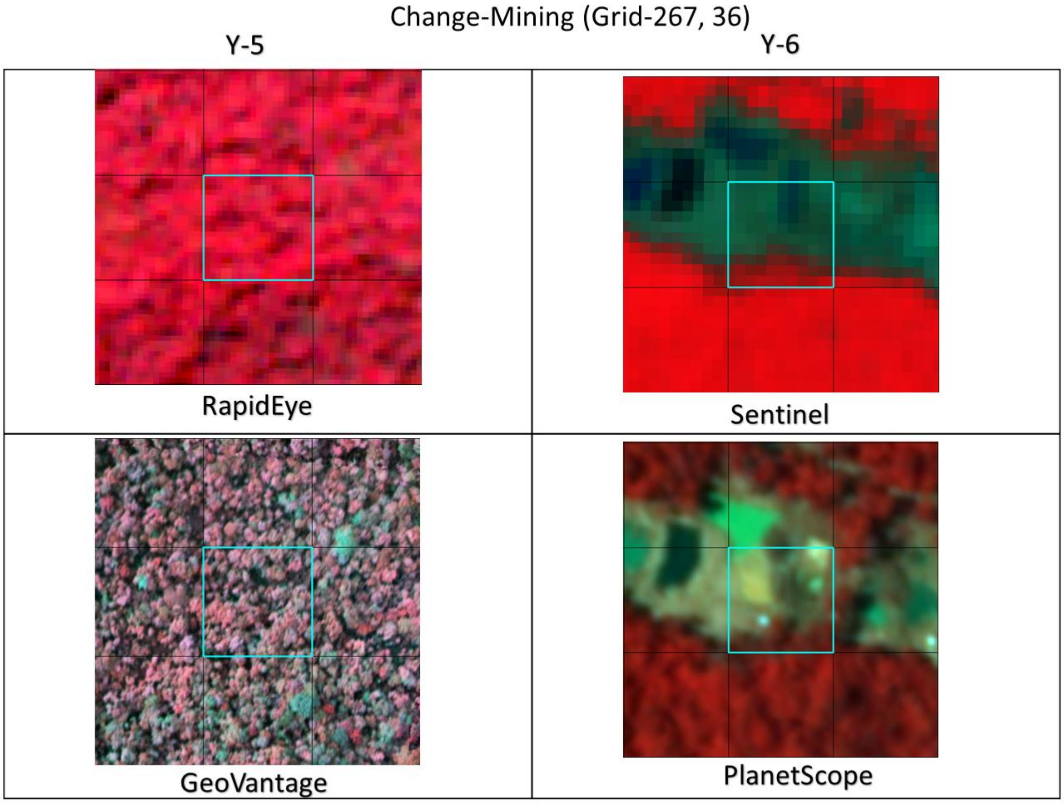


Figure 3.4.2. Image interpretation for change sample analysis

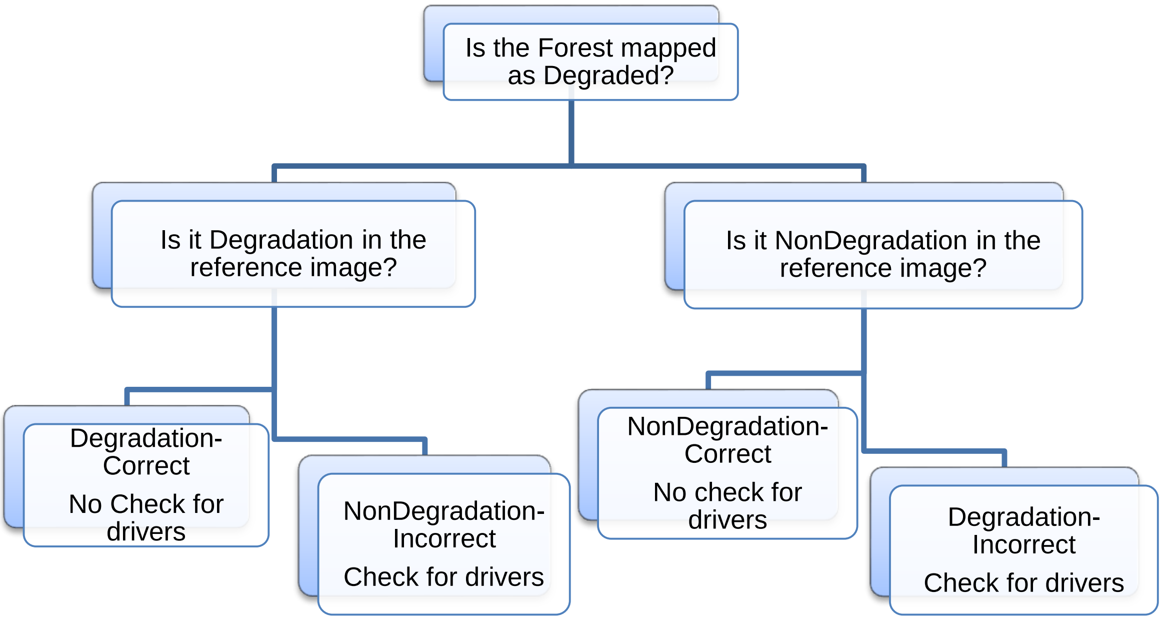


Figure 3.4.3 **The intrerpretation steps for forest degradation accuracy assessment.**

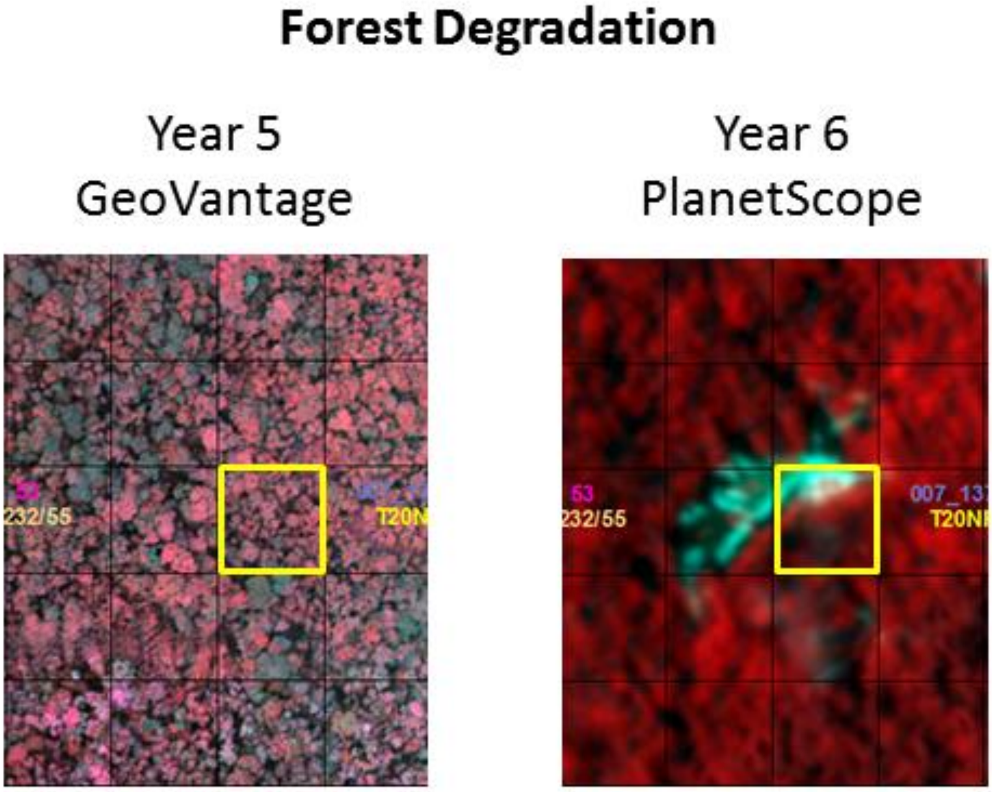


Figure 3.4.4 Identifying Forest Degradation

When assessing degradation it is important to follow the Mapping Rules that define degraded-forest and non-forest that are detailed in the Standard Operating Procedure for Forest Change Assessment.
The most important points to note are:

1. Only areas of forest degradation that relate to Years 5 and 6 assessed.
2. Areas of shifting cultivation are classified as “Pioneer” and “Rotational” even if they are smaller in size than the minimum mapping unit (1 ha). “Pioneer” areas are evaluated as deforestation and “Rotational” as forest degradation.
3. Areas of water bodies are classified as non-forest.
4. Areas cloud and shadow or missing data are labeled as *Omitted*.

Figure 3.4.4 illustrates the reference data used to assist assessment of change between Year 5 and Year 6. The images in the figure show a sample hectare where the operator must assess whether change has occurred between the pair of images in Y5 (left hand side) and Y6 (right hand side) and record the nature of this change on the interpretation toolbar..

The rules for validating each sample unit point account for small discrepancies with the geometric alignment between the various remote sensing data sets. The change samples are ideally interpreted at 1:15,000 scale using Y5 imagery (RapidEye or GeoVantage) and Y6 imagery (PlanetScope or

Sentinel 2) imagery. Minor discrepancies include a known misalignment between the RapidEye, Sentinel 2, PlanetScope, and the GeoVantage aerial imagery. Other factors, other than human error, that might explain misinterpretation include land obscured by cloud or cloud shadow and change that is too small to be detected on the available cloud-free imagery.
Furthermore, where a discrepancy between the mapping and the validation data is detected, an interpretation will be made of the correct assignment for the sample point. The toolbar included a confidence label on a 0-4 scale. The uncertainty refers to confidence in interpreting either change or the driver for change and is recorded on a four interval percentage scale. This allows for uncertainties in interpretation to be removed from the estimation and validation process if required.

e. Precision of Area Estimates for Deforestation and Forest Degradation

The two-stage sampling with stratification of the primary units design optimises the probability of sampling deforestation and forest degradation in Year 6 when the area concerned represents only a tiny fraction of the national land area. Furthermore, there are several factors such as cloud cover, accessibility, safety and cost that limit the availability and quality of reference data.

A key consideration is minimising the risk of intoducing any possible bias into the estimates. Bias may arise from sampling, from cloud cover patterns and perhaps from the distribution and coverage of the reference data. Sampling bias can be assessed from the joint probabliity matrices. The distribution of cloud cover has been assessed qualitatively from cloud cover masks but this can be quantified more formally from the sample area data and from the cloud mask data derived from analysis of the RapidEye satellite imagery.

The validation team consists of four well qualified and experienced image interpreters, all of whom visited Guyana many times and have participated in field visits and over-flights. The analysis involved identifying change and paying strict attention of the definitions of ‘forest cover’, degraded forest cover’ and non-forest as well as interpreting the processes driving deforestation and forest degradation. The rules followed are those detailed in the Standard Operating Procedures for Forest Change Assessment: A Guide for Remote Sensing Processing & GIS Mapping. The validation team are very familiar with interpretation of satellite imagery.

4. RESULTS

a. Change Sample Estimates

1.1.5 Methodology

We treat the design as a stratified cluster design. The clusters are rectangles. The strata are HR, MR and LR. A simple random sample of rectangles from each stratum is taken. Then, within each rectangle, all hectares are systematically evaluated and all change measured quantitatively. This sample design can be analysed routinely using several statistical packages, which we describe below.

The reference data consisted of 93,900 primary sample units stratified into HR (17,400 ha), MR (15,300 ha) and LR (61,200 ha) areas as described in the sampling design (Section 4.3) and randomly sampled within each stratum. This design allows a probability-based inference approach to be applied. This approach assumes (1) that samples are selected from each stratum randomly; (2) that the probability of sample selection from each stratum can be estimated; (3) the sampling fraction in each stratum is proportional to the total population and that the relative sample size reflects, in this case, a ratio of 18:17:65 between HR+MR and LR stratum respectively.

The total number of 1 ha samples analysed in the whole survey was 93,900. Of this total 5,360 were Omitted due to cloud cover or cloud shadow in the reference imagery. The proportion of the total omitted is 0.05708 which represents 5.7 % of the sample.

