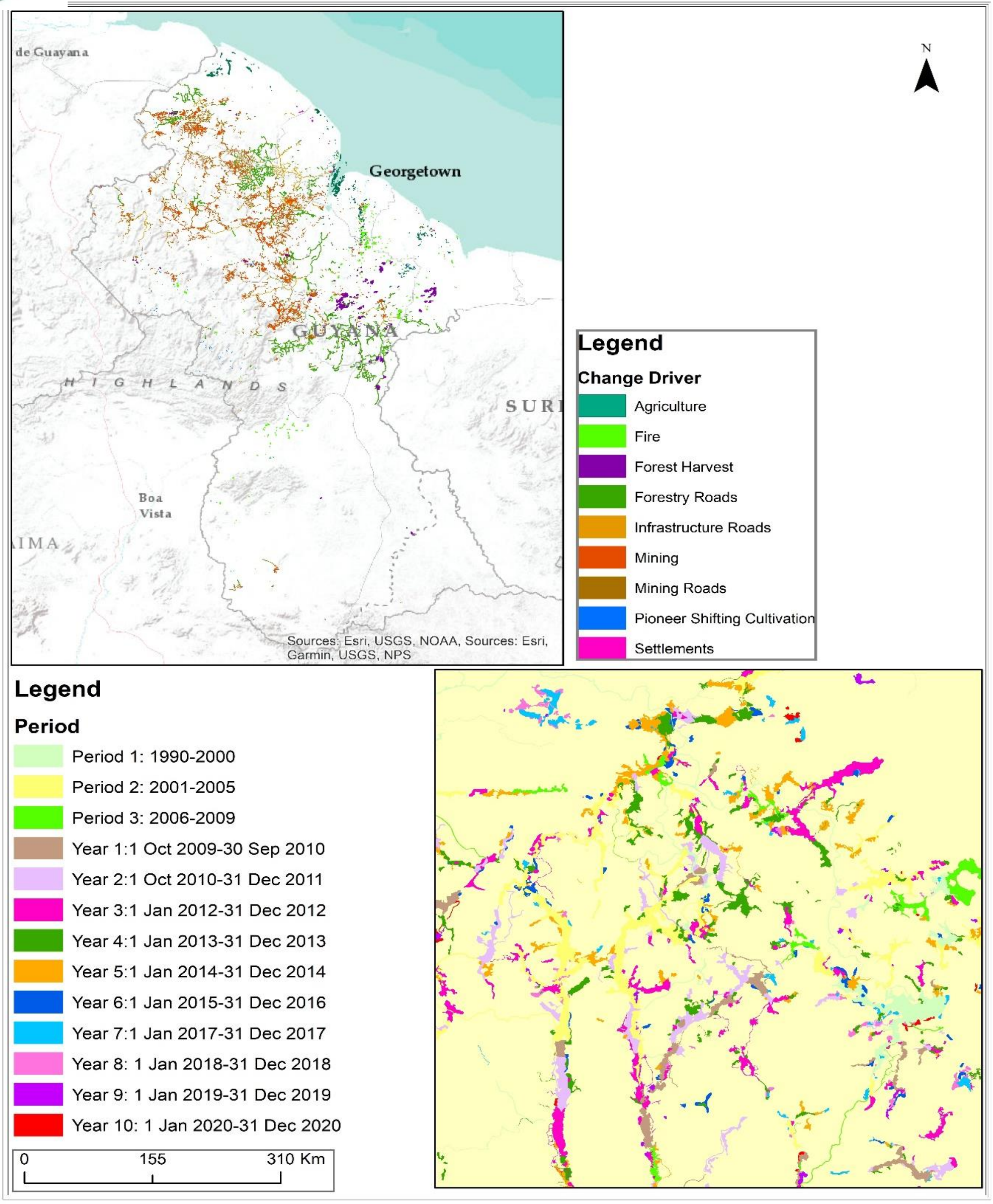
Guyana REDD+ Monitoring Reporting & Verification System (MRVS)

MRVS Report – Assessment Year 2020



September 2021

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PREFACE

Guyana has commenced implementation of Assessment Year 2020 of the MRVS with continued support from the Government of Norway. This is a successor to MRVS Phases 1 and 2 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.

The Year 2020 assessment, support the establishment and long-term sustainability of a world-class MRVS, as a key component of Guyana's national REDD+ programme. This system will further expand 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 essential that the MRVS is a continuous learning process that is progressively improved. This is particularly relevant as the MRV matures and forest change trends are better understood.

Critically, the results generated from the MRV System have potential applications to a range of functions relating to policy setting and decision-making within the natural resources sector and, in particular, to forest management. Guyana's MRV System has, over the past ten years, generated a wealth of data that can be used to understand the multiple uses of forests.

As started in Year 2018, reporting is based on full forest carbon emissions and removals by drivers of deforestation and forest degradation.

In 2009 Guyana developed a framework for a national MRVS. This framework was created as a "Roadmap[1]" that outlines progressive steps over a 3-year period that would build towards a full MRVS being implemented. The MRVS aims 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 was developed for the MRVS. The overall objective of the Roadmap Phase 2 sought to consolidate and expand capacities for national REDD+ monitoring and MRV. This supported Guyana in meeting the evolving international reporting requirements from the UNFCCC while continuing to fulfil additional reporting requirements. In 2020, Guyana developed its Phase 3 Roadmap. This charted the path forward for the next phase of the MRVS to a fully operational forest carbon reporting platform, suitable for a potential market based mechanism and meeting all UNFCCC recommendations.

To date, ten national assessments (2010 to 2020) have been conducted, including the one outlined in this Report. This Report covers the period January to December 2020.

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

Mr James Singh

Guyana Forestry Commission

[1] http://www.forestry.gov.gy/Downloads/Guyana_MRV_workshop_report_Nov09.pdf

SUMMARY

In 2020 the Monitoring Reporting and Verification System (MRVS) moved into its third phase in line with tasks set out in the MRVS Road Map. This document outlines the stepwise progression and development of the MRVS for the next five years 2020 – 2024.

In Year 8 (2018), the GFC reported total forest carbon emissions and removals, focusing on reporting emissions. This move was part of the continuous improvement to the system, allowing the GFC to move away from the Interim Indicators progressively. The reference measures and the interim performance indicators were to be applied while aspects of the MRVS were under development and were to eventually be phased out and replaced by a complete forest carbon accounting system as methodologies are further developed. Year 8 has placed Guyana at this stage. In 2020, there is a full move towards full accounting of forest carbon emissions under the MRVS.

For reference, the ongoing comparison of performance for the area-based interim indicators is against the values reported in the 2009 "Benchmark Map[2]". From that point onwards, the reporting periods are numbed sequentially, with Year 1 covering 2009 to 2010. This report presents the findings of the tenth national assessment, which spans a twelve-month period, 1 January 2020 to 31 December 2020.

The purpose of the MRVS is to track at a national-level forest change of deforestation and degradation by change driver. Deforestation is monitored using a national coverage of satellite imagery. The GFC has sought to incorporate continuous improvements into the MRVS to allow for further efficiencies and sustainability elements to be included. For instance, estimates of degradation resulting from mining and infrastructure are now computed using new methods developed over the years 2018 and 2019. This new method does not necessitate costly high-resolution imagery or aerial surveys to derive these estimates. Further, the procedure for accounting for shifting cultivation was updated, while reporting on timber harvesting and illegal logging has been mainstreamed under full emissions accounting using existing methods. These improvements provide robust measures of both deforestation and degradation that aligns with Guyana's desire to pursue a low or no-cost REDD+ implementation option – this is an integral part of the Phase 2 objective whilst moving toward total emissions accounting.

Deforestation for the period between 1 January 2020 and 31 December 2020 is estimated at 10,232 ha. This equates to an annualised deforestation rate of 0.057%, lower than the change reported in the previous year (0.071%). As with previous assessments, the GFC's deforestation area has been verified by the Durham University (DU) team using a statistically representative independent sample. The area of deforestation reported by DU closely aligns with the values reported by the GFC (see Appendix 1).

The main deforestation driver for the current forest year reported is Mining, which accounts for 63% of the deforestation in this period. The majority of the deforestation is observed within State Lands. The temporal analysis of forest changes post-1990 indicates that most of the change is clustered around existing road infrastructure and navigable rivers. The findings of this assessment assist in designing 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 main results are outlined in Tables S1.

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[2] 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 (a): MRVS Results 2020 (Year 10)

Measure Ref.	Reporting Measure on Spatial Indicators	Indicator	Reporting Unit	Adopted Reference Measure	Year 2020	Difference between Year 2020 and Reference Measure
1	Deforestation Indicator	Rate of conversion of forest area as compared to the agreed reference level	Rate of change (%)/yr	0.275%	0.057%	0.218%

Table S1 (b): MRVS Results 2020

Deforestation			
Driver	**Area (ha)**	**EF (t CO2/ha)[3]**	**Emissions (t CO2)**
Mining	5,895	1,051	6,197,878
Mining Infrastructure	557	1,051	585,398
Forestry Infrastructure	195	1,051	205,521
Infrastructure	103	1,051	107,744
Agriculture	489	1,110	542,943
Settlements	60	1,051	62,971
Fire	2,933	1,044	3,063,029
Shifting Cultivation*	554	1,097	608,345
Deforestation Total (less Shifting Cultivation)	**10, 232**		**11,373,829**
Degradation			
Driver	**AD (see driver)**	**EF (t CO2/unit AD)**	**Emissions (t CO2)**
Timber Harvest volume (m^3)	545,355	5.32	
Skid trail (kmg)	2,062	171.84	3,253,797
Illegal Logging (m^3)	1,281	5.32	6,809
Mining and Infrastructure Degradation (ha)	22,795	8.1	183,877
Degradation Total			**3,444,489**
TOTAL CO_2 EMISSIONS FOR GUYANA FOR 2020 FROM FOREST SECTOR			**14,818,312**

Notes:

* Shifting cultivation is reported in the full emissions reporting above, but is not included in the deforestation total owing to the nature of the change.

**Reporting on forest carbon removal from REDD+ activities will commence when these activities are initiated.

[3] *Emission Factors rounded to the nearest whole number for presentation purposes.*

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SUPPORTING APPENDICES

ACKNOWLEDGEMENTS

In addition to GFC, several agencies and individuals have assisted in providing inputs into the MRVS programme. GFC and Indufor Asia Pacific 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 are 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.
- WWF-Guyana 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.

AA	Accuracy Assessment
AD	Activity Data
BAU	Business as Usual
CMRV	Community Monitoring Reporting and Verification
CRMS	Continuous Resource Monitoring System
DMC	Disaster Monitoring Constellation
EF	Emission Factors
EPA	Environmental Protection Agency
ESA	European Space Agency
FCMS	Forest Carbon Monitoring System
FCPF	Forest Carbon Partnership Facility
FIRMS	Fire Information for Resource Management System
FRA	Forest Resource Assessment
GFC	Guyana Forestry Commission
GGMC	Guyana Geology and Mines Commission
GIS	Geographic Information System
GLSC	Guyana Lands and Surveys Commission
GOFC GOLD	Global Observation of Forest Cover and Land Dynamics
IFL	Intact Forest Landscape
IPCC	Intergovernmental Panel on Climate Change
JCN	Joint Concept Note
LCDS	Low Carbon Development Strategy
LULUCF	Land Use Land Use Change and Forestry
MNR	Ministry of Natural Resources
MODIS	Moderate Resolution Imaging Spectroradiometer
MRVS	Monitoring Reporting and Verification System
MSI	Multi Spectral Imager
NFMS	National Forest Monitoring System
PAC	Protected Areas Commission
QA/QC	Quality Assurance/Quality Control
REDD+	Reducing Emissions from Deforestation and Forest Degradation Plus
SFA	State Forest Area
SOP	Standard Operating Procedures
UK	United Kingdom
UN REDD	United National Reducing Emissions from Deforestation and Forest Degradation
UNFCCC	United Nations Framework Convention on Climate Change
UoD	University of Durham
UoG	University of Guyana
VCS	Verified Carbon Standard

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 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 centre 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 Establishing and Monitoring Changes to Guyana's Forested Area

Land classified as forest follows the definition as outlined in the Marrakech Accord (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 of 1990, based on this definition, is used as a start point. The interim measures are benchmarked against 2009 reported values.