Apart from no-change samples (Forest to Forest or NonForest to NonForest or Forest Degradation to Forest Degradation) between Year 5 and Year 6, the key changes include: Forest to NonForest, Forest to Forest degradation, Forest degradation to NonForest, NonForest to Forest degradation.

1.1.6 Software and estimators

To carry out the analysis, we have used the survey package available with the statistical package R Core Team (2014). This package is free and used by and supported by most of the world's academic statisticians, and increasingly is the commercial tool of choice. The survey package provided in Lumley (2004, 2014) provides functionality similar to that provided by the SAS package[36], and uses the same standard formulae for estimation of means and variances. These formulae are set out below and described conveniently in Lumley (2014).

Definitions and Notation

For a stratified clustered sample design, together with the sampling weights, the sample can be represented by an $n \times (P+1)$ matrix

$$(W,Y) = \left(w_{hij}, y_{hij}\right)$$
$$= (w_{hij}, y_{hij}^{(1)} y_{hij}^{(2)}, \dots \dots \dots, y_{hij}^{(p)})$$

Where

$h = 1,2, \dots \dots \dots, H$ is the stratum number, with a total of H strata
$i = 1,2, \dots \dots \dots, n_h$ is the cluster number within stratum h, with a total of n_h clusters
$j = 1,2, \dots \dots \dots, m_{hi}$ is the unit number within cluster i of stratum h, with a total of m_{hi} units
$p = 1,2, \dots \dots \dots, P$ is the analysis variable number, with a total of P variables
$n = \sum_{h=1}^{H} \sum_{i=1}^{n_h} m_{hi}$ is the total number of observations in the sample

w_{hij} denotes the sampling weight for observation j in cluster i of stratum h

[36] SAS SURVEYMEANS procedure. http://www.math.wpi.edu/saspdf/stat/pdfidx.htm

$y_{hij} = (y_{hij}^{(1)} y_{hij}^{(2)}, \dots \dots \dots, y_{hij}^{(p)})$ are the observed values of the analysis variables for observation j in cluster i of stratum h, including both the values of numerical variables and the values of indicator variables for levels of categorical variables.

Mean

$$\hat{\bar{Y}} = \frac{(\sum_{h=1}^{H} \sum_{i=1}^{n_h} \sum_{j=1}^{m_{hi}} w_{hij} y_{hij})}{w}$$

Where

$$w_{...} = \sum_{h=1}^{H} \sum_{i=1}^{n_h} \sum_{j=1}^{m_{hi}} w_{hij}$$

Is the sum of the weights over all observations in the sample.

Confidence limit for the mean

The confidence limit is computed as

$$\hat{\bar{Y}} \pm StdErr\left(\hat{\bar{Y}}\right). t_{df,\infty/2}$$

Where $\hat{\bar{Y}}$ is the estimate of the mean, $StdErr\left(\hat{\bar{Y}}\right)$ is the standard error of the mean, and $t_{df,\infty/2}$is the $100(1 - {}^{\infty}/_{2})$ percentile of the t distribution with the dfcalculated as described in the section “t Test for the Mean”.

Proportions

The procedure estimates the proportion in level $c_k$for variable C as

$$\hat{p} = \frac{\sum_{h=1}^{H} \sum_{i=1}^{n_h} \sum_{j=1}^{m_{hi}} w_{hij} y_{hij}^{(q)}}{\sum_{h=1}^{H} \sum_{i=1}^{n_h} \sum_{j=1}^{m_{hi}} w_{hij}}$$

Where $y_{hij}^{(q)}$ is value of the indicator function for level $C = c_k$
$y_{hij}^{(q)}$equals $\mathbf{1}$ if the observed value of variables C equals c_k, and
$y_{hij}^{(q)}$ equals $\mathbf{0}$ otherwise.

Total

The estimate of the total weighted sum over the sample,

$$\hat{Y} = \sum_{h=1}^{H} \sum_{i=1}^{n_h} \sum_{j=1}^{m_{hi}} w_{hij} y_{hij}$$

For a categorical variable level, $\hat{Y}$ estimates its total frequency in the population.

Variance and standard deviation of the total

$$\hat{V}(\hat{Y}) = \sum_{h=1}^{H} \frac{n_h(1 - f_h)}{n_h - 1} \sum_{i=1}^{n_h} (y_{hi\cdot} - \bar{y}_{h\cdot\cdot})^2$$

Where

$$y_{hi\cdot} = \sum_{j=1}^{m_{hi}} w_{hij} y_{hij}$$

$$\bar{y}_{h\cdot\cdot} = (\sum_{i=1}^{n_h} y_{hi\cdot})/n_h$$

The standard deviation of the total equals

$$Std(\hat{Y}) = \sqrt{\hat{V}(\hat{Y})}$$

Confidence limits of a total

$$\hat{Y} \pm StdErr\,(\hat{Y}).\,t_{df,\infty/2}$$

b. Results

1.1.7 Estimates of forest cover in Year 5

We can ignore that we have Year 6 information and obtain estimates of Year 5 forest cover. These can be compared to estimates obtained by other means. Table 4.2.1 shows the total areas classified as Degraded, Forest, and NonForest, together with a standard error and a 95% confidence interval. For example, the estimate of non-degraded Forest cover in Year 5 is 16,891,242 ha, standard error 23,237 ha, and 95% confidence interval (16,845,699; 16,936,784) ha.

Table 4.2.2 gives the same information as in Table 4.2.1, but shows proportions rather than totals. So, the proportion of Year 5 Forest cover is 0.8824, standard error 0.0012, 95% confidence interval (0.8801, 0.8848). Note that proportions add to one.

Table 4.2.1. Analysis of Y5 hectares of all classes

	Hectares	SE	2.5%	97.5%
Y5 Degraded forest	181,256.7	6,573.8	168,372.2	194,141.2
Y5 Non degraded forest	16,891,241.5	23,236.5	16,845,698.8	16,936,784.3
Y5 Non forest	2,069,036.5	22,559.1	2,024,821.5	2,113,251.5

Table 4.2.2. Analysis of Y5 proportions of all classes

	Mean	SE	2.5%	97.5%
Y5 Degraded forest	0.0095	0.0003	0.0088	0.0101
Y5 Non-degraded forest	0.88248	0.0012	0.8801	0.8848
Y5 Non-forest	0.1081	0.0012	0.1058	0.1104

1.1.8 Estimates of forest cover in Year 6

We now repeat these analyses for Year 6. Table 4.2.3 shows the total areas classified as degraded forest, non-degraded forest, and non-forest, together with a standard error and a 95% confidence interval. For example, the estimate of non-degraded forest cover in Year 6 is 17,602,715 hectares, standard error 23,307 hectares, and 95% confidence interval (17,557,033; 17,648,396) hectares.

Table 4.3.4 shows proportions instead of totals. Otherwise the interpretation is as for Year 5.

4.2.3 Analysis of Y6 hectares of all classes				
	Hectares	SE	2.5%	97.5%
Y6 Degraded forest	185,549.6	6,636.8	172,541.6	198,557.5
Y6 Non-degraded forest	16,860,331.3	23,343.5	16,814,578.9	16,906,083.7
Y6 Non forest	2,095,653.9	22,660.1	2,051,240.9	2,140,066.9

4.2.4 Analysis of Y6 proportions of all classes				
	Mean	SE	2.5%	97.5%
Y6 Degraded forest	0.0097	0.0003	0.0090	0.0104
Y6 Non-degraded forest	0.8808	0.0012	0.8784	0.8832
Y6 Non forest	0.1095	0.0012	0.1072	0.1118

1.1.9 Estimates of change from Year 5 to Year 6.

We analyse change from Year 5 to Year 6 as follows. We have matched pairs of sample data, where the hectares seen in Year 5 are seen again in Year 6. Therefore it is natural to concentrate upon the change for each pair. This is analogous to the matched paired t-test, where we calculate differences between pairs, and then analyse the differences.

There are three possible outcomes for each pair, depending on how the hectare was classified in Year 5. If the classification had been Forest (non-degraded), the possibilities are Forest in Year 5 and Year 6, Forest in Year 5 and Degraded in Year 6, and Forest in Year 5 and Non Forest in Year 6. Therefore, these will result a total of nine possible combinations of change.

Table A1 (see appendix) shows estimates for the total number of hectares of each possible combination. As an example, we estimate the area of Guyana which was classified as Forest (non-degraded) in Year 5 and Forest (non-degraded) in Year 6. The estimate is 16,860,331 hectares, standard error 2,678, 95% confidence interval (16,855,083; 16,865,580).

In Table 4.2.5 we estimate the area of Guyana which was classified as Forest in Year 5 and NonForest in Year 6. The estimate is 16,238 hectares, standard error 1,940 hectares, 95% confidence interval (12,436 ha; 20,041 ha). Appendix 1 gives the same information as Table 4.3.5, but disaggregated by stratum. Appendix A gives the same information, but shows proportions rather than totals. In Year 6 we found no change from Non-Forest to Forest or Degraded Forest (reforestation). Note that it would be difficult to identify reforestation with any certainty in the LR stratum because only Sentinel-2 and Landsat data is available. Nevertheless, no reforestation was found in either the HR or MR strata using the high resolution PlanetScope or Sentinel-2 imagery.

Table 4.2.5. Total deforestation in hectares Y5 to Y6				
	Hectares	SE	2.5%	97.5%
Forest loss	16,238.5	1,940.3	12,435.5	20,041.4

The change from forest to degraded forest shown is estimated quantitatively using 10 m grids within each hectare. The amount of loss is classed as degraded forest up to the point that 30% or less of the area is forest canopy covered, then it would be classed as deforested. In this way partial deforestation and forest degradation is assessed quantitatively within each sample area. The total area for change from Forest to Degraded forest is 14,672 hectares, standard error 1,850 hectares, 95% confidence interval (11,046 ha; 18,297 ha), see table 4.2.7. Table 4.3.8 shows the same data disaggregated by stratum.

Table 4.2.6 Proportion Forest Degraded (as %) per hectare by stratum between Y5 and Y6				
Forest Degradation	Mean	SE	2.5%	97.5%
HR	0.00324	0.00044	0.00237	0.00411
MR	0.00096	0.00029	0.00039	0.00152
LR	0.00013	0.00011	0.00074	0.00119

Table 4.2.7 Total area change from Forest to Degraded from Y5 to Y6				
	Hectares	SE	2.5%	97.5%
Forest Degradation	14,672	1,850	11,046	18,297

Table 4.2.8 Estimate of forest area degraded (in hectares) between Y5 and Y6 by stratum				
Forest Degradation	Hectares	SE	2.5%	97.5%
HR	9,178			
MR	4,189			
LR	1,304			

c. Estimating rate of change.

The key issue is to estimate the rate of change of gross deforestation. To do this, we restrict attention to hectares which in Year 5 were classified as forest or degraded, and then estimate the rates at which they continued to be Forest, or were classified as non-forest.

The estimated number of hectares of forest in Year 5 changed to Degraded Forest in Year 6 is 14,672 ha with a standard error of 1,850 ha and a 95% confidence interval (11,046 ha, 18,297 ha). The estimated number of hectares of forest in Year 5 lost to non-forest in Year 6 is 16,239 hectares. These changes translate into an estimated annualised rate of deforestation of 0.0548% with a standard error of 0.0064% and a 95% confidence interval (0.0423%, 0.0673%)., see table 4.3.1.

Table 4.3.1 Mean Deforestation annualised rate per hectare (%)				
	Mean	SE	2.5%	97.5%
Year 6 Forest loss	0.0548	0.0064	0.0423	0.0673

d. Deforestation rate comparison

Table 4.4.1 shows the Year 5 to Year 6 deforestation area and rate data compared. Note that the map-based estimate does not have a standard error associated with it but that the mapping and the change sample estimates are of similar magnitude. Note that the sample-based estimate considers only the areas available to sample, that is, the LR, MR and HR strata. We also defined a zero-risk stratum, with an area of 990,000 ha that is not included in calculation of the rate of change. This would account for the map-based estimate of change to be slightly higher that the probability-based estimate, despite the map estimate showing a smaller amount of deforestation. The observed differences are within the sampling error.