In summary, the MRV monitoring process has involved:

- Determination of the 1990 forest area using medium resolution satellite images (Landsat) by excluding non-forest areas (including existing infrastructure) as of 1990. It should be noted that continual updates have been introduced to improve the non-forest boundary based on improved satellite resolution and repeat observation of the forest fringe.
- From this point forward, we account for any forest to non-forest land-use changes between 1990 and 2009 using a temporal series of satellite data.
- Establishing the benchmark period (1990-2009) and using 30 September 2009 Benchmark Map as a reference point.
- Comparing annual change post-2009 against the 2009 benchmark values

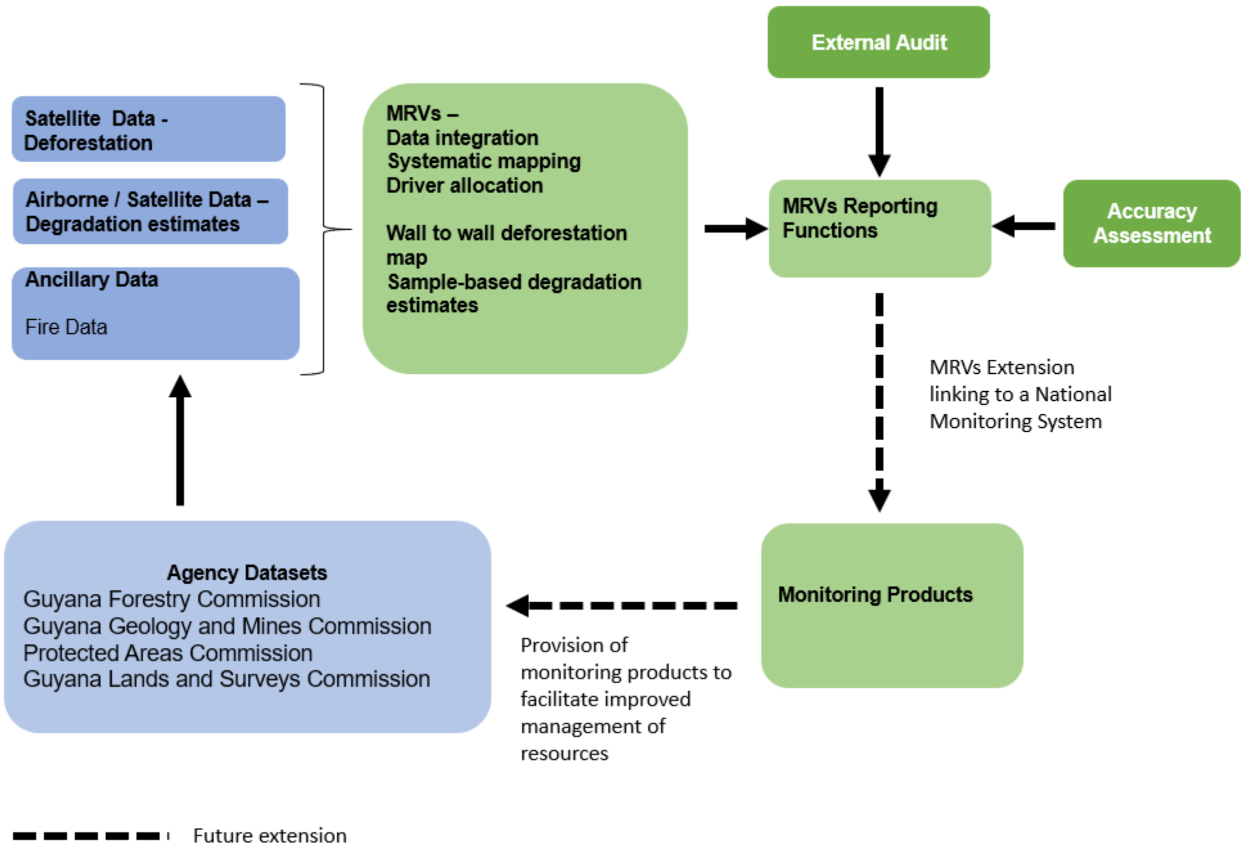
1.3 Guyana's Forest Monitoring System

An overview of the processes, datasets and outputs of the MRVS is given in Figure 1. It shows how the different parts of the MRV system are linked and used to generate annual forest change reports.

Central to the system are inputs from satellite and airborne and datasets provided by Guyana's agencies. GFC's Forest Resource Assessment Unit interprets and analyses these data and generates maps and associated spatial layers required to meet annual reporting requirements. Two external audits are included within the process. The first is the map accuracy assessment. Since the MRVs inception, this analysis has been conducted externally by a team from Durham University.

The final layer is input from external auditors who review and verify methods and analytical processes that meet specified reporting requirements

Figure 1-1 Overview of Guyana's MRVs



1.4 National Monitoring - Future Directions

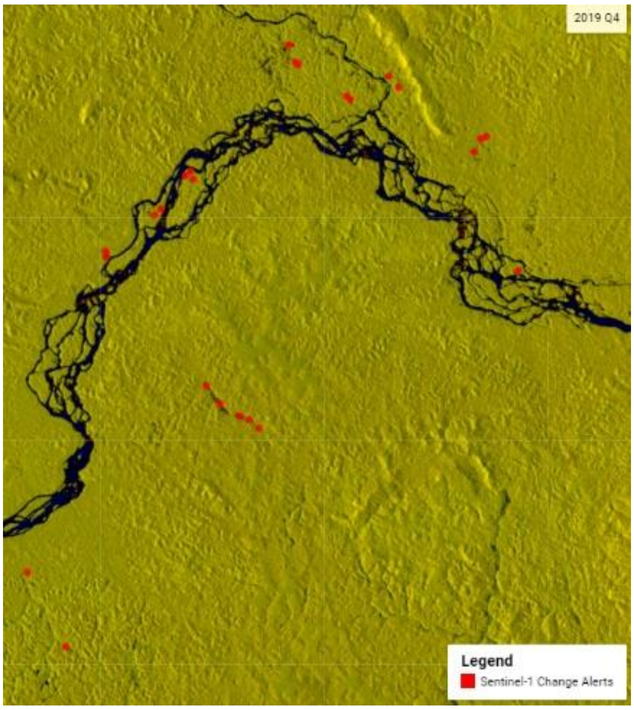
As Phase 3 commences, the efforts and funding support received over the last decade have led to the development of a world-class national monitoring verification system. The system and verification processes, refined over time, provide confidence that nationally forest cover changes are accurate.

Today, Guyana is well-placed to join initiatives like forest protection initiatives that tie sustainable forest management to forest carbon markets. The Norwegian supported ART TREES initiative provides such an opportunity that has the potential to support the continuation and further improvement of MRVs.

Several areas of development are identified to help propel the current monitoring system forward to extend its present application. Within the next phase, the GFC and other land management agencies see a compelling need to monitor land cover change more frequently – a feature that offers benefits beyond the intended application of the monitoring system. Some of these features already exist within the prototype developed at the end of Phase 2 (2019).

Figure 1-2 illustrates one such improvement that uses radar imagery to produce forest change alerts.

Figure 1-2 Example showing near-real-time detection of deforestation using Radar images

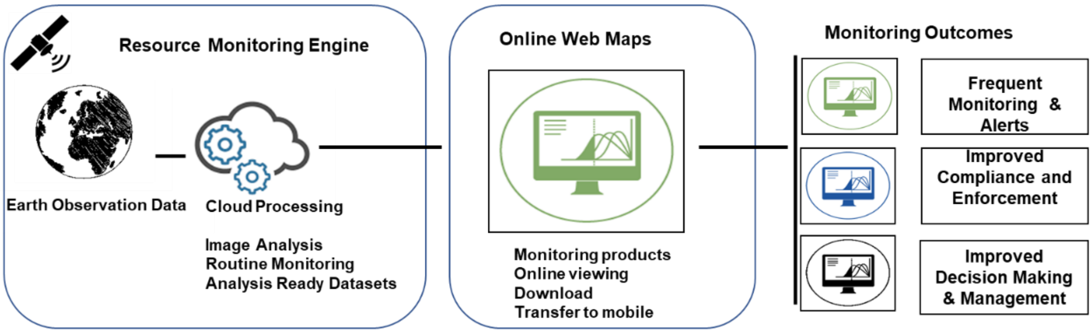


Phase 3 is expected to commence in full in 2021 and will focus on distributing the layers and information to Guyana's land management agencies to facilitate data sharing and align monitoring efforts.

The solution design incorporates several novel features that consider the working environment, resident expertise and advancements in the availability and processing of satellite data. The general process is illustrated in Figure 1-3, which shows the link between satellite imagery now held and processed in the cloud and the final output layers hosted on a web-based GIS.

The intention is that the products created will be shared across different agencies who would receive monitoring alerts and maps that can be downloaded to a mobile device via the internet and used offline.

Figure 1-3 Future Monitoring System



These improvements aim to further extend Guyana's monitoring and compliance capabilities and improve information and data sharing between different agencies responsible for managing Guyana's natural resources.

A key strength of the MRVS program and its success has been a coordinated approach to the system's in-country development and Guyana's desire to improve the underlying monitoring processes.

Today the MRVS provides a tool that supports the design of REDD+ activities that aim to maintain forest cover while enabling continued sustainable development and improved livelihoods for Guyanese.

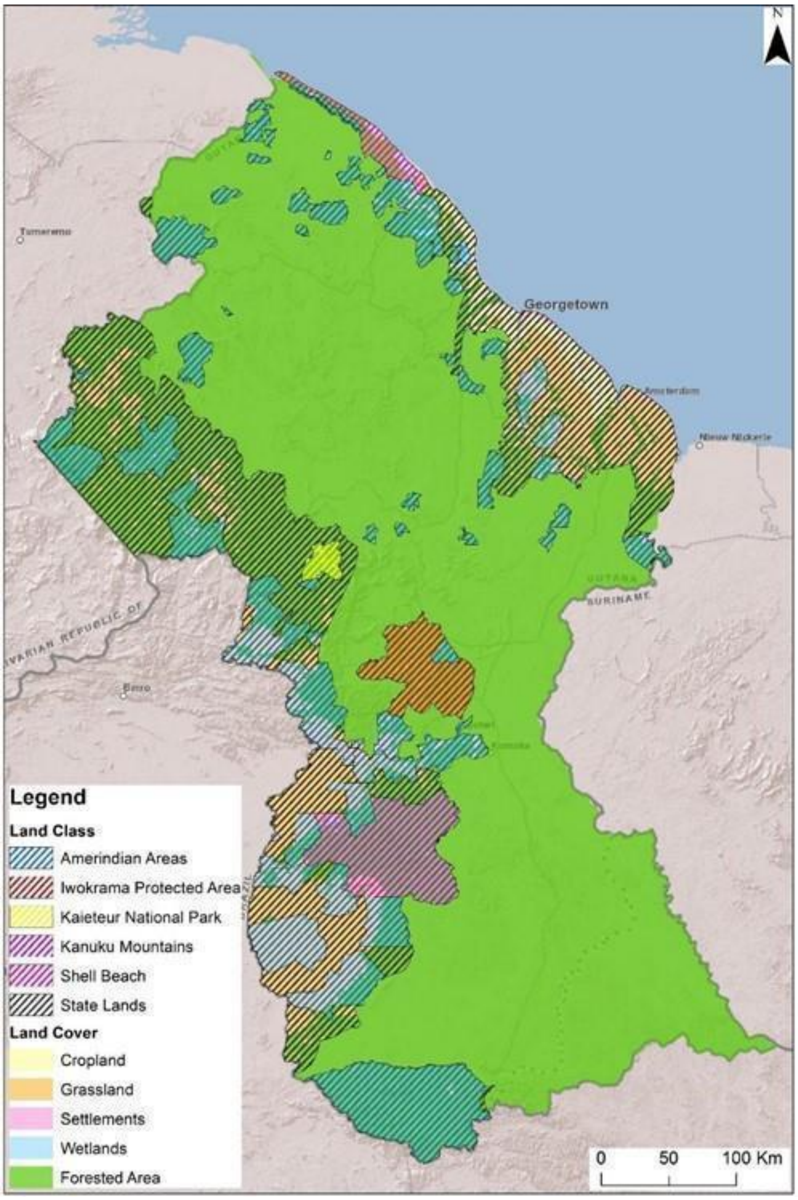
2. OVERVIEW OF GUYANA'S LAND CLASSES

There are four main tenure classifications in Guyana; the largest is State Forest which is 60% of the total land area, followed by State Lands (19%), Amerindian lands (15%), and Protected Areas (6%). At the commencement of the MRVS, existing maps of Guyana's land cover developed in 2001 were evaluated and coalesced to align to the six broad land use categories in accordance with IPCC reporting guideline. A description of the land use categories is provided in the Forest Change SOP. The location of these areas is shown below.

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.

Figure 2-1 Guyana's Land Classes



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 is 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.

Distribution of Tenure & by IPCC Land Classes

Table 2-1 shows the area by the adopted IPCC classes, as at the start of Year 10 (2020). The revised forest area in Table 2-1 includes the forest area mapped as deforestation as part of the Year 10 mapping period. Non-forest classes can shift from one (non-forest) class to another non-forest type.

Table 2-1 Tenure by Adopted IPCC Land Cover Classes

2018 Land Classes	**Forest**	**Non-Forest**					
		Grassland	**Cropland**	**Settlements**	**Wetlands**	**Other Land**	**Total**
	(Area '000 ha)						
State Forest Area	12 142	194	19	12	121	106	12 594
Titled Amerindian lands (*including newly titled lands*)	2 298	637	7	7	26	331	3 306
State Lands	2 469	910	344	48	125	178	4 074
Protected Areas	1 092	30	0	0	12	4	1 138
Total Area	18 001	1 771	370	67	284	619	21 112

3. DATASETS

The process developed aims to enable areas of change (>1 ha) to be tracked spatially through time by the 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 IPCC Approach 3). Mapping is undertaken by a dedicated team located at GFC. All spatial data is stored on the local server at GFC and builds on the archived and manipulated data output from the previous analyses. The server is managed by the IT department at GFC and is routinely backed up and stored off-site.

3.1 Agency Datasets

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

Table 3-1 Agency Datasets Provided

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

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

3.2 Monitoring Datasets - Satellite Imagery

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

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

The datasets used for the change analysis have evolved. 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.

From 2017, data from the Sentinel (2A/2B) multispectral imager (MSI) has been the primary dataset for monitoring deforestation, supplemented by Landsat and fire monitoring datasets. Over the 2020 census period, 400 tiles were acquired spanning from August to December (150 Sentinel 2A, 49 Landsat 8 and 201 Cloudless Sentinel) .

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

4. KEY CATEGORIES - METHODS AND ANALYSIS

The following Table 4-1 divides the reporting into either deforestation or degradation and interim measures. Interim measures will be phased out beyond 2021. Also summarised is an overview of drivers and associated deforestation or degradation activities reported within 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 combined with its spectral properties.

Table 4-1 Summary of Activities & Drivers Captured in the GIS

Reporting Class	Activity	Driver	Criteria	Ancillary Info Available	Spatially Mapped	End Land Use Class
Deforestation	Roads	Infrastructure	Roads > 10m	Mapped layers, Satellite imagery	Yes	Settlements
	Settlements	Settlements	Areas of new human Settlement >1 ha	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
	Agriculture[4]	Deforestation	Deforestation sites > 1 ha	Registered agricultural leases, satellite imagery	Yes	Bareland or crop land
		Fire	Deforestation sites > 1 ha	FIRMs fire points, Spatial trends satellite imagery	Yes	Bareland or crop land
Degradation	Forestry	SFM	Harvested timber volumes and illegal logging totals.	Annual harvest plans, GIS extent of timber concessions	No	Degraded forest by type

[4] Note shifting cultivation activities are also captured within the MRV. The area of deforestation is used to calculate total emissions for this driver. The annual value is reported as a total emission in Table 4.

	Mining	Degradation	Buffer approach based on mapped mining and infrastructure deforestation areas.	Existing infrastructure incl. deforestation sites post-2011, Satellite imagery was used to map the extent. Since replaced with a buffer approach that is computed on mapped deforestation areas.	Yes	Degraded forest by type
Reported Interim Measures	Fire	Degradation	The reference level is the area burnt for 1990 to September 2009 period. Over this 19-year period, a total of 33 700 ha of forest was identified as degraded by burning[5]. This equated to a mean annual area of 1 700 ha.	FIRMs fire points	Yes	Bareland or crop land

5. DEFORESTATION

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

5.1 Deforestation Definition

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

The anthropogenic change drivers that lead to deforestation include:

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). Deforestation for example occurs when areas are cleared for shifting activities
6. Settlements change, such as new housing developments.

5.2 Deforestation Analysis Methods

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 a 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.

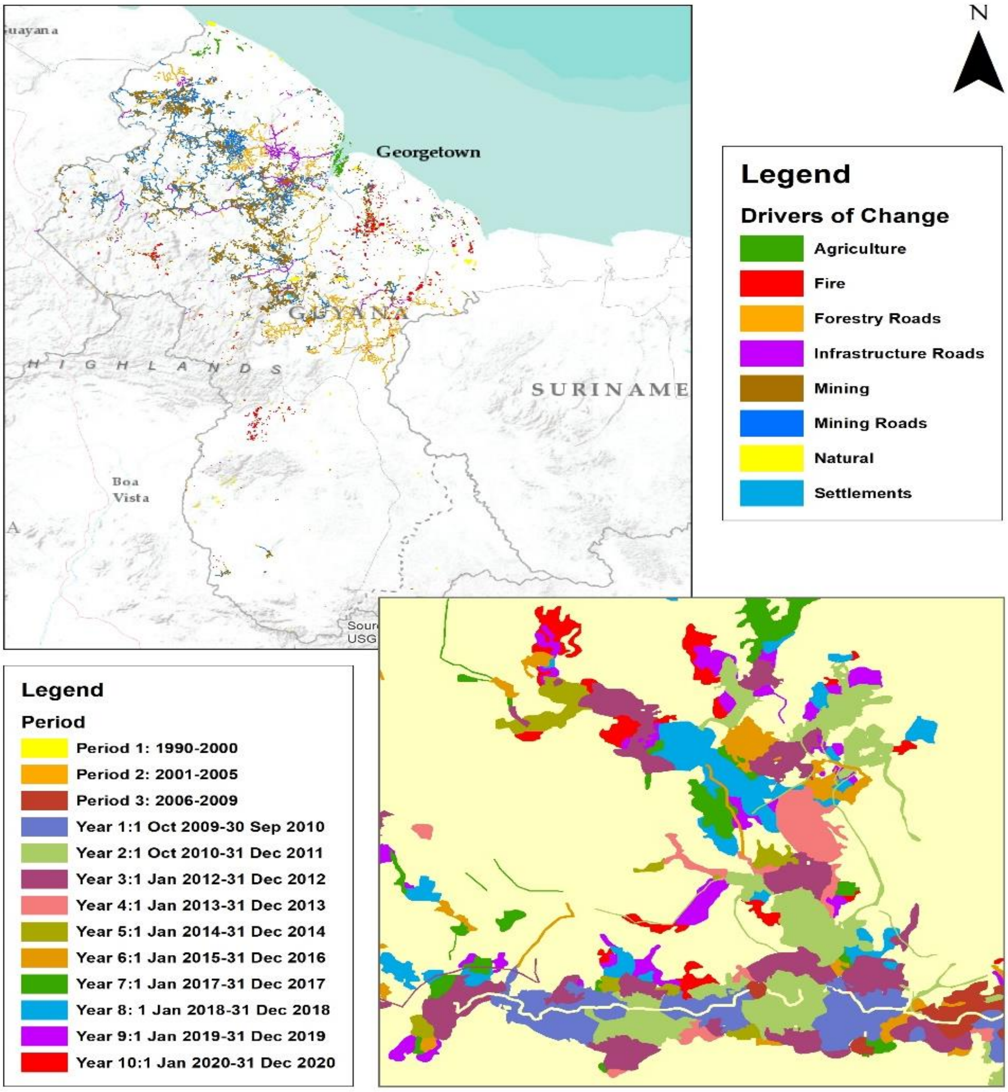
[5] This does not include areas deforested because of fire events. This has been recorded as deforestation. The .El Niño weather pattern is known to have occurred during this period.

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 of the mapping team and is responsible for reviewing each tile as it is completed.

Additional 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, or Standard Operating Procedures (SOPs). 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 5-1 Example of Forest Change Mapping



5.3 Natural Events

Natural events are considered a non-anthropogenic change, so they 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.

6. 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 primary sources of degradation are identified as:

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

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

A buffer of 100m was produced around each individual polygon of loss due to **mining and roads (mining roads, forestry roads, and infrastructure roads)** for years 6 through 11 (2015-2020). If two or more buffers from different years overlapped, the overlapping region was erased out of the newer buffer area to avoid double counting and ensure that only **new** degradation was accounted in each year. Any deforestation or non-forest area (excluding reforestation and afforestation) were also erased from the 100m degradation buffer.

Forest management and illegal logging are monitored through the Gain Loss Method.

6.1 Forest Management

Forest management includes selective logging activities in natural or semi-natural forests.

This measure intends to ensure sustainable forest management 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 2019 to 31 December 2020, with the annualised total presented:

- Production by forest concession
- Total production.

The reporting requirements include data on extracted timber volumes available for verification. The Gain Loss method is used as described by the IPCC for forests remaining forests. In addition to harvested volume, a default expansion factor is used to account for losses due to harvesting, i.e. collateral damage.

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 multiple stakeholder groups 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 large active concessions, resident forest officers perform the function of ensuring that all monitoring and legality procedures are strictly complied with. In instances of a breach, an investigation is conducted, and, based on the outcome, action is instituted according to GFC's standard procedures for illegal activities and procedural violations.

Prior to harvesting, all forest concessions must have 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 the 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, the diameter of forest product (in case of logs) and other relevant information. This is one of the initial control mechanisms in place whereby monitoring is done for proper documentation and on the declared produce. 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 the operator also allows QA/QC to be undertaken for individual operators' use. Thus, checks are allowed across time, by the 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. Even if these areas are within the legally issued concessions, harvesting outside of those blocks 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 those 12 months, 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 the legality of the origin of forest produce.

In the case of Amerindian lands and private property, the documentary procedures outlined above regarding the removal permitting and log tracking are only required if the product is being moved outside the area's boundaries. From this point onwards, the procedures that apply to State Forest concessions apply to this product 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 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. These checks include tags being used by unauthorised operators, or permits being incorrectly, incompletely or otherwise misused. The system also allows cross-checking of basic entry issues including levels of production conversion rates, etc.

In the second stage of QA/QC process, 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, change tracking of production information by staff and others. At the end of every month, data is posted to the archives. A separate unit of the GFC is responsible for cross-checking volume totals by species, concession and period, and preparing the necessary report for external consumption.

Forest Products included in MRVS Report: 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)

6.2 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 Guyana. The following field data have been collected with which the emission factors have been developed: The development process included.

1. Measurements of a sample of logging gaps. Measurement of the extracted timber biomass and carbon per timber tree and any 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 are calculated 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 several 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 the 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 remove 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.

$$C_{WP} = C*(1-WW)*(1-SLF)*(1-OF)$$

(Eq. 2)

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}

= 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

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.

For the year 2020 t CO_2 has reduced by 3,253,797CO_2.

6.3 Illegal Logging

Areas and processes of illegal logging must be monitored and documented as far as practicable. Monitoring and estimation of such areas are recommended to be done by assessing the volumes of illegally harvested wood.

The rate of illegal logging for the assessment Year 10, 1 January 2020 to 31 December 2020, is informed by a custom-designed database updated monthly and subject to routine internal audits. This database records infractions of illegal logging in Guyana in all areas.

Reporting on illegal logging activities is done via the GFC's 36 forest stations located strategically countrywide and 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.

For the year 2020 t CO_2 has reduced by 6,809t CO_2.

7. DEFORESTATION RESULTS

The results presented summarise the Year 10 period (1 January 2020 to 31 December 2020) forest change from deforestation and forest degradation.

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

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

Over time, the forest area has been updated after a review of higher resolution satellite images. The outcome has been that the forest/non-forest boundaries were improved, but the forest area also changed-particularly at two points in time 2012 and 2014. In 2018, the forest area was revised to remove areas of historic shifting cultivation. This change was made based on a further study that concluded that these areas should be considered non-forest which aligns with Guyana's definition of forests.