Table 4.4.1 Comparison of Forest Change Estimates Source			
	Forest area change (ha) Year 5- Year 6	Annualised Change Rate (%)	SE of Y6 Rate (%)
GFC / Indufor GIS Map Estimate	18,878		
Durham Change Sample Estimate	16,239	0.0548	0.0063
Difference	2,639		

5. DISCUSSION

The results divide into two areas that warrant further discussion:

i) reliability of the sampling strategy used to identify deforestation and estimate change areafrom satellite imagery
ii) estimation of the drivers of forest loss;

a. Sampling

The approach taken by GFC to produce a comprehensive (wall-to-wall) map for forest / non-forest for Guyana is ambitious and provides very precise, location-specific data. The mapped area of gross deforestation agrees well with the sample-based estimate giving confidence in the precision of the MRV mapping based on Landsat and Sentinel-2 imagery. The accuracy assessment did not check the map product, rather it estimated forest loss from an independent probability-based sample. The results suggest that (1) forest loss can be mapped to a good level of accuracy using Landsat and Sentinel-2-data, and (2) that the level of forest loss estimated from the sample has a mean value within 2,000 ha of the mapped value.

Estimating forest degradation is more challenging and for Y6, in the absence of RapidEye imagery, GFC decided to rely of the change sample analysis to provide an estimate of forest degradation.

Using a change sample is clearly the most efficient and powerful way to detect change over a year. The levels of precision achieved are not likely to be much improved by taking a larger sample. For example, in Year 5 the number of first-stage samples increased from 143 to 313 and the total sample size increased from 55,119 ha to 93,900 ha. However the Standard Error of the estimate of forest loss only decreased from 1,800 ha to 1,500 ha. This suggests and taking a larger sample is unlikely to result in any improvement in precision.

b. Drivers of Forest Change

The results from the stratified sample estimates confirms GFCs conclusion that mining and mining related infrastructure is the overwhelming driver for deforestation and forest degradation. In the Year 2 Accuracy Assessment report we noted that degradation was difficult to identify particularly in Landsat imagery. In Years 3 and 4 the amount of forest mapped as degraded has risen sharply, most probably because of the ability to identify canopy openings and other forms of disturbance from the improved spatial and spectral resolution RapidEye data and the availability of GeoVantage aerial image data for accuracy assessment. RapidEye imagery was not available to the GFC mapping team for the Y6 period and so the quantitative assessment of forest degradation was undertaken from the change sample analysis alone where PlanetScope imagery was a key tool for identifying and quantifying forest degradation.

Tables 5.2.1 and 5.2.2 show the deforestation and forest degradation data broken down by driver for the assessment sample. The data in table 5.2.1 shows that 75% of deforestation is associated with mining and mining infrastructure. There are a small number of areas (3%) of forest clearance for agriculture as well as change associated with anthropogenic fire (3%) and conversion to bareland (6%). It must be noted (i) that drivers of change are easier to identify on PlanetScope imagery than on Sentinel-2 and (ii) that PlanetScope was not available for the Low Risk stratum giving a possible bias in driver classification by stratum.

The annualised breakdown of forest degradation by driver is shown in table 5.2.2. This also reveals that mining is the dominant driver for forest degradation in year 6. A complete breakdown of all the change observed from the reference data in Year 5 and Year 6 is shown in the tables of Appendix A of the report.

Table 5.2.1 Drivers of Deforestation	
Driver	Proportion
Agriculture	3%
Bare land	6%
Forest road	0%
Mining	70%
Mining Road	5%
Settlements	0%
Fire	3%
Unknown	13%

Table 5.2.2 Drivers of degradation	**Indicator**	**Unit**	**Adopted Reference Measure**	**Year 4 Period**	**Year 5 Period**	**Year 6 Period (Annualised Results)**
Degradation Indicator	Determine the extent of degradation associated with new infrastructure such as mining, roads, settlements [7].	*ha/yr*	4 368	4 352	4 251	5,679
Emissions resulting from anthropogenic forest fires	Area of forest burnt each year should decrease.	*ha/yr*	1 706[1]	395	265	762
Emissions resulting from subsistence forestry, land use and shifting cultivation lands	Emissions resulting from communities to meet their local needs may increase as a result of inter alia a shorter fallow cycle or area expansion.	*ha/yr*	-	765	167	93

[1] Degradation from forest fires is taken from an average over the past 20 years. This value is inclusive of all degradation drivers except for rotational shifting agriculture.

Natural / Unknown		*ha/yr*				802
Annualised total		*ha*				7,336
Total for Y6 24 month Period		*ha*				14,672

6. SUMMARY AND CONCLUSIONS

- We conclude that the estimates of deforestation based on the mapping undertaken by GFC based largely on interpretation of Landsat and Sentinel 2 imagery is of a good standard.
- The methods used by GFC, and assisted by IAP, follow the good practice recommendations set out in the GOFC-GOLD guidelines and considerable effort has been made to acquire cloud free imagery towards the end of the census period January 2015 to December 2016 (Year 6).
- The estimate of the total area of change in the 24 month Year 6 period - Forest to Non-forest and Degraded forest to Non-forest is 16,239 ha with a standard error of 1,940 ha and a 95% confidence interval (12,436 ha; 20,041 ha)
- The estimate of the annualised rate of deforestation that occurred over the Year 6 two year period is 0.0548% with a standard error of 0.0064% and a 95% confidence interval (0.0423%, 0.0673%).
- The estimate the total area of change in the 24 month Year 6 period from Forest to Degraded forest between Y5 and Y6 is 14,672 ha with a standard error of 1,850 ha and a 95% confidence interval (11,046 ha, 18,297 ha).
- No changes were detected with samples located within the boundary of the Intact Forest Landscape.

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8. APPENDIX A: STATISTICAL TABLES

Table A2 – ANALYSIS OF Y5 Hectares OF ALL CLASSES

	Hectares	SE	2.50 %	97.50 %
Y5 Degradation	181,256.7	6,573.8	168,372.2	194,141.2
Y5 Forest	16,891,241.5	23,236.5	16,845,698.8	16,936,784.3
Y5 NonForest	2,069,036.5	22,559.1	2,024,821.5	2,113,251.5

Table A3 - ANALYSIS OF Y5 Hectares OF ALL CLASSES BY STRATUM

	Hectares	SE	2.50 %	97.50 %
HR:Y5 Degradation	80,524.3	3,685.9	73,300.1	87,748.6
LR:Y5 Degradation	43,605.5	2,844.6	38,030.2	49,180.9
MR:Y5 Degradation	57,126.9	4,640.9	48,030.9	66,222.8
HR:Y5 Forest	2,834,456.2	6,765.1	2,821,196.9	2,847,715.6
LR:Y5 Forest	9,677,820.9	11,016.5	9,656,228.9	9,699,412.8
MR:Y5 Forest	4,378,964.5	19,308.2	4,341,121.2	4,416,807.7
HR:Y5 NonForest	210,921.8	5,836.3	199,482.8	222,360.8
LR:Y5 NonForest	654,642.1	10,691.0	633,688.2	675,596.1
MR:Y5 NonForest	1,203,472.6	18,988.2	1,166,256.3	1,240,688.8

Table A4 - ANALYSIS OF Y5 Proportions OF ALL CLASSES

	Mean	SE	2.50%	97.50%
Y5 Degradation	0.0095	0.0003	0.0088	0.0101
Y5 Forest	0.8824	0.0012	0.8801	0.8848
Y5 NonForest	0.1081	0.0012	0.1058	0.1104

Table A5 - ANALYSIS OF Y5 Proportions OF ALL CLASSES BY STRATUM

	Mean	SE	2.50%	97.50%
HR:Y5 Degradation	0.0258	0.0012	0.0234	0.0281
LR:Y5 Degradation	0.0042	0.0003	0.0037	0.0047
MR:Y5 Degradation	0.0101	0.0008	0.0085	0.0117
HR:Y5 Forest	0.9068	0.0022	0.9025	0.911
LR:Y5 Forest	0.9327	0.0011	0.9306	0.9348
MR:Y5 Forest	0.7765	0.0034	0.7698	0.7832
HR:Y5 NonForest	0.0675	0.0019	0.0638	0.0711
LR:Y5 NonForest	0.0631	0.001	0.0611	0.0651
MR:Y5 NonForest	0.2134	0.0034	0.2068	0.22

Table A6 - ANALYSIS OF Y6 Hectares OF ALL CLASSES

	Hectares	SE	2.50%	97.50%
Y6 Degradation	185,549.6	6,636.8	172,541.6	198,557.5
Y6 Forest	16,860,331.3	23,343.5	16,814,578.9	16,906,083.7
Y6 NonForest	2,095,653.9	22,660.1	2,051,240.9	2,140,066.9

Table A7 - ANALYSIS OF Y6 Hectares OF ALL CLASSES BY STRATUM

Stratum / Class	Hectares	SE	2.50%	97.50%
HR:Y6 Degradation	85,546.3	3,796.0	78,106.3	92,986.3
LR:Y6 Degradation	42,114.8	2,795.8	36,635.2	47,594.4
MR:Y6 Degradation	57,888.6	4,671.4	48,732.8	67,044.3
HR:Y6 Forest	2,814,541.6	6,967.8	2,800,884.9	2,828,198.3
LR:Y6 Forest	9,675,584.7	11,032.9	9,653,960.7	9,697,208.7
MR:Y6 Forest	4,370,205.0	19,355.7	4,332,268.5	4,408,141.5
HR:Y6 NonForest	225,814.5	6,023.4	214,008.8	237,620.1
LR:Y6 NonForest	658,369.1	10,719.3	637,359.6	679,378.6
MR:Y6 NonForest	1,211,470.3	19,034.1	1,174,164.3	1,248,776.4

Table A8 - ANALYSIS OF Y6 Proportions OF ALL CLASSES

	Mean	SE	2.50%	97.50%
Y6 Degradation	0.0097	0.0003	0.009	0.0104
Y6 Forest	0.8808	0.0012	0.8784	0.8832
Y6 NonForest	0.1095	0.0012	0.1072	0.1118

Table A9 - ANALYSIS OF Y6 Proportions OF ALL CLASSES BY STRATUM

Stratum / Class	Mean	SE	2.50%	97.50%
HR:Y6 Degradation	0.0274	0.0012	0.025	0.0297
LR:Y6 Degradation	0.0041	0.0003	0.0035	0.0046
MR:Y6 Degradation	0.0103	0.0008	0.0086	0.0119
HR:Y6 Forest	0.9004	0.0022	0.896	0.9048
LR:Y6 Forest	0.9325	0.0011	0.9304	0.9346
MR:Y6 Forest	0.7749	0.0034	0.7682	0.7816
HR:Y6 NonForest	0.0722	0.0019	0.0685	0.076
LR:Y6 NonForest	0.0635	0.001	0.0614	0.0655
MR:Y6 NonForest	0.2148	0.0034	0.2082	0.2214

Table A10 - ANALYSIS OF Y5-Y6 TOTALS OF CLASS CHANGES

	Hectares	SE	2.50 %	97.50 %
Y5-Y6 Degradation.Degradation	170,877.8	6,382.4	158,368.5	183,387.1
Y5-Y6 Forest.Degradation	14,671.8	1,849.9	11,046.0	18,297.6
Y5-Y6 Forest.Forest	16,860,331.3	23,343.5	16,814,578.9	16,906,083.7
Y5-Y6 Degradation.NonForest	10,378.9	1,595.1	7,252.7	13,505.2
Y5-Y6 Forest.NonForest	16,238.5	1,940.6	12,435.0	20,041.9
Y5-Y6 NonForest.NonForest	2,069,036.5	22,559.1	2,024,821.5	2,113,251.5