Table 7-1 summarises the total change and change for the entire country as a percentage of forest remaining. The forest area at the start of Year 9 is 18.01 million ha.

Table 7-1 National Area Deforested 1990 to 2020

Reporting Period	Year	Period (Years)	Satellite Image Resolution	Forest Area	Annualised Change	
				('000 ha)		(%)
Initial forest area 1990	1990		30 m	18 473.39		
Benchmark (Sept 2009)	2009	19.75	30 m	18 398.48	74.92	0.021
Year 1 (Sept 2010)	2010	1	30 m	18 388.19	10.28	0.056
Year 2	2011	1.25	30 m & 5 m	18 378.30	9.88	0.054
Year 3	2012	1	5 m	*18 487.88	14.65	0.079
Year 4	2013	1	5 m	18 475.14	12.73	0.068
Year 5	2014	1	5 m	*18 470.57	11.98	0.065
Year 6	2015-16	2	10 m & 30 m	18 452.16	9.20	0.050
Year 7	2017	1	10 m & 30 m	18 442.96	8.85	0.048
Year 8	2018	1	10 m & 30 m	*18 070.08	9.22	0.051
Year 9	2019	1	10 m & 30 m	*18 019.35	12.74	0.071
Year 10	2020	1	10 m & 30 m	*18 001.79	10.23	0.057

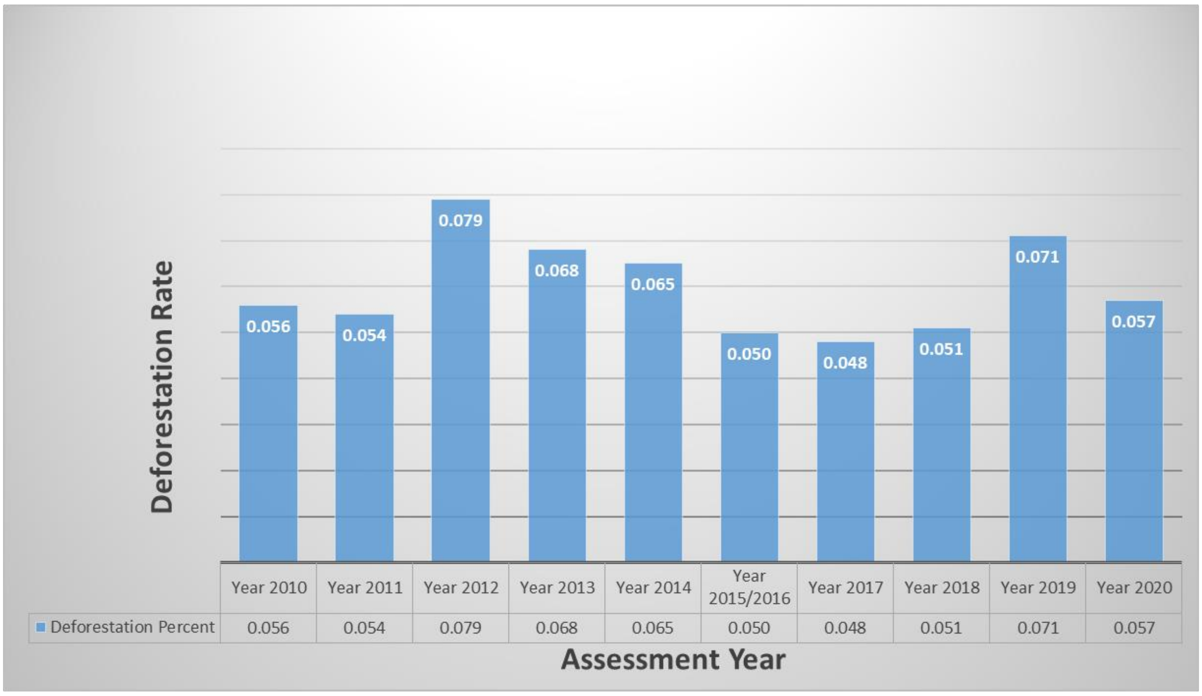
*Continual forest area updates based on remapping, using high spatial and temporal resolution imagery and removal of shifting cultivation areas.

* For future monitoring, the precedent established under the Guyana-Norway partnership will be carried forward into future engagement on forest carbon markets, and the proposed footprint for the Amaila Falls Project will sit outside the definition of forest cover.

Overall, Guyana's deforestation rate is low when compared to the rest of South America.

The following figure shows the annualised deforestation trends for all change periods. The trend shows that deforestation rates increased from the 1990 level, and in parallel with gold price increases peaked in 2012 (0.079%). Post-2012, the rate of change fell and in recent years fluctuated between 0.048 to 0.071% and then decreased in 2020 to 0.057%.

Figure 7-1 Annual Rate of Deforestation by Period from 1990 to 2020



7.1 Forest Change by Driver - Deforestation

Forest change caused by deforestation is divided and assessed by the driver. Table 7-2 provides a breakdown by forest change drivers. The temporal analysis offers a valuable insight into deforestation trends relative to 1990. A more meaningful comparison is provided if the rates of change are divided by driver and annualised. In general, the following trends by driver are observed:

- In this reporting period, Mining is the most significant contributor to deforestation, at 6,452 ha.
- Like in the previous year (2019) fire remains a substantial driver of change at 2,933 ha, albeit not the largest driver for year 2020.
- Forestry related change has remained relatively stable is around 195 ha. As in the case of earlier assessments, forest roads are attributed to a forestry driver rather than attributing this change to Infrastructure.
- Agricultural developments causing deforestation peaked at Year 5, with an increase to 817 ha. Over the past two reporting periods, it has been less than 500 ha. This figure has been reported at 489 ha for year 2020.

Table 7-2 Annualised Rate of Forest Change by Period & Driver from 1990 to 2020

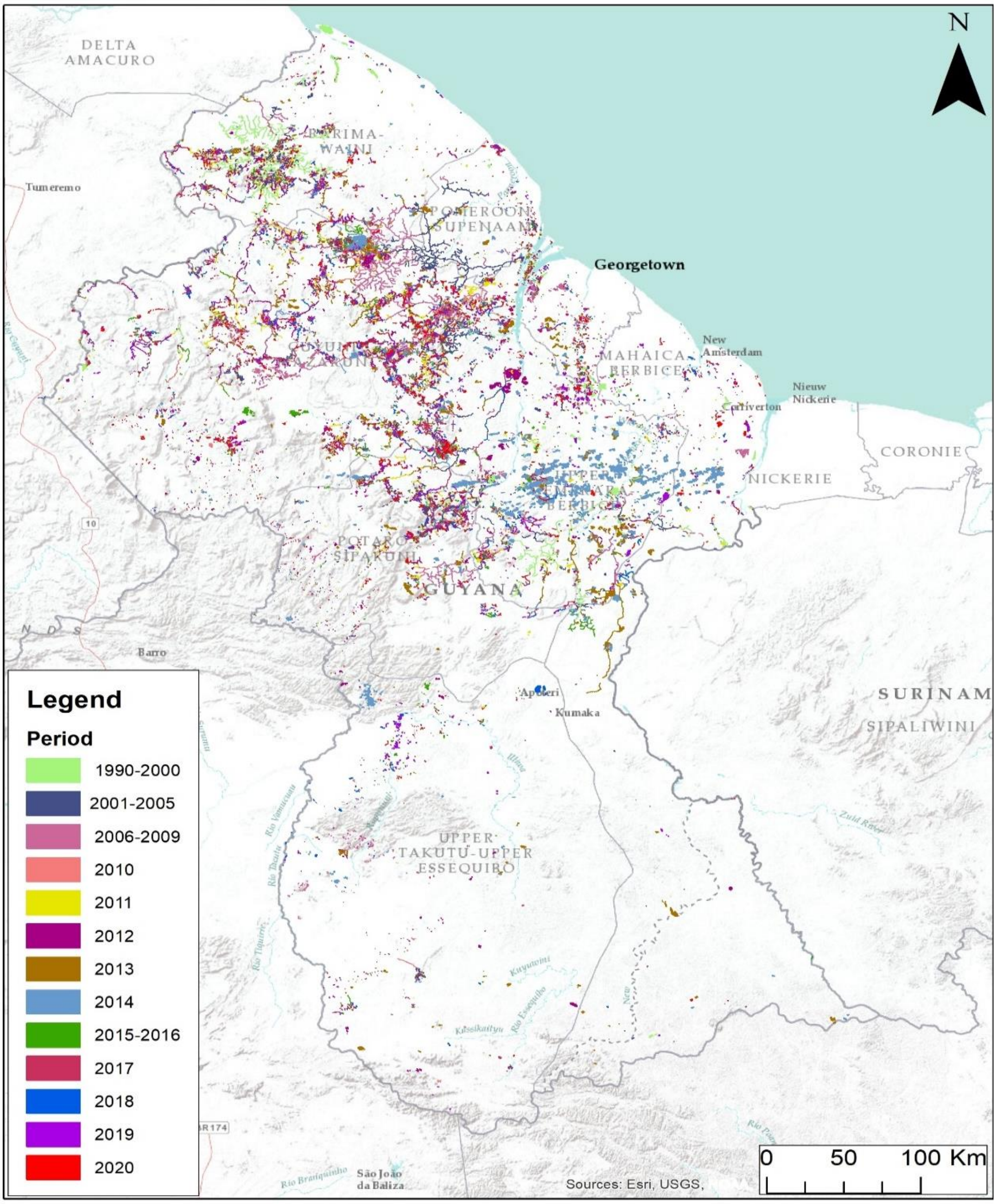
Reference Period	Change Period	Change Period	Annualised Rate of Change by Driver						Annual Rate of Change
			Forestry	Agriculture	Mining	Infrastructure	Fire	Settlements	
		Year	Annual Area (ha)						(ha)
Historic	1990-00	10	609	203	1 084	59	171	-	2 127
	2001-05	5	1 684	570	4 288	261	47	-	6 850
	2006-09	4.8	1 007	378	2 658	41	-	-	4 084
	2009-11	1	294	513	9 384	64	32	-	10 287
MRV Phase 1	2010-2011	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	10 919	141	259	71	11 975
MRV Phase 2	2015-2016	2	313	379	6 782	217	1 509	8	9 208
	2017	1	227	477	7 442	195	502	7	8 851
	2018	1	356	512	7 624	67	661	7	9 227
	2019	1	226	246	5 821	52	6 371	22	12 738
MRV Transition Phase	2020	1	195	489	6 452	103	2 933	60	10 232

7.2 Deforestation Patterns

The temporal analysis of deforestation by reporting periods is shown in Figure 7-2. The map, which presents change from all drivers, shows that most of the change is clustered[6] and that new areas tend to be developed near existing activities. Most of Year 2020 deforestation activities occur close to or inside the footprint of historical change areas in the north and west.

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

Figure 7-2 Forest Change by Reference Period



7.3 Forest Change Across Land Classes

The following table provides a summary by change driver and land class for the 2020 assessment.

Table 7-3 2020 Area Change by Driver & Land Class

Land Class	Area Change by Driver & Land Class						Total Change	Proportion of Total (%)
	Forestry	Agriculture	Mining	Infrastructure	Fire	Settl.		
	Area (ha)							
State Forest Area	159.6	122.6	5 787.3	30	620.6	9.5	6 730	65.77%
Titled Amerindian Lands (including newly titled lands)	20	30	351.8	1	282	1	686	6.7%
State Lands	2.6	336	311.8	71.62	2 030	49.7	2 802	27.38%
Protected Areas	12.8	0	0.77	0		0	14	0.13%
Total	195	489	6 452	103	2 933	60	10 232	100%

Trends by driver for the reporting year follow and are supported by the driver map presented.

Mining

As with the previous year's, most of the deforestation activity occurs in the State Forest Area (SFA). Mining activities are consolidated in the centre of Guyana. The area mined has decreased and sits well below the 2012 value, which marked a point where the gold price was the highest since 1980. Post-2012, the price has declined to around USD1200/ounce. This combined with limited accessibility, has gradually reduced the area mined.

Forestry

Most forestry activities are located inside the SFA. During this period, all deforestation events are associated with forestry harvest operations. The leading causes of forest clearance include road and log market construction. The reported value of 195 ha is a decrease when compared to the previous year.

Infrastructure

Infrastructure developments (102 ha) contributes to a small area with the level change relatively stable between reporting periods. The area of clearance is in a similar location. The main difference is related to road construction activities and tends to be near townships. Figure 6-3 shows the distribution of infrastructure developments. There have been a few new hinterland roads constructed to enhance access to villages.

Agricultural Development

Agricultural developments lead to 489 ha deforestation. The main areas of development are located close to Georgetown and the northeastern regions of Guyana. Development tends to be near river networks.

Biomass Burning - Fire

Fire events have a high increase compared to the years prior to 2019, but has declined in year 2020 when compared to year 2019 with with 2 933 ha mapped for year 2020. Spatially, they follow historical trends, where events occur in the white sand forest area surrounding Linden and extend towards the eastern border of Guyana.

The significant fire events are tied to a prolonged dry spell and are most commonly observed on the drier sand and grassland areas. Although Guyana has seen an increase in forest fires since 2019, it is not as significant as seen in neighbouring countries.[7]

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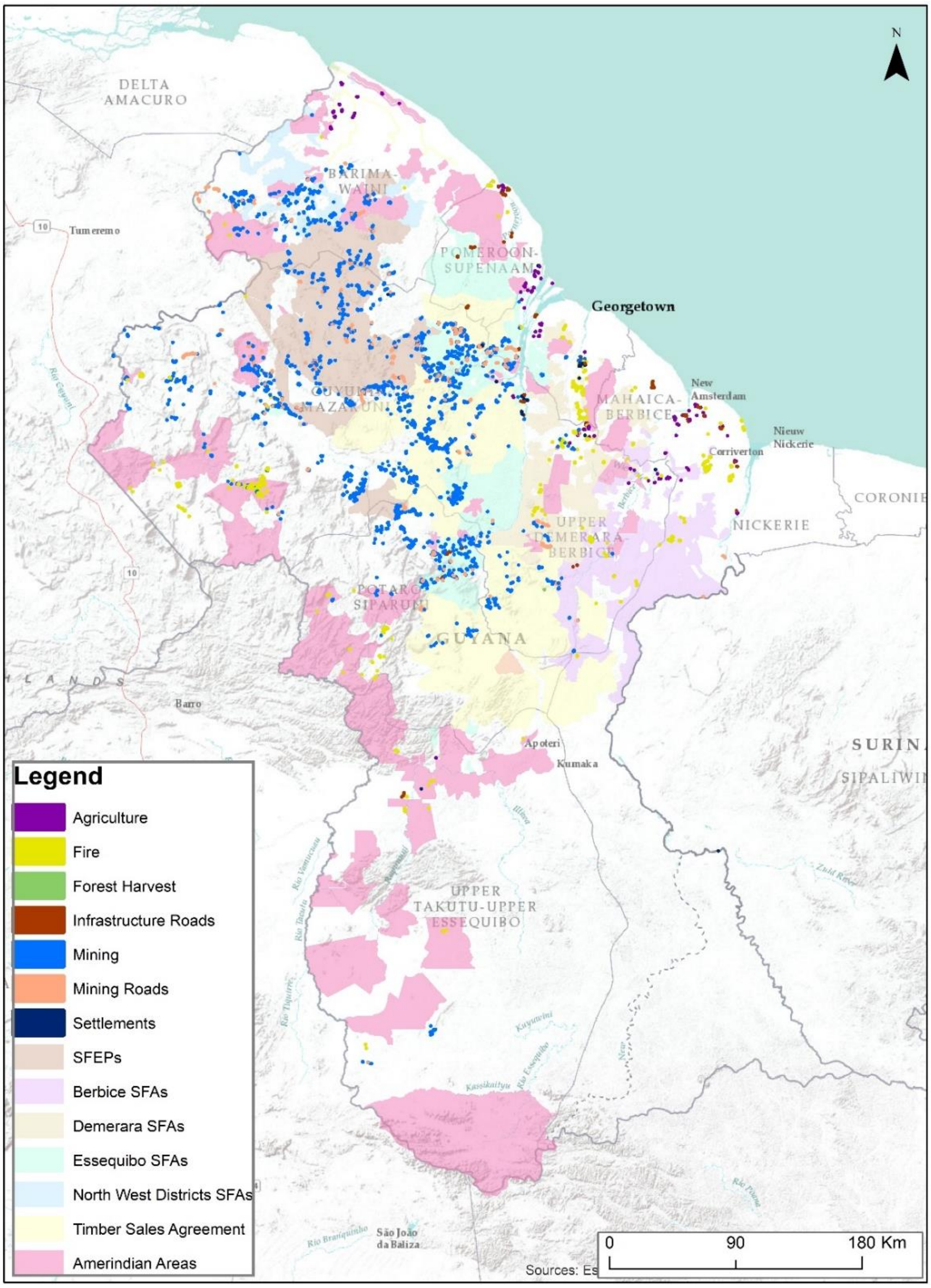
[7] As of August 29, 2019, INPE reported more than 80,000 fires across all of Brazil, a 77% year-to-year increase for the same tracking period, with more than 40,000 in the Brazil's Legal Amazon (*Amazônia Legal* or BLA), which contains 60% of the Amazon. Similar year-to-year increases in fires were subsequently reported in Bolivia, Paraguay and Peru, with the 2019 fire counts within each nation of over 19,000, 11,000 and 6,700, respectively, as of August 29, 2019.[1]

The following map shows the temporal and spatial distribution of deforestation by driver (mining, forestry and agricultural and biomass burning) for the 2020 reporting period. Mining dominates the map as it is the largest single driver of change.

Figure 7-3 Spatial Distribution of Forest Change Drivers (2020)



8. EMISSIONS REPORTING AND ACTIVITY DATA

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

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

Guyana has moved toward full emissions reporting, as presented in Table 8-1 (b). However, one useful metric, which compares the rate of forest loss against the 2009 reference level, has been retained. The calculations to determine the rate of deforestation (ref. measure 1) are reported in Section 7. Outputs and results forest management indicators are outlined in this section.

Table 8-2 (a) MRVS Results 2020 (Year 10)

Measure Ref.	Reporting Measure on Spatial Indicators	Indicator	Reporting Unit	Adopted Reference Measure	Year 2020	Difference between Year 9 and Reference Measure Difference
1	Deforestation Indicator	Rate of conversion of forest area as compared to the agreed reference level	Rate of change (%)/yr	0.275%	0.057%	0.218%

Table 8-3 (b) Results 2020

Deforestation			
Driver	**Area (ha)**	**EF (t CO2/ha)[9]**	**Emissions (t CO2)**
Mining	5,895	1,051	6,197,878
Mining Infrastructure	557	1,051	585,398
Forestry Infrastructure	195	1,051	205,521
Infrastructure	103	1,051	107,744
Agriculture	489	1,110	542,943
Settlements	60	1,051	62,971
Fire	2,933	1,044	3,063,029
Shifting Cultivation*	554	1,097	608,345
Deforestation Total (less Shifting Cultivation)	**10, 232**		**11,373,829**
Degradation			
Driver	**AD (see driver)**	**EF (t CO2/unit AD)**	**Emissions (t CO2)**
Timber Harvest volume (m³)	545,355	5.32	
Skid trail (kmg)	2,062	171.84	3,253,797
Illegal Logging (m³)	1,281	5.32	6,809
Mining and Infrastructure Degradation (ha)	22,795	8.1	183,877
Degradation Total			**3,444,489**
TOTAL CO_2 EMISSIONS FOR GUYANA FOR 2020 FROM FOREST SECTOR			**14,818,312**

* Shifting cultivation is reported, but is for reference only it is not included in the deforestation total.

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

[9] *Emission Factors rounded to the nearest whole number for presentation purposes.*

Appendix 1: Accuracy Assessment Report

Guyana REDD+ Monitoring Reporting and Verification System (MRVS)

Accuracy Assessment Report

Year 10

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May 2021

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1. EXECUTIVE SUMMARY

1.1 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, and forest area change estimates for the period January–December 2020. Specifically, the terms of reference asked that confidence limits be attached to forest area estimates.

1.2 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 January-December 2020 (Interim Measures Period – Year 10). NASA Landsat, ESA Sentinel-2, Planet-PlanetScope, and Aeroptic (aka GeoVantage) imagery was used to assess change.

1.3 A change analysis using two-stage stratified random sampling design was conducted to provide precise estimates of forest area. Three strata were selected according to "risk of deforestation". The drivers (cause) of change were identified from expert image interpretation of high spatial resolution satellite imagery.

1.4 The estimate of the total area of change in the 12-month Year 10 period from forest to non-forest and degraded forest to non-forest is 10,667 ha, with a standard error of 1,597 ha and a 97.5% confidence interval (7,538 ha; 13,797 ha).

1.5 The estimate of the annual rate of deforestation that occurred over the Year 10 (12 month) period is 0.0834 % with a standard error of 0.0220 % and a 97.5% confidence interval (0.0402%; 0.1266%).

1.6 The sample-based estimates for land cover class areas for December 2020 are as follows:

Forest = 19,155,790 ha; Degraded forest = 206,987 ha; Non-forest = 1,581,396 ha

Note that the total area of Guyana in the sample-based estimates is 1.5% different from the GIS-based area because the stratification uses a 5 km by 15 km grid that intersects with the national boundary polygon.

2. AREAS OF ACTIVITY

2.1. To assess Year 10 deforestation, taking note of IPCC Good Practice Guidelines and GOFC/GOLD recommendations.

2.2. To outline a methodology for accuracy assessment, including an outline of the (1) sample design, (2) response design, and (3) analysis design10. For the design component, reference data to be used should be identified, and literature cited for methods proposed. The design must ensure the representativeness of the scenes selected for analysis. The sampling specifications used must be stated.

2.3. To support independent verification of the REDD+ interim measures and national estimates (Gross Deforestation 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 10 as an area change total and by driver.

2.4. To conduct an independent assessment of the deforestation mapping undertaken by the Guyana Forestry Commission and comment on the attribution of types of changes, e.g. 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 the 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 of 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.

3. AREA REPRESENTED

3.1. The total land area for Guyana is 21,123,486 hectares, calculated from the national boundary GIS 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.

3.2. 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.

3.3. The forest area was mapped by GFC 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.

3.4. The assessment in this report does not look at the GFC mapping; it is an independent analysis. For reference, we note that the Y10 mapping process involves a systematic review of Landsat and Sentinel data. Details of the GFC Y10 mapping are explained in the Standard Operating Procedure (SOP) 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.

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

3.5. The purpose of this report is to build upon the estimates of deforestation established for the Norway-Guyana agreement and to quantify the precision of the estimate of deforestation observed in the Year 10 period. A second task is to identify the processes (drivers) that are responsible for deforestation, and where possible to estimate the precision of area estimates.

4. SAMPLING DESIGN FOR YEAR 10 FOREST CHANGE

4.1 Change sample design

The Year 10 assessment for gross deforestation in Guyana used a two-stage stratified random sampling design. Stratification was based on past patterns of deforestation from Period 1 (1990) through to Year 8 (Dec 2018), 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 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 area and forest area change 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 was mapped from multiple looks of orthorectified RapidEye resampled data to 5m pixel size. For Year 6, 7, 8 and 9 the GFC Forest Area Assessment Unit (FAAU) used Landsat and Sentinel-2 imagery as the primary mapping tool. The Y10 response design used PlanetScope, GeoVantage, and Sentinel-2 imagery (see table 1) as an appropriate fine-resolution source of data to validate land cover changes in all but the low risk of change areas where the assessment was based on interpretation 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 area.

A change sample for reference data will:

- have a smaller variance than an estimate of change derived from two equivalently sized sets of independent observations, provided the correlation coefficient is positive;
- increase the precision of the change estimate by virtue of the reduction of the variance of estimated change;
- 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);
- for the same sample size, require no additional resource but allow both map accuracy and area estimation to be performed;
- be an alternative to wall-to-wall mapping and may be preferred because of lower costs, typically smaller classification error, and rapid reporting of results;

- have value when assessing any additional forest change map product such as the University of Maryland Global Change map 2000-2018 (Galiatsatos et al., 2020) 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 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 Asia Pacific Ltd, 2015) outlines approaches used to minimise 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).