Table A11 - ANALYSIS OF Y5-Y6 TOTALS OF CLASS CHANGES BY STRATUM

Stratum / Class	Hectares	SE	2.50%	97.50%
HR:Y5-Y6 Degradation.Degradation	76,368.2	3,592.0	69,328.1	83,408.4
LR:Y5-Y6 Degradation.Degradation	40,810.3	2,752.3	35,415.9	46,204.7
MR:Y5-Y6Degradation.Degradation	53,699.3	4,500.9	44,877.7	62,520.8
HR:Y5-Y6 Forest.Degradation	9,178.0	1,258.9	6,710.7	11,645.4
LR:Y5-Y6 Forest.Degradation	1,304.4	493.0	338.2	2,270.7
MR:Y5-Y6 Forest.Degradation	4,189.3	1,262.7	1,714.5	6,664.1
HR:Y5-Y6 Forest.Forest	2,814,541.6	6,967.8	2,800,884.9	2,828,198.3
LR:Y5-Y6 Forest.Forest	9,675,584.7	11,032.9	9,653,960.7	9,697,208.7
MR:Y5-Y6 Forest.Forest	4,370,205.0	19,355.7	4,332,268.5	4,408,141.5
HR:Y5-Y6 Degradation.NonForest	4,156.1	847.8	2,494.4	5,817.8
LR:Y5-Y6 Degradation.NonForest	2,795.2	721.6	1,380.9	4,209.6
MR:Y5-Y6 Degradation.NonForest	3,427.6	1,142.2	1,188.9	5,666.3
HR:Y5-Y6 Forest.NonForest	10,736.6	1,361.2	8,068.6	13,404.6
LR:Y5-Y6 Forest.NonForest	931.7	416.7	115.1	1,748.4
MR:Y5-Y6 Forest.NonForest	4,570.1	1,318.8	1,985.4	7,154.9
HR:Y5-Y6 NonForest.NonForest	210,921.8	5,836.3	199,482.8	222,360.8
LR:Y5-Y6 NonForest.NonForest	654,642.1	10,691.0	633,688.2	675,596.1
MR:Y5-Y6 NonForest.NonForest	1,203,472.6	18,988.2	1,166,256.3	1,240,688.8

Table A12 - ANALYSIS OF Y5-Y6 proportions OF CLASS CHANGES

	Mean	SE	2.5	%
Y5-Y6 Degradation.Degradation	0.00893	0.00033	0.00827	0.00958
Y5-Y6 Forest.Degradation	0.00077	0.0001	0.00058	0.00096
Y5-Y6 Forest.Forest	0.88082	0.00122	0.87843	0.88321
Y5-Y6 Degradation.NonForest	0.00054	0.00008	0.00038	0.00071

Y5-Y6 Forest.NonForest	0.00085	0.0001	0.00065	0.00105
Y5-Y6 NonForest.NonForest	0.10809	0.00118	0.10578	0.1104

Table A13 - ANALYSIS OF Y5-Y6 proportions OF CLASS CHANGES BY STRATUM

Stratum / Class	Mean	SE	2.50%	97.50%
HR:Y5-Y6 Degradation.Degradation	0.02443	0.00115	0.02218	0.02668
LR:Y5-Y6 Degradation.Degradation	0.00393	0.00027	0.00341	0.00445
MR:Y5-Y6 Degradation.Degradation	0.00952	0.0008	0.00796	0.01109
HR:Y5-Y6 Forest.Degradation	0.00294	0.0004	0.00215	0.00373
LR:Y5-Y6 Forest.Degradation	0.00013	0.00005	0.00003	0.00022
MR:Y5-Y6 Forest.Degradation	0.00074	0.00022	0.0003	0.00118
HR:Y5-Y6 Forest.Forest	0.90039	0.00223	0.89602	0.90476
LR:Y5-Y6 Forest.Forest	0.93249	0.00106	0.93041	0.93457
MR:Y5-Y6 Forest.Forest	0.77492	0.00343	0.76819	0.78165
HR:Y5-Y6 Degradation.NonForest	0.00133	0.00027	0.0008	0.00186
LR:Y5-Y6 Degradation.NonForest	0.00027	0.00007	0.00013	0.00041
MR:Y5-Y6 Degradation.NonForest	0.00061	0.0002	0.00021	0.001
HR:Y5-Y6 Forest.NonForest	0.00343	0.00044	0.00258	0.00429
LR:Y5-Y6 Forest.NonForest	0.00009	0.00004	0.00001	0.00017
MR:Y5-Y6 Forest.NonForest	0.00081	0.00023	0.00035	0.00127
HR:Y5-Y6 NonForest.NonForest	0.06748	0.00187	0.06382	0.07113
LR:Y5-Y6 NonForest.NonForest	0.06309	0.00103	0.06107	0.06511
MR:Y5-Y6 NonForest.NonForest	0.2134	0.00337	0.2068	0.22

Table A14 - ANALYSIS OF Y5-Y6 TOTALS OF CLASS CHANGES FROM FOREST/DEGRADED

	Hectares	SE	2.50%	97.50%
Y5FY6Forest/Degraded.Degradation	185,550	6,637	172,542	198,558
Y5FY6Forest/Degraded.Forest	16,860,331	23,344	16,814,579	16,906,084
Y5FY6Forest/Degraded.NonForest	26,617	2,511	21,697	31,538
Y5FY6NonForest.NonForest	2,069,037	22,559	2,024,822	2,113,252

Table A15 - ANALYSIS OF Y5-Y6 TOTALS OF CLASS CHANGES BY STRATUMFROM FOREST/DEGRADED

Stratum / Class	Hectares	SE	2.50%	97.50%
HR:Y5FY6Forest/Degraded.Degradation	85,546.3	3,796.0	78,106.3	92,986.3
LR:Y5FY6Forest/Degraded.Degradation	42,114.8	2,795.8	36,635.2	47,594.4
MR:Y5FY6Forest/Degraded.Degradation	57,888.6	4,671.4	48,732.8	67,044.3
HR:Y5FY6Forest/Degraded.Forest	2,814,541.6	6,967.8	2,800,884.9	2,828,198.3
LR:Y5FY6Forest/Degraded.Forest	9,675,584.7	11,032.9	9,653,960.7	9,697,208.7
MR:Y5FY6Forest/Degraded.Forest	4,370,205.0	19,355.7	4,332,268.5	4,408,141.5
HR:Y5FY6Forest/Degraded.NonForest	14,892.7	1,602.1	11,752.5	18,032.8
LR:Y5FY6Forest/Degraded.NonForest	3,727.0	833.2	2,093.9	5,360.1
MR:Y5FY6Forest/Degraded.NonForest	7,997.8	1,744.1	4,579.4	11,416.1
HR:Y5FY6NonForest.NonForest	210,921.8	5,836.3	199,482.8	222,360.8
LR:Y5FY6NonForest.NonForest	654,642.1	10,691.0	633,688.2	675,596.1
MR:Y5FY6NonForest.NonForest	1,203,472.6	18,988.2	1,166,256.3	1,240,688.8

Table A16 - ANALYSIS OF Y5-Y6 proportions OF CLASS CHANGES FROM FOREST/DEGRADED

Class	Mean	SE	2.50 %	97.50 %
Y5FY6Forest/Degraded.Degradation	0.00969	0.00035	0.00901	0.01037
Y5FY6Forest/Degraded.Forest	0.88082	0.00122	0.87843	0.88321
Y5FY6Forest/Degraded.NonForest	0.00139	0.00013	0.00113	0.00165
Y5FY6NonForest.NonForest	0.10809	0.00118	0.10578	0.1104

Table A17 - ANALYSIS OF Y5-Y6 proportions OF CLASS CHANGES BY STRATUM FROM FOREST/DEGRADED

Stratum / Class	Mean	SE	2.50%	97.50%
HR:Y5FY6Forest/Degraded.Degradation	0.02737	0.00121	0.02499	0.02975
LR:Y5FY6Forest/Degraded.Degradation	0.00406	0.00027	0.00353	0.00459
MR:Y5FY6Forest/Degraded.Degradation	0.01026	0.00083	0.00864	0.01189
HR:Y5FY6Forest/Degraded.Forest	0.90039	0.00223	0.89602	0.90476
LR:Y5FY6Forest/Degraded.Forest	0.93249	0.00106	0.93041	0.93457
MR:Y5FY6Forest/Degraded.Forest	0.77492	0.00343	0.76819	0.78165
HR:Y5FY6Forest/Degraded.NonForest	0.00476	0.00051	0.00376	0.00577

LR:Y5FY6Forest/Degraded.NonForest	0.00036	0.00008	0.0002	0.00052
MR:Y5FY6Forest/Degraded.NonForest	0.00142	0.00031	0.00081	0.00202
HR:Y5FY6NonForest.NonForest	0.06748	0.00187	0.06382	0.07113
LR:Y5FY6NonForest.NonForest	0.06309	0.00103	0.06107	0.06511
MR:Y5FY6NonForest.NonForest	0.2134	0.00337	0.2068	0.22

Table A18 - ANALYSIS OF Y5-Y6 TOTALS OF CLASS CHANGES FROM FOREST

Stratum / Class	Hectares	SE	2.50%	97.50%
Y5-Y6 Forest.Degradation	14,671.8	1,849.7	11,046.4	18,297.2
Y5-Y6 Forest.Forest	16,860,331.3	2,677.8	16,855,082.8	16,865,579.8
Y5-Y6 Forest.NonForest	16,238.5	1,940.3	12,435.5	20,041.4

Table A19 - ANALYSIS OF Y5-Y6 TOTALS OF CLASS CHANGES FROM FOREST BY STRATUM

Stratum / Class	Hectares	SE	2.50%	97.50%
HR:Y5-Y6 Forest.Degradation	9,178.0	1,258.7	6,711.0	11,645.0
LR:Y5-Y6 Forest.Degradation	1,304.4	493.0	338.2	2,270.7
MR:Y5-Y6 Forest.Degradation	4,189.3	1,262.6	1,714.7	6,663.9
HR:Y5-Y6 Forest.Forest	2,814,541.6	1,850.6	2,810,914.6	2,818,168.7
LR:Y5-Y6 Forest.Forest	9,675,584.7	645.5	9,674,319.6	9,676,849.8
MR:Y5-Y6 Forest.Forest	4,370,205.0	1,824.7	4,366,628.6	4,373,781.4
HR:Y5-Y6 Forest.NonForest	10,736.6	1,361.0	8,069.1	13,404.1
LR:Y5-Y6 Forest.NonForest	931.7	416.7	115.1	1,748.4
MR:Y5-Y6 Forest.NonForest	4,570.1	1,318.7	1,985.6	7,154.7

Table A20 - ANALYSIS OF Y5-Y6 proportions OF CLASS CHANGES FROM FOREST

Stratum / Class	Mean	SE	2.50%	97.50%
Y5-Y6 Forest.Degradation	0.00087	0.00011	0.00065	0.00108
Y5-Y6 Forest.Forest	0.99817	0.00016	0.99786	0.99848
Y5-Y6 Forest.NonForest	0.00096	0.00011	0.00074	0.00119

Table A21 - ANALYSIS OF Y5-Y6 proportions OF CLASS CHANGES FROM FOREST

Stratum / Class	Mean	SE	2.50%	97.50%
HR:Y5-Y6 Forest.Degradation	0.00324	0.00044	0.00237	0.00411

LR:Y5-Y6 Forest.Degradation	0.00013	0.00005	0.00003	0.00023
MR:Y5-Y6 Forest.Degradation	0.00096	0.00029	0.00039	0.00152
HR:Y5-Y6 Forest.Forest	0.99297	0.00065	0.99169	0.99425
LR:Y5-Y6 Forest.Forest	0.99977	0.00007	0.99964	0.9999
MR:Y5-Y6 Forest.Forest	0.998	0.00042	0.99718	0.99882
HR:Y5-Y6 Forest.NonForest	0.00379	0.00048	0.00285	0.00473
LR:Y5-Y6 Forest.NonForest	0.0001	0.00004	0.00001	0.00018
MR:Y5-Y6 Forest.NonForest	0.00104	0.0003	0.00045	0.00163

This analysis is restricted to hectares known to be forest in Y5.

Table A22 - Mean Deforestation (to Degraded/NonForest) per hectare

	Mean	SE	2.50%	97.50%
loss	0.0010959	0.000127	0.0008462	0.0013455

Table A23 - Mean Deforestation (to Degraded/NonForest) per hectare BY STRATUM

Stratum	Mean	SE	2.50%	97.50%
HR	0.003849	0.000484	0.0029003	0.0047976
LR	0.000077	3.85E-05	0.0000015	0.0001525
MR	0.0015655	0.000369	0.0008428	0.0022882

This analysis is the amount of deforestation in the area sampled, using actual area of deforestation per sample.