4.2 Response Design

Table 4.1 summarises the data available to validate the deforestation change estimates for 2019, that is from the end of 2019 to the end of 2020 (year 10). It also specifies the areal coverage of the imagery used for change assessment.

Table 4.1: 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	Sept 19	0.25-0.60	90,906	0.43
PlanetScope	Planet	Four channel multispectral sensor	Visible and NIR	Oct-Dec 2020	3	1,279,067	100
Sentinel-2	ESA	Four channel multispectral sensor (at 10m)	Visible and NIR	Aug-Dec 19 Oct-Dec 20	10	19,347,200	91.5
Landsat	USGS	ALI	Visible and NIR	Aug-Dec 19 Aug-Dec 20	30	21,127,762	100

Table 4-2 – Year10 Deforestation Assessment Exclusions

Reference	Criteria
1	Land use change that occurred prior to 1 January 2019 or after 31 December 2020
2	Roads less than a 10 m width.
3	Naturally occurring areas – i.e. water bodies
4	Cloud and cloud shadow

4.3 Dataset summaries

- **GeoVantage**

GeoVantage is an aerial imaging camera system mounted externally to a light aircraft, in our case a Cessna 172. The camera system comprises a multispectral 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 a pixel size of 25 cm to 60 cm. 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. GeoVantage imagery was acquired in August-September 2019 in mostly High and Medium Risk strata for 109 sample areas.

The GeoVantage data were acquired by Agrisat S.A, who also performed image mosaicking, rectification and colour balancing. The majority of GeoVantage imagery for 2 were of good geometric quality; some frames exhibited saturation which made land cover interpretation difficult.

- **PlanetScope**

PlanetScope data were downloaded from the Planet Explorer Beta GUI tool that can be used to search Planet's catalogue of imagery, view metadata, and download full-resolution images[11].

PlanetScope is a swarm of more than 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

[11] http://www.planet.com/explorer (last accessed: December 2019)

Sample Distance of 3.7m. The radiometrically-corrected orthorectified product (that was used in this project) is resampled to 3m.

The radiometric resolution is theoretically 12-bit but the basemaps accessed via Global Forest Watch (GFW) as the normalized analytic product which is SR but the data accessed are only 8-bit PNG. The 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). PlanetScope imagery was found to be of variable radiometric quality but good geometric quality.

- **Sentinel-2**

The Sentinel satellites are launched by ESA in support of the EU Copernicus programme. Sentinel- 2A and -2B carry 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[12] 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. GFC acquired multiple Sentinel-2 scenes to cover the whole land area of Guyana for Aug-Dec 2019. For the period Oct-Dec 2020 Google Earth Engine was used to select the best cloud-free images that matched the target sampling period. These were clipped to the PSUs and downloaded. The S2 provided via GEE was level 1C, and cloudiness was calculated using the ESA s2cloudless and CDI* with areas of likely cloud shadow also included as 'cloud' (Frantz et al. 2018).

4.4 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[13]. 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 the pattern of deforestation is 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

[12] https://earth.esa.int/web/sentinel/toolboxes/sentinel-2 (last accessed: December 2019)

[13] According to the Interim Measures Report October 2013, the national boundary (that was used for the stratification) was defined by following information received from the GL&SC and with the aid of RapidEye imagery.

estimate of variance that will be more precise than 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 8). 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 rectangle with value 00000011 intersects deforestation events that were recorded for Years 7 and 8. When there have been 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. In particular, data about the location of logging camps, mining dredges, settlements, and the existing road network were used (see Table 4.3 and Figure 4.1). 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.

This resulted in the classification of grid rectangles into three strata: 611 HR, 773 MR, and 1453 LR. (see Figure 4.1 – left).

Table 4-3 – 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	Roads_Gy_2016	3-6 months	All GPS roads and trails as of August 2016.
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 several larger settlements from the place names point feature class.

The map in Figure 4.1 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 69 HR rectangles, 65 MR rectangles and 190 LR rectangles (see figure 4.1 - right).

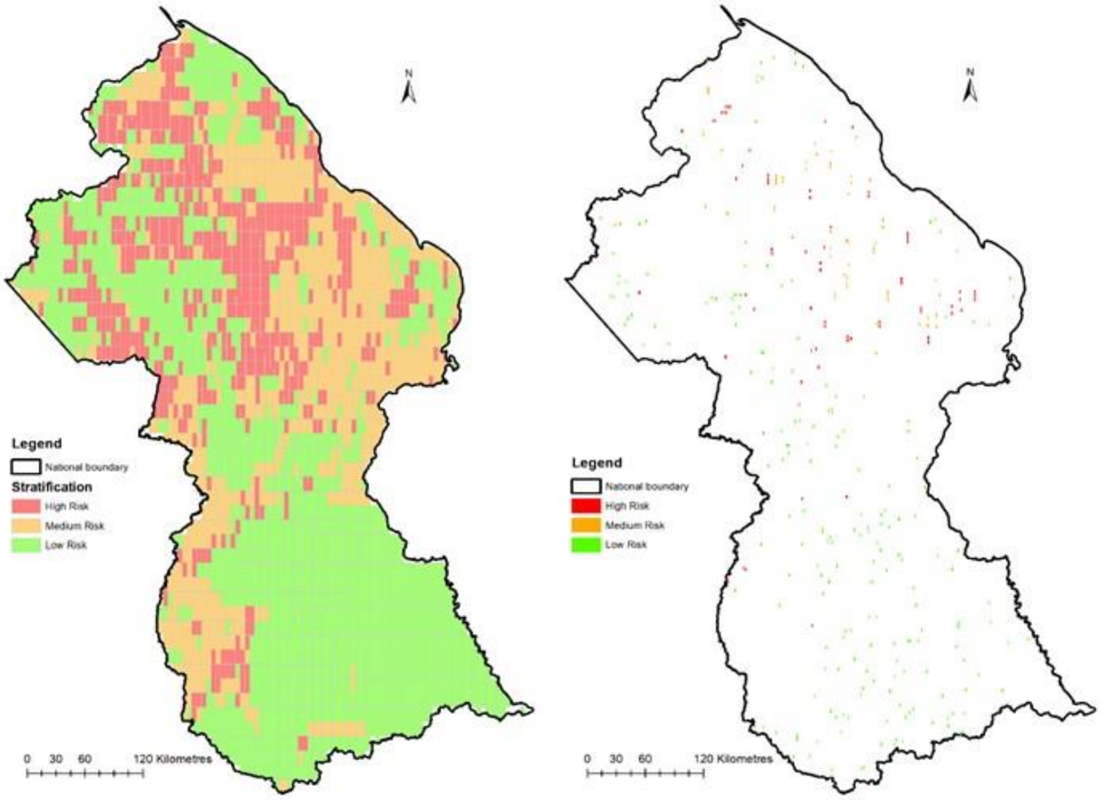

Figure 4.1 – High, Medium, Low, and Zero Risk strata (left) and final random sampling of the strata (right image).

A systematic grid of 300 hectares was then generated at the centre point of each of the first-stage samples. In total, 97,200 one-hectare samples became available for accuracy assessment.

For each primary sampling unit, the land cover class (e.g. Forest or Non-Forest, Degradation or Non- Degradation) is determined for the Year 10 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 10 land cover change included high-resolution satellite imagery (see Table 4.1). Also available were GIS data indicating mining, forestry and agricultural concessions.

Year 10 Change Assessment involved the collection of 324 equally-sized primary sample units (each with 300 ha) with a direct correspondence with Year 9. The reference data selected for the change assessment in Year 10 was a combination of Planetscope and Sentinel-2 imagery for the High and Medium Risk strata, and Sentinel-2, PlanetScope and Landsat imagery for the Low Risk stratum.

4.5 Precision of Area Estimates for Deforestation

The two-stage sampling with stratification of the primary units design optimises the probability of sampling deforestation in Year 10 when the area concerned represents only a small 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 introducing 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 probability 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 satellite imagery.

4.6 Decision Tree for 2019-20 (Year 10) Change Analysis

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. The Standard Operating Procedures provide information about how decisions are made when a deforestation or afforestation event is met by the interpreter, to complete the contingency matrix (see Table 4.4).

Table 4-4 Contingency matrix to represent change as detected by the assessment team.

End Reference Class				
Start Reference Class	Forest	Degradation	NonForest	**Total**
Forest	Stable Forest	Loss	Loss	
Degradation	Gain	Stable Degradation	Loss	
NonForest	Gain	Gain	Stable NonForest	
Total				

The rules for validating each sample unit point account for small discrepancies with the geometric alignment among the various remote sensing data sets. The change samples are ideally interpreted at 1:5,000 scale using 2019 imagery (GeoVantage, PlanetScope, or Sentinel-2 / Landsat) and 2020 imagery (GeoVantage or Sentinel-2 / Landsat) imagery. 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.

5. STATISTICAL 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 using the best available reference data.

The reference data consisted of 324 primary sample units stratified into HR (20,700 ha), MR (19,500 ha) and LR (57,000 ha) areas as described in the sampling design (Section 3.6) 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; and (3) the sampling fraction in each stratum is approximately proportional to the total population and that the relative sample size reflects.

The total number of 1-ha samples analysed in the whole survey was 97,200. Of this total, only 870 were omitted due to cloud cover or cloud shadow in the reference imagery. The proportion of the total omitted in Year 10 is 0.009, which represents 0.9 % of the sample.

Key inputs to the analysis are the total number of samples in each stratum. These are 4,810,002 ha (20,700 sampled hectares) for HR, 5,658,869 ha (19,500 sampled hectares) for MR and 10,654,582 (57,000 sampled hectares) for LR.

Apart from no change samples (Forest-Forest; NonForest-NonForest; Degradation-Degradation), the key changes are Forest-NonForest, Forest-Forest Degradation, and Forest Degradation-NonForest.

5.1 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[14], and uses the same standard formulae for estimation of means and variances. These formulae are set out below and described conveniently in Lumley (2014).

5.2 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

$$(W, Y) = (w_{hij}, y_{hij})$$

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

Where

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

$h = 1,2, \dots \dots \dots, H$ 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

$y_{hij} = (y_{hij}^{(1)} y_{hij}^{(2)}, \dots \dots \dots, y_{hij}^{(p)})$ 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

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

Where

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

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 df calculated 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

$$\hat{V}(\hat{Y}) = \sum_{h=1}^{H} \frac{n_h(1-f_h)}{n_h - 1} \sum_{i=1}^{n_h} (y_{hi\cdot} - \bar{y}_{h\cdots})^2$$

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

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

6. RESULTS

6.1 Estimates of forest cover in Year 9

We can ignore that we have Year 9 information and obtain estimates of Year 9 forest cover. These can be compared to estimates obtained by other means. Table 6.1 shows the total areas classified as Degraded, Forest, and NonForest, together with a standard error and a 97.5% confidence interval. For example, the estimate of non- degraded Forest cover in 2019 (year 9) is 19,174,193 ha, standard error 19,232 ha, and 97.5% confidence interval (19,136,499; 19,211,888) ha.

Table 6.2 gives the same information as in Table 6.1 but shows proportions rather than totals. So, the proportion of Forest cover in 2019 is 0.891, standard error 0.001, 97.5% confidence interval (0.889, 0.893). Note that proportions add to one.

Table 6.1 Analysis of Y9 hectares of all classes

	Hectares	SE	2.5%	97.5%
2019 Degraded forest	201,110	6,906	187,574	214,646
2019 Non degraded forest	19,174,193	19,232	19,136,499	19,211,888
2019 Non forest	1,568,870	18,265	1,533,070	1,604,670

Table 6.2 Analysis of Y9 proportions of all classes

	Mean	SE	2.5%	97.5%
2019 Degraded forest	0.0096	3.00E-04	0.009	0.010
2019 Non-degraded forest	0.9155	9.00E-04	0.913	0.917
2019 Non-forest	0.0749	9.00E-04	0.073	0.077

6.2 Estimates of forest cover in Year 10

We now repeat these analyses for Year 10. Table 6.3 shows the total areas classified as degraded forest, non-degraded forest, and non-forest, together with a standard error and a 97.5% confidence interval. For example, the estimate of non-degraded forest cover in Year 10 is 19,155,790 hectares, standard error 19,314 hectares, and 97.5% confidence interval (19,117,936; 19,193,644) hectares. Table 6.4 shows proportions instead of totals. Otherwise, the interpretation is as for Year 9.

Table 6.3 Analysis of Y10 hectares of all classes

	Hectares	SE	2.5%	97.5%
2020 Degraded forest	206,987	7,012	193,243	220,731
2020 Non-degraded forest	19,155,790	19,314	19,117,936	19,193,644
2020 Non forest	1,581,396	18,324	1,545,483	1,617,310

Table 6.4 Analysis of Y10 proportions of all classes

	Mean	SE	2.5%	97.5%
2020 Degraded forest	0.0099	3.00E-04	0.0092	0.0105
2020 Non-degraded forest	0.9146	9.00E-04	0.9128	0.9164
2020 Non forest	0.0755	9.00E-04	0.0738	0.0772

6.3 Estimates of change from Year 9 to Year 10

We analyse the change from Year 9 to Year 10 as follows. We have matched pairs of sample data, where the hectares seen in Year 9 are seen again in Year 10. 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 10. If the classification had been Forest (non-degraded), the possibilities are Forest in Year

9 and Year 10, Forest in Year 9 and Degraded in Year 10, and Forest in Year 9 and Non-Forest in Year 10. Therefore, these will result in a total of nine possible combinations of change.

Table 6.5 Totals of Class Changes from Forest for 2019-2020 (see also Table 10.17)

Stratum / Class	Hectares	SE	2.50%	97.50%
2019-2020 Forest/Degraded -> NonForest	10,667	1,597	7,538	13,797
2019-2020 Forest -> Forest	19,155,790	2,121	19,151,633	19,159,948

In Table 6.5 we estimate the area of Guyana which was classified as Forest in Year 9 and NonForest in Year 10. The estimate is 10,667 hectares, standard error 1,597 hectares, 97.5% confidence interval (7,537 ha; 13,797 ha). Section 9 gives the same information as Table 6.5 but disaggregated by stratum and by proportions rather than totals.

In Year 10 the GFC mapping team found no change from Non-Forest to Forest or Degraded Forest (reforestation). Note that it would be challenging 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 GeoVantage imagery.

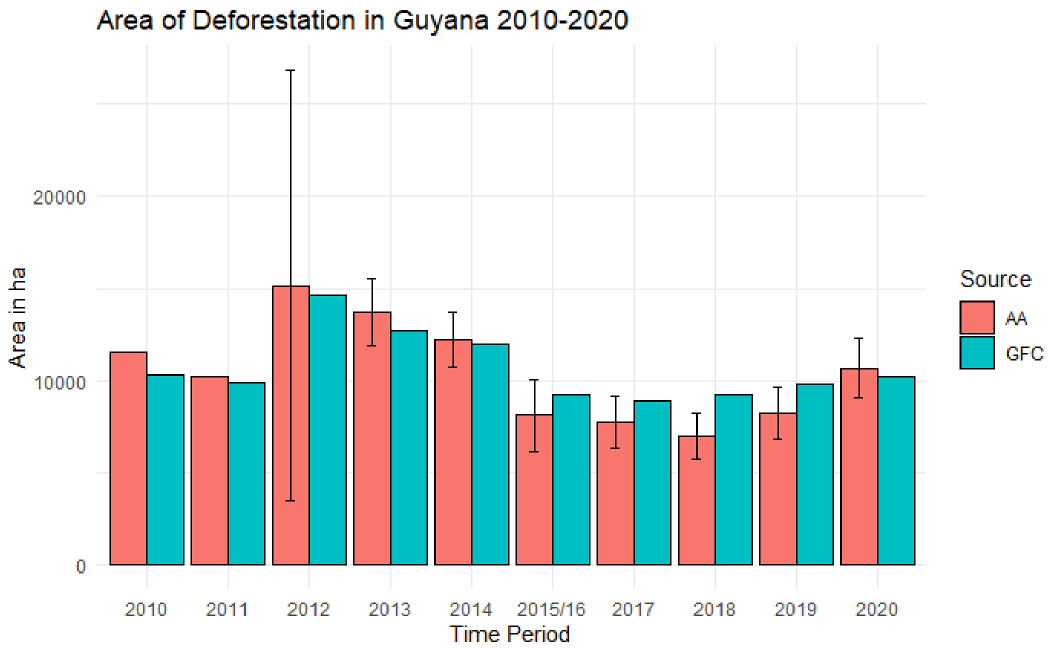

Figure 6.1 Trends in Deforestation observed from GFC MRVS and sample-based accuracy estimates AA

6.4 Estimate of the 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 9 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 9 changed to Non Forest in Year 10 is 10,667 hectares with a standard error of 1596 hectares, 97.5% confidence interval (7,538 ha; 13,796 ha). These changes translate into a mean rate of deforestation on 0.0645 % with a SE of 0.00789 % with a 97.5% confidence interval for the rate of change of 0.0491 % to 0.0800 %, see Table 6.6.

Table 6.6 Mean Deforestation annual rate per hectare (%) see also tables 10.21 and 10.23				
	Mean	SE	2.5%	97.5%
Year 10 (2020) Forest loss	0.09545	0.0084	0.0789	0.1119
Year 10 (2020) Forest loss using the actual area of deforestation per sample	0.08343	0.0218	0.0402	0.1266

6.5 Change Rate comparison

Table 6.7 shows the Year 9 to Year 10 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. Figure 6.2 shows the trend in deforestation rate from 2010 to 2020. Year 10 shows a small increase in the rate of change according to the sample-based change estimates. The rate of loss shown in Table 6.6 assumes that all of the forest in every change sample is lost. However, it is possible for a sample to retain some forest cover even though the sample does not meet the definition of forest cover set out in Section 2.1; that is a minimum of 30% canopy cover. Table 6.7 and Figure 6.2 show a lower change rate of 0.0834 % if the actual area of change is incorporated into the analysis.

Table 6.7 Comparison of Forest Change Estimates Source			
	Forest area change (ha)	Change Rate (%)	SE of Y10 Rate (%)
GFC Map Estimate	10,232	0.057	
Change Sample Estimate	10,667	0.0954	0.0084
Change Rate Estimate using actual area of deforestation per sample		0.0834	0.0218

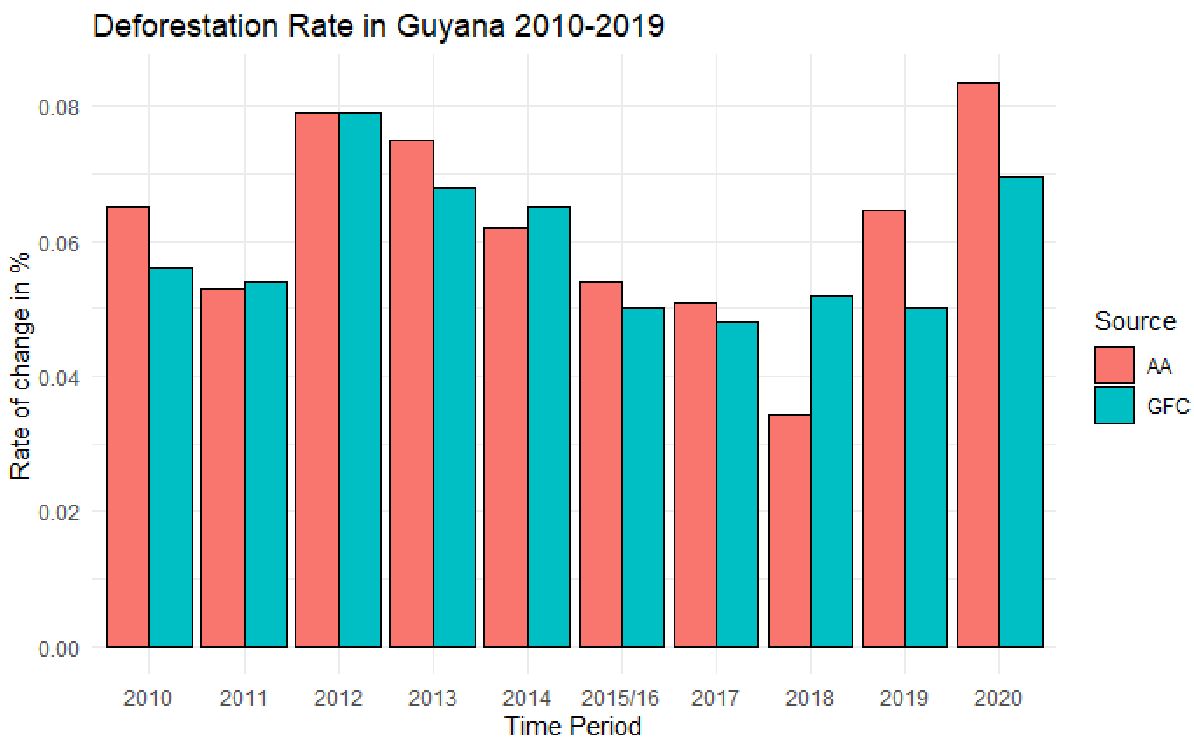

Figure 6.2 Deforestation Rates observed from GFC MRVS and Accuracy Assessment (AA) sample-based estimates. Note that 2020 uses the actual area of deforestation per sample to estimate the change rate

6.6 Assesment of GFC Mapping accuracy

The accuracy assessment results presented above are obtained independently from the Guyana Forestry Commission's annual wall-to-wall mapping of landcover change based on satellite imagery. The GFC mapping is integrated into the MRVS GIS database and this provides a consolidated map of forest loss from 1990 to 2020. We took the opportunity to use the reference data used for the change sample analysis and compare the 2020 landcover with the landcover from the MRVS provided by the FC mapping team.

The analysis proceeds by first clipping the MRVS dataset to the primary sampling unit (PSU) area in the accuracy assessment reference data. The output was then split to the Secondary Sampling Units (SSUs) so that both maps are matched at the SSU level. As the Guyana MRVS dataset does not contain the non-forest 1990 areas, the non-forest 1990 dataset is also clipped and split in the same way. They are both then joined with the reference dataset and compared following the Guyana-MRVS definition of forest and non-forest land cover types, see figure 6.3 for a diagram of the workflow.

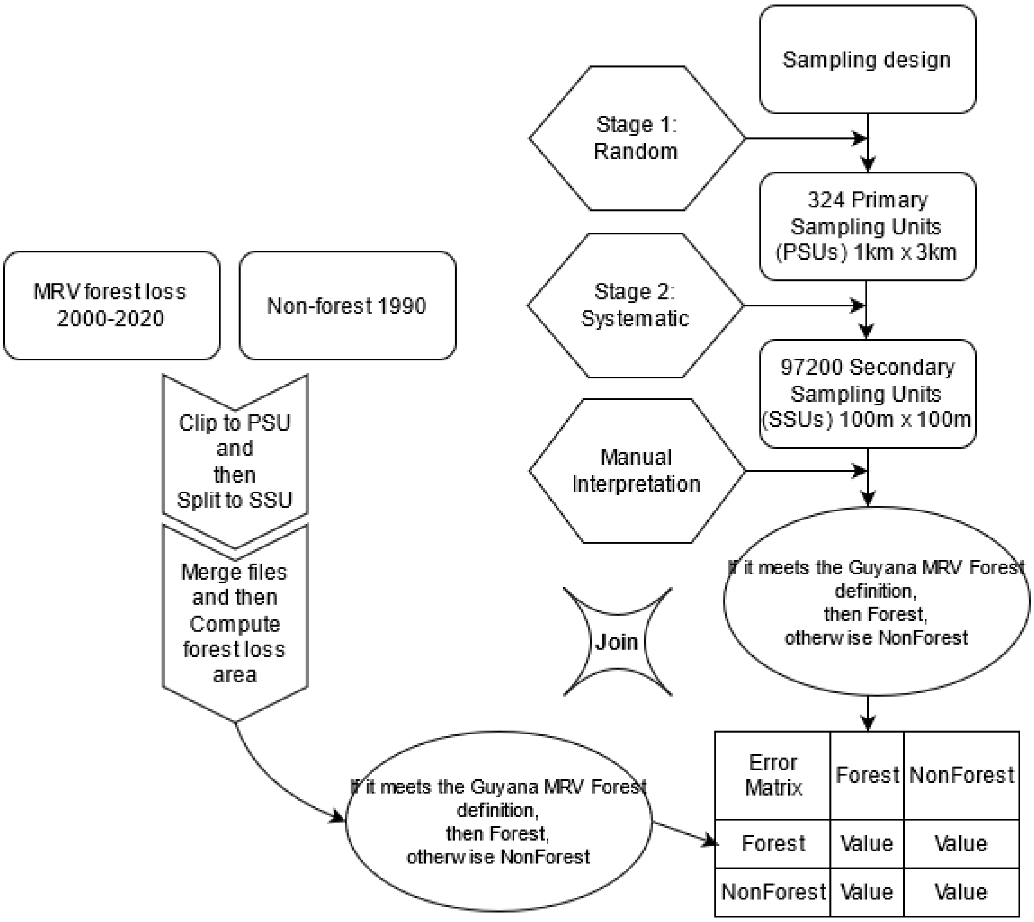

Figure 6.3 - Diagram of the methodology used to compare the Guyana-MRV and the reference (Accuracy Assessment) datasets, to create the error matrix (see table 6.8).