Table A24 - Mean Area that is not Forest per hectare

	Mean	SE	2.50%	97.50%
Area	0.00135202	0.000426	0.000516338	0.002187701

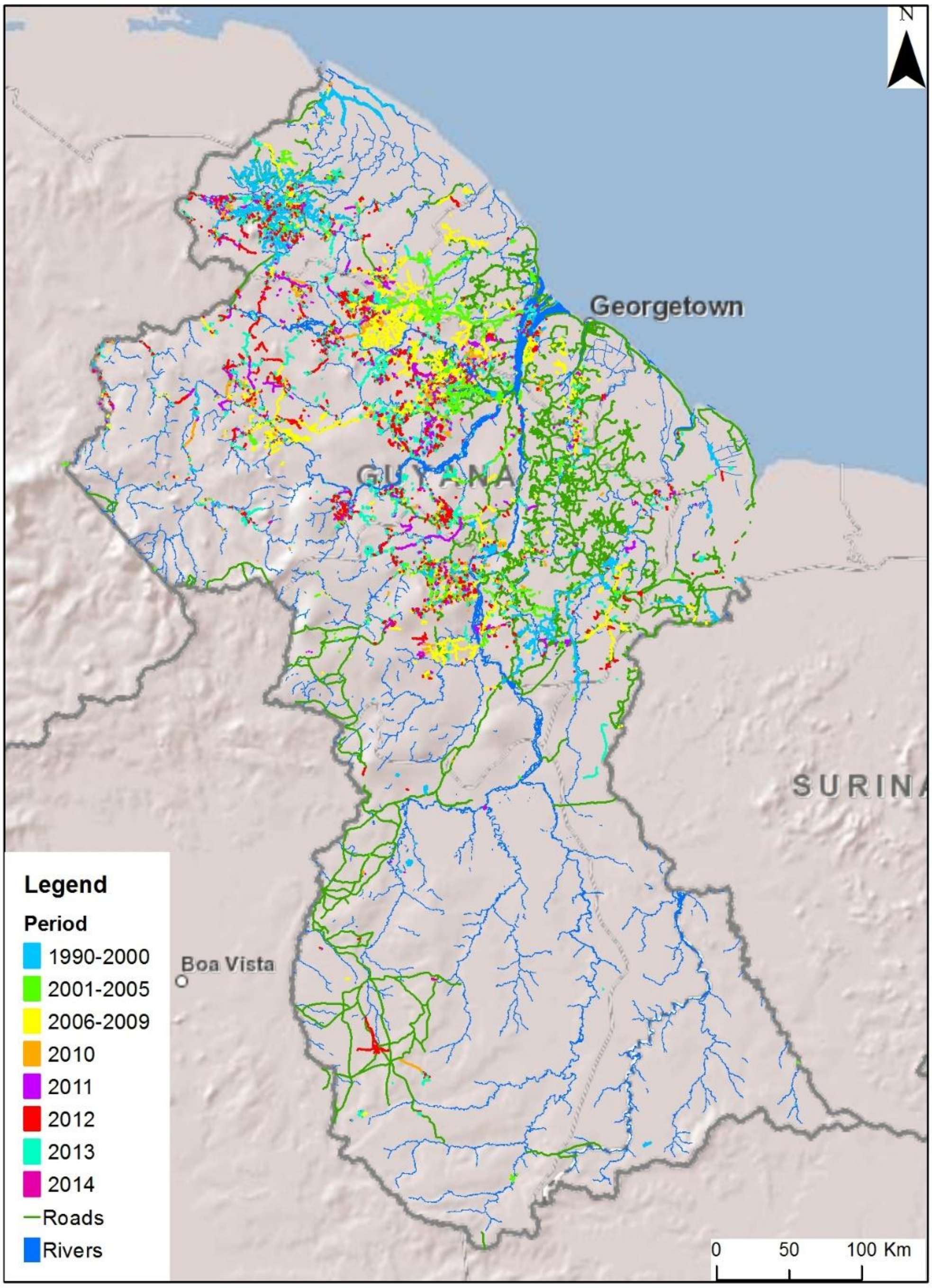
Table A25 - Mean Area that is not Forest per hectare BY STRATUM

Stratum	Mean	SE	2.50%	97.50%
HR	0.004234	0.001436	0.0014202	0.0070478
LR	0.0002	0.000112	-0.0000204	0.0004204
MR	0.0019695	0.001231	-0.0004427	0.0043817

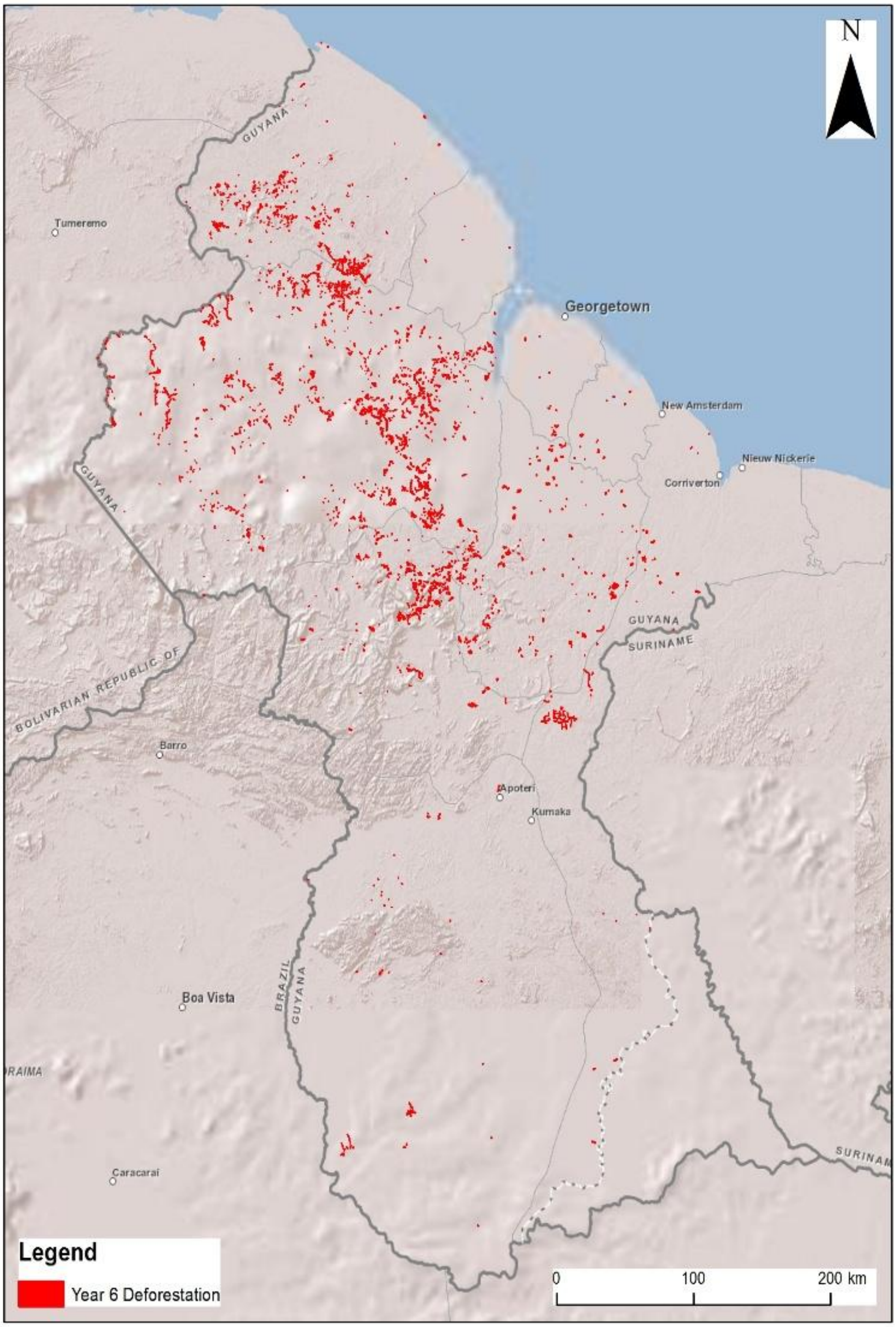
Appendix 8

Maps of Forest Area Change

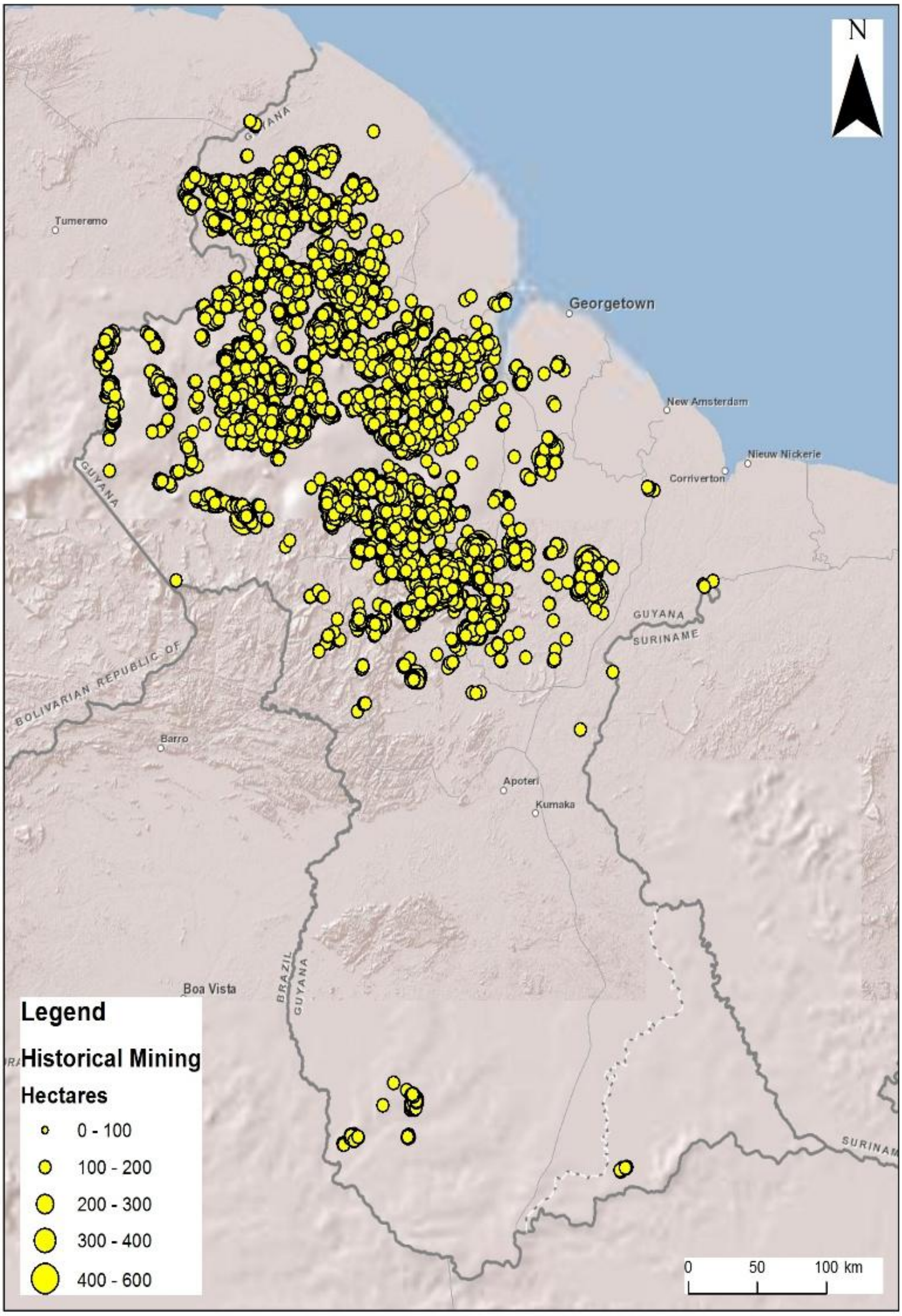
Historical Forest Area Change



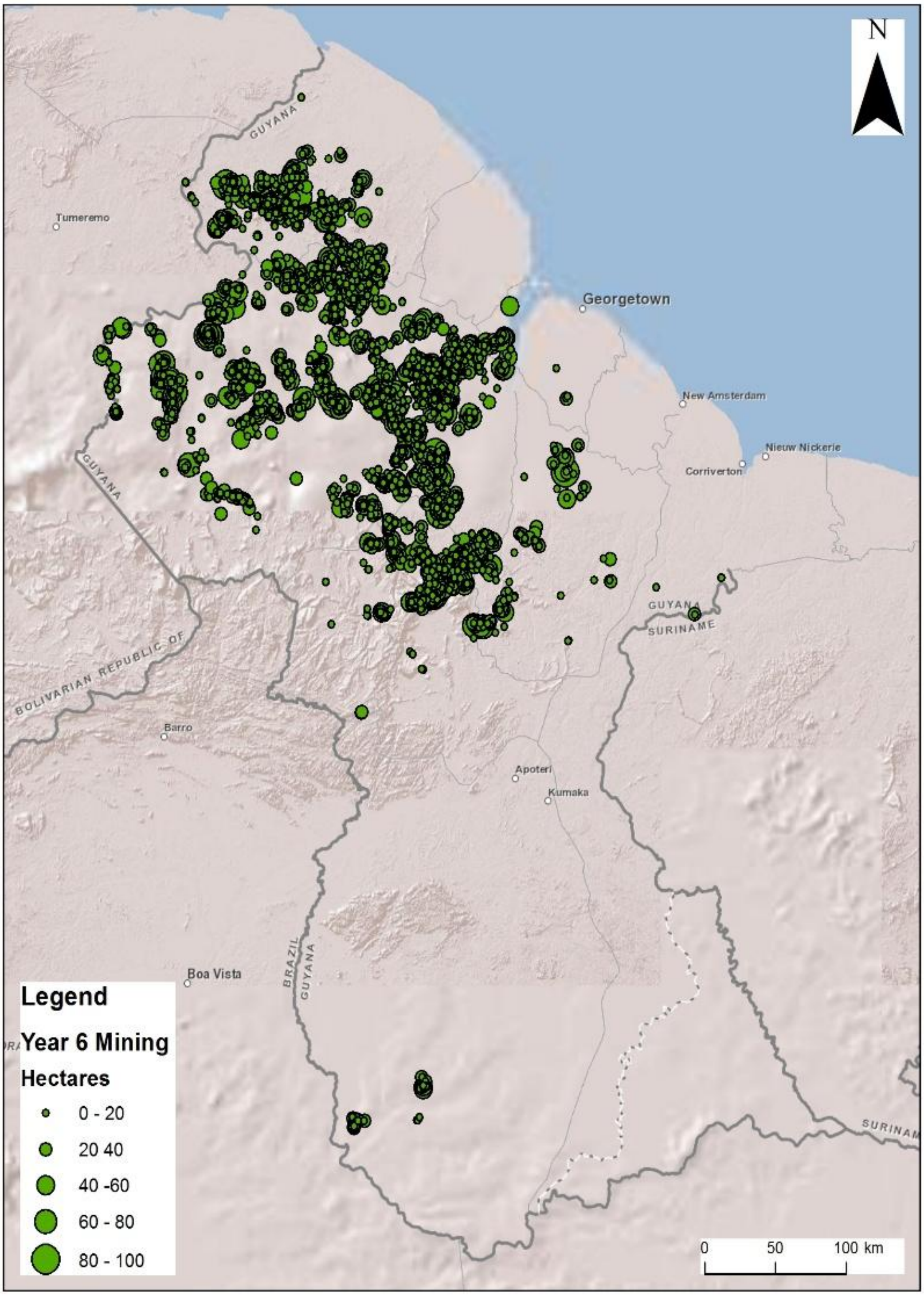
Year 6 Forest Area Change



Historical Spatial Area of Deforestation – Mining



Year 6 Spatial Area of Deforestation – Mining



Appendix 9

Feedback from Public Review Process

Comments were provided by a broad range of stakeholders from national and international levels. These embodied general and specific comments and are presented below, identifying the name of the Reviewer, with responses by the GFC. Where necessary, updates have been made to both the full and summary reports. Stakeholders who provided comments were provided with feedback on their comments, along with the revised Report.

	Comments on MRVS Year 6 Interim Measures Report	GFC's Response to Comments	Reviewer
General observations	Thank you for submitting an interesting MRVS report. I note that several technical developments have taken place since the last report, and I commend Guyana for all the hard work and effort that have gone into the development of the MRVS in general and this report specifically.	The GFC has attempted to embrace the broader thrust of the MRVS Phase 2 in looking for new and emerging technical solutions to related MRVS areas, as well as to embrace the requirements of implementing a non-REDD+ payment option for the MRVS. This process has started in MRVS Year 6 and we thank you for keeping track on how these aspects are evolving. Text inserted in Preface.	Maarten van der Eynden
	This review is intended to provide a technical assessment of the Year 6 MRVS Interim Report. Guyana's MRVS is a national system with great potential to set the learning curve and standard for the development of similar systems globally. The Guyana Forestry Commission (GFC) and partners should be commended once again for their dedication towards conducting the Forest Area and Carbon Assessments and reporting at such a high technical calibre. Specifically, it is important to acknowledge the credible move toward newer satellite constellations with the aim of improving overall efficiency of the report. At the same time, this allows reporting to evolve from interim reporting to a fully-fledged forest monitoring system that responds to the interests of the various sectors, especially as Guyana moves towards green economic development.	Moving towards new developments in the field of MRVS is a critical area for the GFC in ensuring that the most technically sound but yet cost effective options are utilised in the national monitoring. Year 6 has embraced this in large part. There are plans in place to move beyond reporting on the interim indicators in Year 7.	CI, Guyana
	The integration of the MRVS at decision making at land use and policy levels should be enhanced. This current situation may be mostly because the system is well advanced from the current spatial technologies and capacity available across other natural resource	The results of the MRVS have allowed for the product of the MRVS work to be used for several applications currently, including: the modelling effort under Guyana's Green State Development Strategy and related analytical applications;	

	agencies and the disintegrated way forests are managed. It would be of use to elaborate any plans to rectify this.	identifying potential sites for hydro power; regional planning at municipal level; and planning of mineral allocation sites, to name a few areas. It is intended that this will continue in other areas of work. One of the main enablers for this will be making the results of the MRVS work publicly accessible through the information platform. This is currently in development. It is intended that through the ongoing efforts by the Guyana Lands and Surveys Commission in developing a National Land Policy for Guyana, that the MRVS data and results will be used to inform national planning across land uses.	
	There should be mention of CMRV related work in the Report; it would be of use to include some thinking around this especially as it relates to the integration of efforts in the North Rupununi and Kanashen into the national system.	The GFC has been working with partners including WWF, to advance work on CMRV. These will likely link to a potential new bilateral agreement and the Opt In Mechanism currently being developed by the Office of Climate Change. Among the main areas of progress in the year 6 that have been advanced by WWF are: • The North Rupununi District Development Board's (NRDDB) 19 communities on 10 titled parcels (234,006 hectares of forest) have received training and facilitation to produce resource-use maps, village histories, village development and spatial plans sufficient to make them eligible to opt-in to a payment mechanism for forest carbon. They have also received training in FPIC, bookkeeping, conflict resolution and governance. • 38 monitors, two from each of the 19 communities have completed their CMRV training and have gathered and compiled the data for their village's (updated) baseline.	

		• A CMRV resource center has been outfitted at Bina Hill to provide technical back up to the monitors and assistance in analysis and mapmaking • Provided training and facilitation in opt-in readiness planning and capacity development for the Opt-in Pilot community of Muritaro. • Beginning in February 2018, monitors will be trained from 16 KMCRG communities and Muritaro in CMRV. It is intended that these efforts, as well as support from the national MRVS, will help to advance the readiness of potential new area into the national system. Insert made in Section 1.4 of MRVS Year 6 Report.	
	The report is quite technical in certain sections and opens the view of how well persons without the required technical orientation can effectively contribute during the 1- month public review process for this draft. The extended holiday period also takes away from the attention the report can receive from the public. Given the MRVS report is a performance- based mechanism, many of the areas beyond the technical work demonstrated in the report, require targeted responses and responsible agencies to carry on such work.	The GFC has also released a Summarised, more user friendly version of the Report as well. In some parts of the Report, it is necessary to explain in full technical detail. The public review period ended on 22nd January, and allowed a full month, and three weeks post-Christmas, for review and feedback. It is intended that the product of the MRVS programme will be taken up for more national policy initiatives such as the development of the National Land Policy, currently in development and led by the Guyana Lands and Surveys Commission. The GFC continues to be accessible (even beyond the comment period) to any stakeholder who may have any question or clarification or would request a demonstration on how MRVS results can fit new/existing demands.	
	It is encouraging to see that even though there was a time lag in commencing with this new phase given the time taken to finalize the	The GFC is keen to keep the momentum up even with the later start for the year 6 which began in September 2017. For this	TAAMOG

	project agreement between Norway and Guyana, that a continuous assessment was still enabled.	reason, there was a concerted effort to complete the year 6 assessment in 2017 and to bring the MRVS up to current date by conducting a 24 month reporting period as the Year 6. It is hoped that for year 7, this will be on track as previous years, and perhaps even earlier.	
	TAAMOG is of the opinion that the process of allowing public comments is commendable and speaks of transparency and good practice by the GFC.	The process has benefited greatly from the public review and feedback process. Several areas are revised via this process and this lend to a stronger Version 2 of the Report. We hope to continue this part of the verification process for the future years of Phase 2.	
	TAAMOG has noted that the deforestation rate has decreased significant from previous years and would like to commend the work of the GFC in leading this drive to maintain forest cover at high levels. The low deforestation rate is testimony to the strong and effective Stewardship of the forest by the Guyana Forestry Commission. The GFC programme under the EU FLEGT VPA will also fit in nicely with this good forest governance and monitoring by the GFC.	The main driver of deforestation for year 6, as was also the case of previous years, was mining. This saw a notable decline in Year 6 and points to several developments that have taken place at the policy level in enhancing monitoring at the mining sector level. These are elaborated in the Section on National Trends of the Report. The GFC is pleased to be part of this effort and outcome and to continue its role in the sustainable management of the State Forest.	
	The move to a no-cost option for data for satellite cover for deforestation monitoring (moving away from rapid eye and using the freely available high resolution cover from sentinel) is a good advancement that will reduce the pressure on financial resources for routine and continuous monitoring in the future, especially in a situation when there is no dedicated project financing.	The GFC has attempted to embrace the broader thrust of the MRVS Phase 2 in looking for new and emerging technical solutions to related MRVS areas, as well as to embrace the requirements of implementing a non-REDD+ payment option for the MRVS. This process has started in MRVS Year 6 and we thank you for keeping track on how these aspects are evolving. Text inserted in Preface.	

	The change in the approach for degradation monitoring is also viewed by TAAMOG as a very positive move. Generating a national map may not be necessary or required to give a reliable account of forest degradation and the sample based approach done by the aerial surveys complemented by planet labs data is viewed as a good alternative approach that was piloted in year 6.	Generating national maps and creating a historic and continuing time series, have been fundamental to a technically sound process. At this time, it is difficult to envision moving totally away from using a national map for deforestation mapping. A national map has the distinct advantage of creating and maintaining a national level data set that can serve as a useful time series for a range of applications – one most notable example is Guyana's submission of its Position on Reference Level for REDD+ to the UNFCCC where Guyana was one of the first 6 counties in the world to make it submission. Guyana's submission received very positive feedback from the UNFCCC's technical assessment process. This entire undertaking was supported by the availability of the national data set and time series enabled by the national map created for every assessment period, including the historic period. However, there is growing momentum at the international level that sample based approach can be considered as a good option for monitoring some aspects of forest change. Using the accuracy assessment as the source data set for the degradation monitoring for year 6, is a reflection of the GFC exploring this option. This was seen as a good avenue since the AA is based on a national sample, and executed through a fairly advanced and mature process with high quality and resolution data.	
	The integration of the pioneering work of the Global advocate of earth observation monitoring- google earth engine, within Guyana's MRVS system brings Guyana's in line with new and modern approach and technologies for MRVS work. This is seen as a good addition to the year 6 work. For year 7, TAAMOG's expectation is for there to be a smooth continuation of the routine reporting and for there to be further advancement of the sample based system of degradation monitoring,	We also agree that the integration of GEE in the GFC's national MRVS was a good addition. This has helped to build efficiencies in a number of key areas of the MRVS. It is hoped that this can further be advanced in the upcoming years, as will further exploring of the sample based approach to degradation monitoring (though continuing with the national	

	as well as for movement towards freely available imagery for deforestation monitoring.	map for deforestation), as well as expanding the use of freely available high resolution imagery – whilst still maintaining a high accuracy on mapping results.	
	TAAMOG hopes that there will be future financial incentives tied to this reporting and thus urge all parties to re-negotiate a new Norway agreement. Finally congratulations to Norway for the continued interest shown in the forest sector of Guyana.	We also share this hope for a new agreement. Norway has continued to be a committed partner to our work on the MRVS.	
	Thank you very much for an interesting report and for making sure that it is open for public comments. The Norwegian government is pleased to see that a lot of hard work has gone into making this report and note that there has been several technical developments since the last report.	The process has benefited greatly from the public review and feedback process. Several areas are revised via this process and this lends to a stronger Version 3 of the Report. We hope to continue this part of the verification process for the future years of Phase 2. The GFC has attempted to embrace the broader thrust of the MRVS Phase 2 in looking for new and emerging technical solutions to related MRVS areas, as well as to embrace the requirements of implementing a non-REDD+ payment option for the MRVS. This process has started in MRVS Year 6 and we thank you for keeping track on how these aspects are evolving.	NICFI
Specific Comments	6 IPCC land use classes: does the GFC have capacities to monitor all area changes activity data?	Yes, we currently monitor the transition of land use and cover over time. At this point the focus has been on forest to non-forest and degradation activities as set out in the Interim reporting measures.	Martin Herold
	RapidEye imagery has not been used for the Year 6 assessment. • Could you elaborate on why not? • Did you perform an assessment of the consequences of moving to Sentinel II as the main data basis? • Is there e.g. a risk that less deforestation is picked up by the system as a consequence of the 10m resolution vs. the more detailed resolution of RapidEye imagery?	The formalising the MRV phase II agreement which concluded in September 2017, between GoG/Norway/CI meant that no commercial arrangement with RapidEye was established back in 2016 for the 2015-2016 period. This meant that alternative imagery (Landsat and Sentinel) were evaluated and used to track deforestation events.	NICFI, Maarten van der Eynden,

		The Sentinel and Landsat imagery were assessed to ensure that they overlaid the existing change base maps. Any change events detected with the Landsat 30 m imagery were compared against Sentinel 2 images to confirm the deforestation boundaries. For deforestation the minimum mapping unit is 1 ha so both datasets are appropriate to detect changes of this size. The spatial resolution of Sentinel is sufficient, in its native format RapidEye pixels are 6.5 m resolution and resampled to 5 m. The increased revisit of the Sentinel satellite (every 5 days) also assists to ensure that change areas are correctly detected, and boundaries defined. Further, the definition of forest has remained the same, the SoP for mapping has remained the same as previous years, and the Accuracy Assessment was also conducted using an independent data set to the Sentinel data set. Yes, the assessment of the movement from Rapid Eye to Sentinel was captured through the independent results of the Accuracy Assessment. An analysis of the findings of the Accuracy Assessment is presented in Section 4 of the Report and has confirmed that the accuracy of the mapped product from a Rapid Eye data source to a Sentinel coverage map has remained high in the year 6 period. Interestingly, the national map concluded on a higher rate of deforestation (for the first time) than the Accuracy Assessment which emphasizes the point that there is low proven tendency for less deforestation being picked up with the Sentinel data set. Text and map inserted in Section 4. The intention moving into the next assessment period is to continue the use of both Sentinel and Landsat. A prototype system has been developed that uses these data in real time to improve the detection and classification of change events.	

		This system will be used in tandem with the current forest monitoring system.	
	It has been noted that Guyana has begun to consider the “non-REDD+ payment” option through: • Multiple data sources being used: L7/8, Rapideye, S2 (Landsat-based all along) – but use accuracy data to confirm consistency for reporting • Commencing exploring the opportunity to refine the methodology for the purpose of increasing efficiency (move away from commercial options (Guyana moved to using Sentinel), role for audit and independent verification (Guyana has moved to Accuracy Assessment being used as sample based approach for degradation assessment), cloud computing (Guyana has moved to using GEE))	All good points. The MRVS has continued to evolve and look at viable opportunities to become increasingly cost efficient. The availability of high quality free imagery has assisted in enabling this. This is further advanced through access to cloud processing platforms. Auditors add to the process by offering an impartial assessment of the validity of the results and importantly providing transparency as required by stakeholders.	Martin Herold
	It is good to see the integration of S2: what are the lessons learned? Access to cloud computing (SEPAL?)	Sentinel data has proven to provide a robust dataset for monitoring change. The large image footprint and revisit period means that it is possible to efficiently monitor large areas. Cloud-based and pixel-level processes increase the utility of GFC’s resource monitoring system. GFC has reviewed the SEPAL system and has a good working relationship with the Forestry team at FAO. A technical training mission with the SEPAL team is planned for mid-2018.	Martin Herold
	Not clear whether “annual” mosaics (of L8, S2 etc.) are used or the full time series • Increasing recognition of “temporal precision”	It is a compilation of both: images are downloaded annually for the assessment year, however we have images to be used as reference data that goes as far back as 1990. Individual Landsat and Sentinel scenes are used for the analysis. In this way the timing of each change event is more accurately recorded.	

	On the proposed activity 1.2.1 the proposal says that work will be undertaken to *Assess current stratification for shifting cultivation and mining degradation and revise as needed to improve emission estimation*. According to the MRVS Y6 report, this work will be undertaken in 2018.	This work has begun in 2017 and will be continued in 2018. A stratification update report has been prepared, exploring the potential need for revised stratification based on changes in potential for change and the road network that have occurred since original stratification was conducted. Additionally, for the first time a definition of degradation has been developed, to be used going forward. For shifting cultivation, the need for revised stratification is largely associated with the definition of degradation, and whether it includes shifting cultivation. For mining degradation, a simplified accounting method is currently being developed, which will help to address need for revised stratification. Added information presented in Section 1.4 of the full Report.	
	On the proposed activity 1.2.3 *to improve emissions factors for some specific processes (towards tier 3)* the report gives little information. We understand it as being work in progress and look forward to more reporting on this for 2017 and 2018.	This will be undertaken in 2018, and will follow from the simplified mining degradation method and the revised stratification (if needed). We are currently analysing existing destructive sampling data to assess whether it would be more appropriate to use different allometric equations than have been used previously (to increase accuracy and reduce uncertainty). The results of this analysis may impact the emission factors as well. Added information presented in Section 1.4 of the full Report.	NICFI
	When it comes to activity 1.2.4 on *Update on forest biomass and carbon stocks data*, the report is not clear on when we can expect to get more information. We would appreciate if the report gives information based on available data and/ or indicates in which year this work will commence.	In year 6, based on the analyses of the need for re-stratification and the potential to use revised allometric equations, along with the final simplified mining degradation methodology, the need for new field data is being re-evaluated. This work has started in 2016-2017 with the collation of the year 6 activity data, assessment of the completeness and compatibility of year 6 with historical layers,	

		and updated information collated on new roads. This work will be further advanced in 2018. Added information presented in Section 1.4 of the full Report.	
	Table 2.1: should/could be presented as change matrix (approach 2 or 3) rather than as net changes (approach 1)	Updated to avoid confusion, removed the Year 5 table, to only include the Year 6 summary as this is the overview section for Year 6. It is possible that non-forest to (other) non-forest changes exist, but this not tracked by GFC, such updates come from other sources/commissions as the data is made available.	Martin Herold
	Treatment of area estimate from mapping versus adjusted area (2015/16): • p.32: 18416 ha • p.49: 16239 ha (CI95: 12436-20041 ha) • Tendency to report adjusted area estimate. • Take a look also at previous years – does the trend change?	P 32 value is the (mapped) deforestation value from the team at GFC using the Sentinel data. A map has been included in Section 4 to show the comparative trend between the mapped and adjusted (AA) rates. P 49 value and CI is derived from the accuracy assessment. This is an independent assessment, separate to the value generated by GFC. This is why there is a differences.	
	After a more general reading of the year 6 report, we would like to point out that it is a bit confusing when annualized rates and absolute rates for the Year 6 reporting are used in different parts of the document. We would suggest that you consider presenting the absolute rates and numbers early in the report, show clearly what the annualized rates are, and then use the annualized rates consistently after that. This could improve clarity. Not sure whether all results tables provide annualized data (clarify)	Thank you for the suggestion, adjustments made for improved clarity on the use of the 24 month and annualised rates throughout the Report.	NICFI, Martin Herold, Maarten van der Eynden
	The report states that Guyana's deforestation rate in 2015- 16 is at 0,05 % per year. There is a marked decrease in deforestation from mining	Among the main factors that have continued to the decrease in deforestation from mining has been the shift towards more	

	and agriculture compared to previous years, but an increase in terms of fire. For public communication purposes, the report could benefit from explaining the assumed reasons for the decline from various drivers of deforestation (see table 4- 3 at page 14 of the summary report) as well as the increase from others.	large scale mining - two main large scale operators are in full operation. A supporting reason is the move to EITI has led to several preparedness efforts at the mining sector to strengthen governance and management. There has been emphasis on looking at effective implementation of codes and guidelines and the field monitoring has also expanded. Other factors that also contributed are the decline in prices and the challenges in access experienced by miners. Deforestation has declined from 2012 (USD1,900/ounce) which marked a point where the gold price was the highest since 1980. Post 2012 the price has declined to around USD1300/ounce. This combined with limited accessibility has gradually reduced the area mined. Explanation included for each Driver in Section on National Trends in the MRVS Report.	NICFI, Martin Herold, Maarten van der Eynden
	Please also comment Table 4-1 in Summary report: The annualized change rate for the period 1990-2009 seems to be for the entire period. Please present the annualized total.	Thank you. Correction made, total now reflect annual results.	
	Any idea on the change in degradation mapping?	In the Year 6 assessment, Degradation values were calculated based on interpretation of the accuracy assessment samples. It has shown some fluctuation between the assessment periods, so it is not unexpected. For this assessment the value is based on the results of the accuracy assessment. A general description is provided as follows: The original sample design is weighted so greater number of samples are interpreted in areas deemed to have a medium to high risk of change – as informed by the historical results of GFC's wall to wall mapping. The degradation value is calculated by reanalysis of the same sampling frame each time the assessment is repeated. In previous assessments the degradation values between GFC and the accuracy assessment fall within the confidence	Martin Herold

		limits of the sampling approach. This correspondence adds a degree of confidence that the degradation events are being captured. It should be noted that GFC method only maps degradation that surrounds established infrastructure. The sample-based design has the advantage that it is representative of the entire land area of Guyana. In moving forward, critical to the degradation discussion is the new definition of forest degradation for Guyana. Based on the definition, we are currently re-evaluating which forms of degradation should be included, and better identifying what is significant, and what is *de minimis*. In particular, if shifting cultivation is defined as deforestation, it will no longer be mapped as degradation, aside from changes in rotation cycle. Updated made to the Degradation Section of both full (Section 7.4) and summary reports (Section 4.4).	
	Interesting to see and understand the pattern by driver: • Some decline in mining related deforestation • Agriculture is down overall (Tab. 7.4) but up in SFA • Large increase in fire emissions (El Nino?) • Harvesting reduced significantly	Yes, mining has continued to develop where there is existing access and agriculture development continues to be conducted at a relatively small scale. The large fire events are tied to prolonged dry spell and more commonly observed on the drier sand and grassland areas. Forest harvesting in general has declined and is linked to some forest concessions ceasing operations. More details have been added on each driver in Section on National Trends.	
	Point 6.5 in the summary report states that "In Year 6 and 7 the same benchmark IFL area was used. The analysis identified 290 ha of deforestation, 177 ha of which was mapped in Amerindian areas and 107 ha in State Lands. It is proposed that deforestation located in Amerindian areas is not counted in calculating the reduction in financial	Thank you for the feedback. Indeed this area has been an evolving one and discussed throughout the years. The IFL definition provides for areas of "exclusion" that allows for utilisation areas, as well as settlements to be excluded for IFL monitoring. This deductions were initially done when the	NICFI

	remuneration. These areas are part of the Government of Guyana's continuous land titling and demarcation programme." Norway is an active supporter of the Government of Guyana's work on land titling for Amerindian peoples and land demarcation. However, we cannot see the reason for why deforestation that takes place inside Amerindian areas is not counted in calculating the reduction in financial remuneration. Deforestation inside Amerindian areas that qualify as IFL should, in our opinion, be calculated in line with other types of deforestation in Guyana.	baseline for IFM was set back in 2010, for all relevant exclusions. Unfortunately this could not be done for all Amerindian Areas as these areas do not have GIS boundary points until they become titled (a continuous and ongoing process). The ideal situation of course, is if all Amerindian Area were to be established upfront, and for these to have been duly deducted from the IFL baseline all at once back in 2010. This was not possible for the reasons stated – being that the process is continuous and ongoing. The question would be whether one would prefer to stay true to the definition of IFL which requires you to make these exclusions or whether we would decide that exclusions would be a onetime circumstance for which deductions would only take place once. The GFC has continued to report on IFL by not altering the benchmark. Any modification will have to be agreed jointly by Guyana and Norway before any change is made in the Report to the benchmark or reporting modalities.	
	9.4 IFL -Efforts are needed to mainstream the MRVS to ensure actions that reduce changes to the IFL beyond the work of the GFC.	This is agreed, it will be ideal if GIS boundaries of areas of titles/extension to Amerindian areas are known early so that provisions can be made within IFL. Additionally, managing areas of Intact Forest can then be a more collaborate approach with forest users as well as villages. GFC will continue to engage with the Protected Areas Commission to share information on IFL areas as these can serve as a baseline for monitoring at that level.	CI, Guyana
	We also take note that Planet data is used for the Year 6 accuracy assessment instead of imagery captured though overflights as in previous years. Is there a chance that the change in spatial resolution could systematically affect the results in some way? We would also like to know why imagery from 2015 was used. It would be our assumption	PlanetScope (note: Planet also provides RapidEye and SkySat) data are advertised at a spatial resolution of 3m, which seemed reasonable to be used for AA (Accuracy Assessment) as it is higher than RapidEye (5m resampled) and thus offers higher precision levels. On top of this, the PlanetScope solution is more cost-effective (both in time and	NICFI

	that imagery from end of 2016 is most relevant if the total change for the whole period of 2015-2016 is to be measured?	funds) than the GeoVantage acquisition. Last but not least, the re-visit time of PlanetScope could potentially be used in the future for real-time monitoring of deforestation or forest degradation. Operationally, it is a risk to alter well-tried approaches, but thinking ahead, there is need to explore further and improve current processes. For example, the new OptiSAR constellation of UrTheCast looks promising regarding automatically detecting changes (SAR) and acquiring them (piggyback Optical sensor). Regarding how the results may be affected in regards to spatial resolution: On paper, we expected little effect on assessing deforestation. We also knew it would make it more difficult to assess degradation. Following our work with PlanetScope, we discovered that the Doves, being small and so many, do not have the radiometric and geometric fidelity of their larger brethren. In other words, the radiometry and positioning varied among the imagery we received. Was it systematic? No. Did it influence the accuracy assessment? In occasions, we couldn't use the PlanetLabs image, and therefore used the Sentinel-2 image. In all cases, the GeoVantage 2015 was very useful (see answer on 2015 image usage).	
	I also note that Planet data is used for the Year 6 accuracy assessment instead of imagery captured though overflights as in previous years. As for the mapping, is there a chance that the change in spatial resolution could systematically affect the results in some way? Why was imagery also from 2015 used? Would not imagery from end 2016 be the most relevant if total change for the total period of 2015-2016 is to be measured?	The GeoVantage 2015 imagery was not used for assessing change for the two years. As you rightly point out, it shouldn't be used for decision making because we are assessing changes until end of 2016, not 2015. Instead, the high spatial resolution of GeoVantage 2015 provided an extra layer of information that assisted the interpreter in better understanding what the lower resolution image shows. For example, occasionally the 2016 imagery was of low resolution (e.g. use of Sentinel-2 in combination with a low radiometry PlanetScope image). The interpreter would use the 2015 high spatial resolution image to better understand what's	Maarten van der Eynden

		happening on the ground, with the knowledge that this is the 2015 dataset and not 2016. Therefore, all decisions were based on what happened between 2014 and 2016, with assistance of a 2015 dataset when needed.	
	The field of REDD+ MRV has been rapidly developing over the past years. Though initiatives such as the Global Forest Observation Initiative, methods and data for forest monitoring is being discussed by world leading experts in the field, and practical Methods and Guidance Documents are developed. One key development is that statistical estimation of forest area change is often recommended over more classical wall-to-wall approaches. Or even better; if these approaches can be combined, this is even better. Following this logic, one could even say that in many ways, the "accuracy assessment" currently being done could in the future be adapted to be the official estimate of deforestation, while the wall-to-wall map could be used to support the statistical estimation, and of course for a wide range of operational and policy development uses. In light of this, I would recommend, in line with earlier discussions, to invite some of the experts connected to the GFOI network to provide suggestions and recommendations for the Guyana MRVS. This would also contribute to disseminating the many impressive and interesting experiences generated by Guyana's MRVS work to the wider MRV community.	Yes, that is a good point and the GFC team have contributed to (GFOI MGD) and learnt also from the evolving expert discussions. The Accuracy assessment process incorporates these ideas and has further expanded on the approaches to make them relevant to Guyana. As additional countries have engaged in national monitoring it has become more apparent that there are several alternatives that provide forest change estimates and the merits of say wall-to-wall maps and sample-based approaches. The GFC welcome the continual interaction with GFOI and FAO and the opportunity to present and discuss the results and developments of Guyana's MRVS.	
	I would encourage to explore which role the SEPAL system (formerly titled "SDMS") administered by the FAO can play in this.	Thank you. We agree. Further exploring Sepal will be one of the areas advanced in 2018 and an exchange is planned for end of April 2018.	
	Pg 3: The resolution of the data used meant it was not possible to conduct national scale monitoring of the impact of forest degradation. - Some reference should be made here on the difference in definition of deforestation and forest degradation. Without this,	Thank you. Text added to the Report (Section 2). The text clearly sets out the distinction with reference to Guyana's definition of forest as, "In the Standard Operating Procedures the definition of deforestation is summarised as the long-term conversion of land from forest use to other non-forest uses (GOFC-GOLD, 2010). An important consideration is that a	CI, Guyana

		there may be some confusion on what it means to not have this included in the report.	forested area ≥ 1 ha is only deemed deforested once the cover falls and remains below the elected crown cover threshold (30% for Guyana). The main anthropogenic change drivers that lead to deforestation, identified in previous work and by the initial workshop at which the MRVS Road map was developed, include: • Mining (ground excavation associated with small, medium and large-scale mining) • Infrastructure such as roads (included are forestry landings and mining roads) ○ In year 4 (2013) a 'Settlements' driver was been added, to delineate areas where deforestation occurs due to human settlements. The area is immaterial, but it was a driver of change that could not adequately be covered by the existing schema. • Agricultural conversion • Fire (all considered anthropogenic and depending on intensity and frequency can lead to deforestation outside of a shifting cultivation landscape) There is 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 forest degradation in Guyana are identified as: • Selective and illegal harvesting of timber (not reported spatially in the MRVS) • Shifting cultivation systems • Fire • 'Edge effect' degradation around mining sites and infrastructure (this is often not persistent and therefore it is questionable as to whether it is true forest degradation). In 2017, Guyana has finalised a definition for Forest Degradation to reflect these national circumstances.	
	Pg 5: Table 2-1/2-2: The breakdown of the table showing forest and non-forest is not clear. E.g. Settlements remain unchanged between both years (58,000 ha), however there seems to be a miscalculation of this figure, perhaps this was influenced by "rounding up". - Possibly the information in section 3 could come before the table in section 2 since it adds meaning. - Map 2-1 : It is difficult to differentiate the legend features based on the symbology presently used. - Map 3.1: Legend text is blurry.	Updated to avoid confusion, removed the Year 5 table, to only include the Year 6 summary as this is the overview section for Year 6. It is possible that non-forest to (other) non-forest changes exist, but this not tracked by GFC, such updates come from other sources/commissions as the data is made available. Map 2.1 updated and Map 3.1 enhanced.	
	4.3 pg 11: Agency Responsibilities - It would be useful here to have the responsibilities of the agencies GGMC and GLSC, be assessed or included based on their role (current or potential) in the MRVS. It clarifies for the agencies themselves, how they are involved beyond the reporting periods.	MRVS related areas added to the Section on Agency Responsibilities.	
	4.5 pg 14- National trends - Several large fires have been identified. Are there any locations or possible ways these can be investigated further to ascertain their nature?	Yes, the location and the boundaries are mapped for any fire event that result in forest change > 1 ha. Fire is quite easily separated from other forest change events.	

	5.3 MRVS Tasks and Development Areas- It would be informative to state whether capacity is being built within the mapping team to be able to actively undertake the research listed in table 5-2.	Yes, it is intended that in the three areas that are associated with the new development aspects the GFC team will lead or be involved in the following ways: - Design of new SoPs – the GFC team will play an integral role in the design of new components and will conduct the analysis necessary for the new area. For areas of the new information platform, the model used by the Geospatial Information Management Unit under the Ministry of Natural Resources will be used for this purpose. This will allow for local inputs to be more readily accessible and available for the GFC's team. - Analysis and Field work – the GFC's team will lead in the execution of field work for new development areas. - Training – the GFC has used in the past a training of trainers approach whereby for new development areas, a core team is trained and these persons can then train new staff.	
	7.5 Transition of Degraded Areas to Deforestation- *Therefore, it is expected that updates from degradation to deforestation, for legacy polygons will resume in Year 7.* - Will this be with the continued use of Sentinel?	Yes, with the increased revisit frequency and spatial resolution any polygons identified as degraded will be updated if they change to a deforested state.	
	Pg 38- A general observation of mining related change occurs centrally within the country, however Region 10 and 6 are emphasized to a smaller extent. Although change numbers in these regions can be quite low, are there ways to flag eminent land use changes that might be ecological or socially threatening? Especially as it relates to land allocation activities in forests.	This point is important since one of the products of the MRVS is to track if new drivers emerge as well as if there is a growing shift in the trends of deforestation and forest degradation. It is intended that this information be used by the GGMC to analyse these emerging shifts and integrate action where necessary to provide for these emerging trends.	

	10 QA/QC Pg 63- Facilitating data sharing between agencies through inter-agency training. - Given the structural changes in the agencies, how has this changed or improved?	Whilst there have been several changes at the structural level, the GGMC and the GFC have remained under the Ministry of Natural Resources. The GFC continues to engage with the GLSC as this Commissioner remains a permanent part of the MRVS Steering Committee. Also, there continues to be a direct communication link between the GFC and these agencies. Facilitating data sharing and training remain well executed and managed.	
	Appendix 1- 5. Task 3.1.13 *Explore options for development of an information platform for access to MRVS results and data.* - Department of Environment is currently in pursuit of developing a platform for the sharing environmental data across the country. Further research on this option is needed.	Thank you for this suggestion. The GFC will liaise with the DOE for further information on this.	