The results of the GFC mapping assessment are presented in table 6.8. It is important to note that these data describe the totality of the landcover change mapping from 1990 to 2020 and do NOT describe the mapping for any individual period or year. The results are simplified into Forest and Non-Forest land cover types and demonstrate that overall the GFC mapping is 99.16% accurate. The forest land cover is mapped to an accuracy of 99.51% and the Non-Forest 94.44%. The errors of omission, where forest loss is not detected represents 5.56% of the non-forest samples in the reference data. This is a higher than the errors of omission for the forest landcover type (0.49%) but is still a low level of error. Bias in the distribution of error is also very low at -0.06%. We conclude that a small amount of forest loss has not been detected in the period 1990-2020.

Table 6.8 - Error matrix after comparison between Guyana MRV and reference dataset with the inclusion of non-forest 1990 data.

All years	Class	Reference data			User accuracy
		Forest	Non-Forest		
GFC Mapping	Forest	89110	377		99.58%
	Non-Forest	435	6408		93.64%
				Bias	-0.06%
	Producer accuracy	99.51%	94.44%	Overall accuracy	99.16%

7. DISCUSSION

The results divide into two areas that warrant further discussion: the reliability of the sampling strategy used to identify deforestation and estimate change area from imagery and estimation of the drivers of forest loss.

7.1 Deforestation levels

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 is very slightly lower than the sample-based estimate, although the mapped area falls within the confidence interval of the sample-based estimate.

There are a number of reasons that might explain the small difference between the two measures of gross deforestation:

- the MRV mapping is based on Sentinel-2 MSI and Landsat 8 imagery, and so areas identified as deforestation might in fact be forest degradation;
- the overall amount of deforestation is low, and so it is probable that a few small areas account for the differences and these areas;
- the proportion (approx. 0.9%) of samples Omitted (because of cloud cover) although lower than in Y9, may obscure change areas;
- The accuracy assessment for deforestation did not check the GIS map product; instead, it estimated forest loss from an independent probability-based sample.

While the GFC mapping team manually identified deforestation with some assistance from cloud removal tools and vegetation indices, they were still restricted by the ground sampling distance of Sentinel-2 (at best, 10m). This reflects to a scale of 1:10,000, which is good enough to identify land cover types (e.g. vegetation vs. bareland; farm fields vs. forest) (Murtha et al., 1997). However, this spatial scale has its limits as to what can be identified in the imagery. At Sentinel-2 scale:

- it is easy to confuse between dense shrubs and trees (e.g. see figure 7.1);
- it is almost impossible to distinguish young secondary forest from older secondary forest – a very common landscape within shifting agriculture areas – (e.g. see figure 7.2);
- it is extremely difficult to identify small scale deforestation occurring within already degraded areas (e.g. see figure 7.3).

There are several possible solutions to enhance the wall-to-wall mapping, however none of them is perfect and each has its advantages/disadvantages. Long-range imaging approaches such as super-resolution and lucky imaging could provide a sharper view than a single image for the interpreter. Active sensors (e.g. Sentinel-1) could alert interpreters to areas of apparent change that could be deforestation, where the interpreters could focus their efforts. Predictive modelling could provide high risk of deforestation areas, where VHR imagery could be sought and acquired.

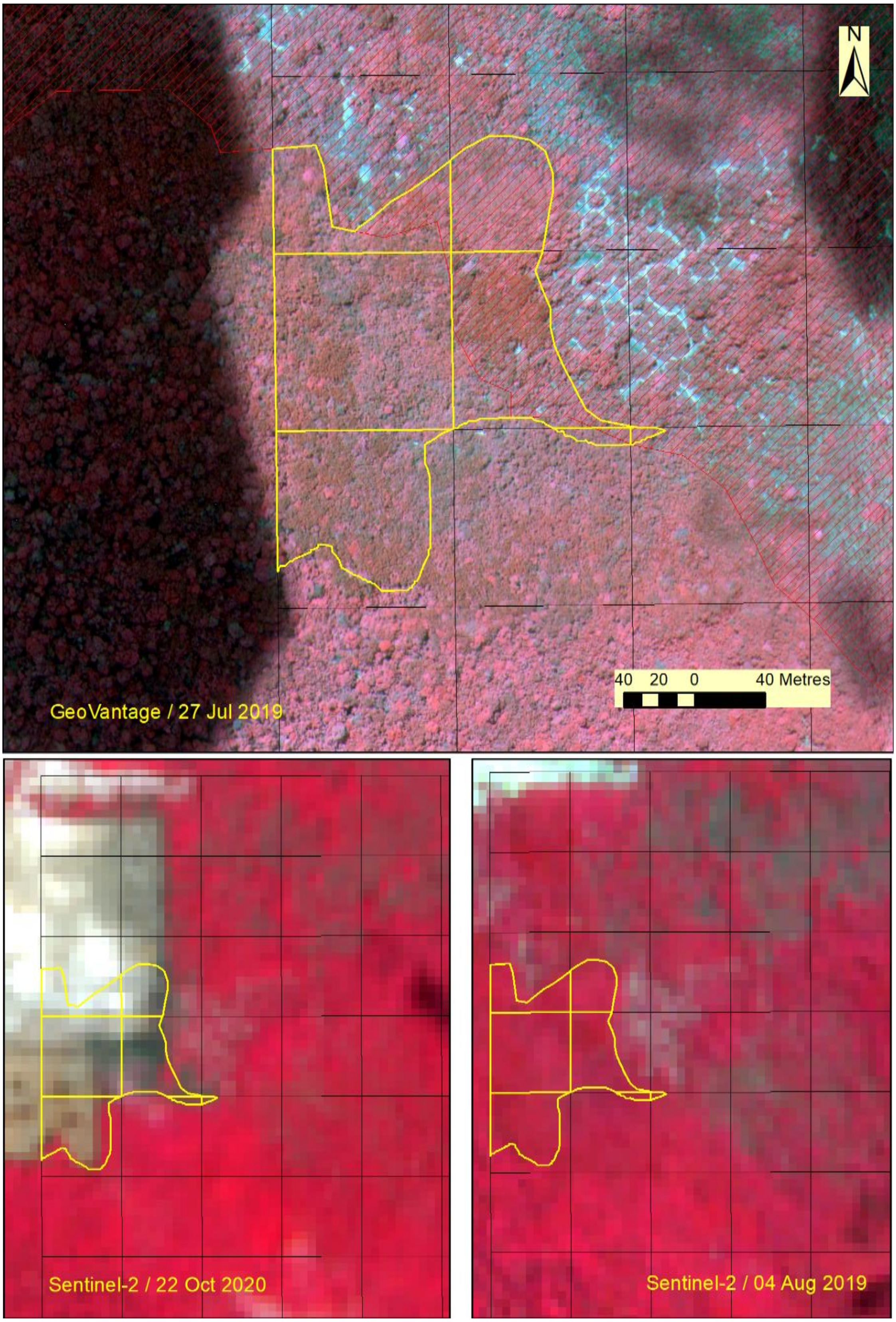

Figure 7.1 –The yellow line shows the area of deforestation identified by the GFC mapping team. The red line shows the 1990 non-forest area. While Sentinel-2 shows vegetation clearance in this area, GeoVantage shows that this vegetation is not forest.

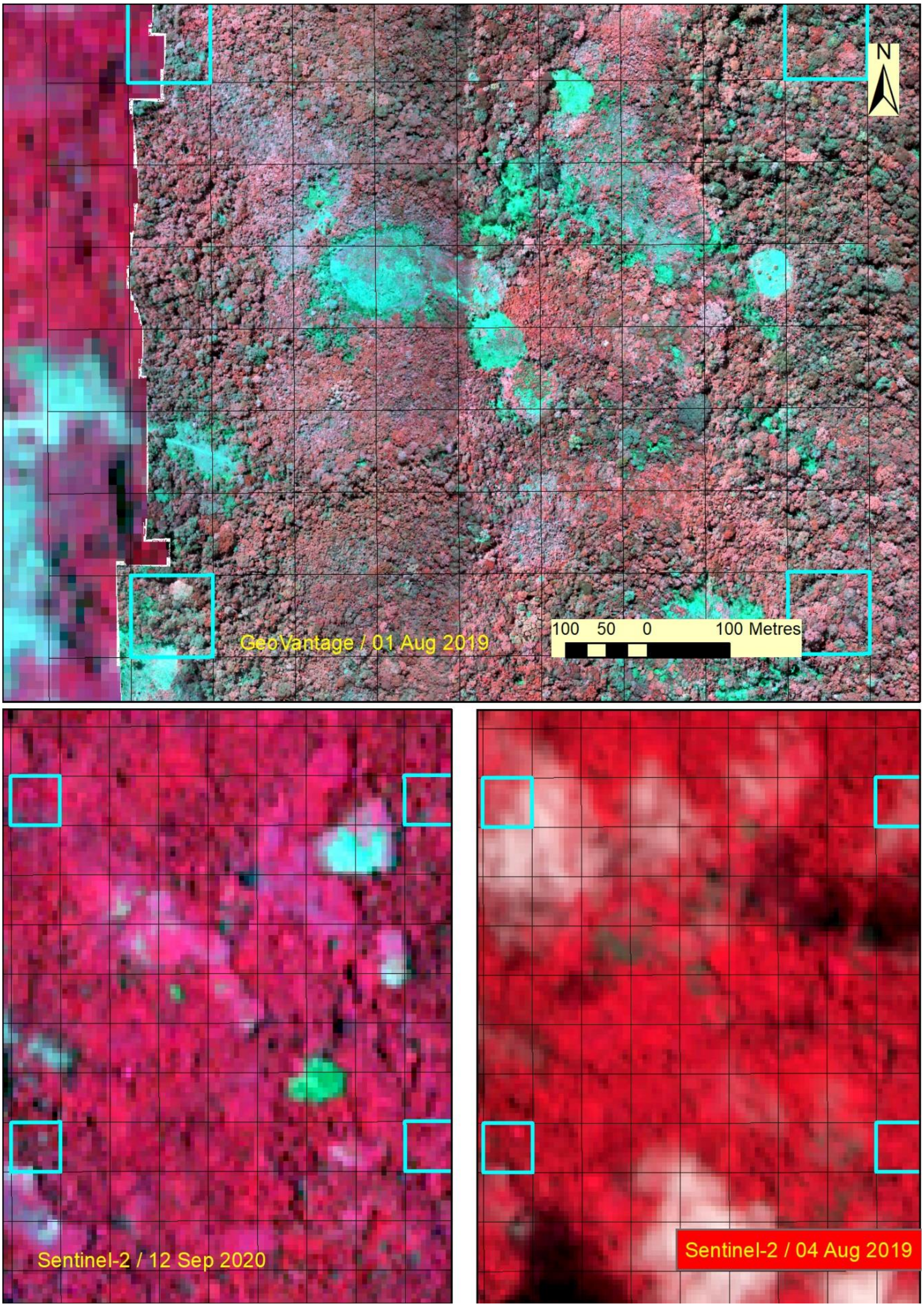

Figure 7.2 – The four blue squares (i.e. selected SSUs) show the common area between the three images. It is impossible to discern forested versus non-forested areas in the Sentinel-2 image of 2019, and it is extremely difficult to identify what is happening in Sentinel-2 of 2020. However, GeoVantage provides a lot of information that help the interpreter develop more confidence with identifying the landscape features.

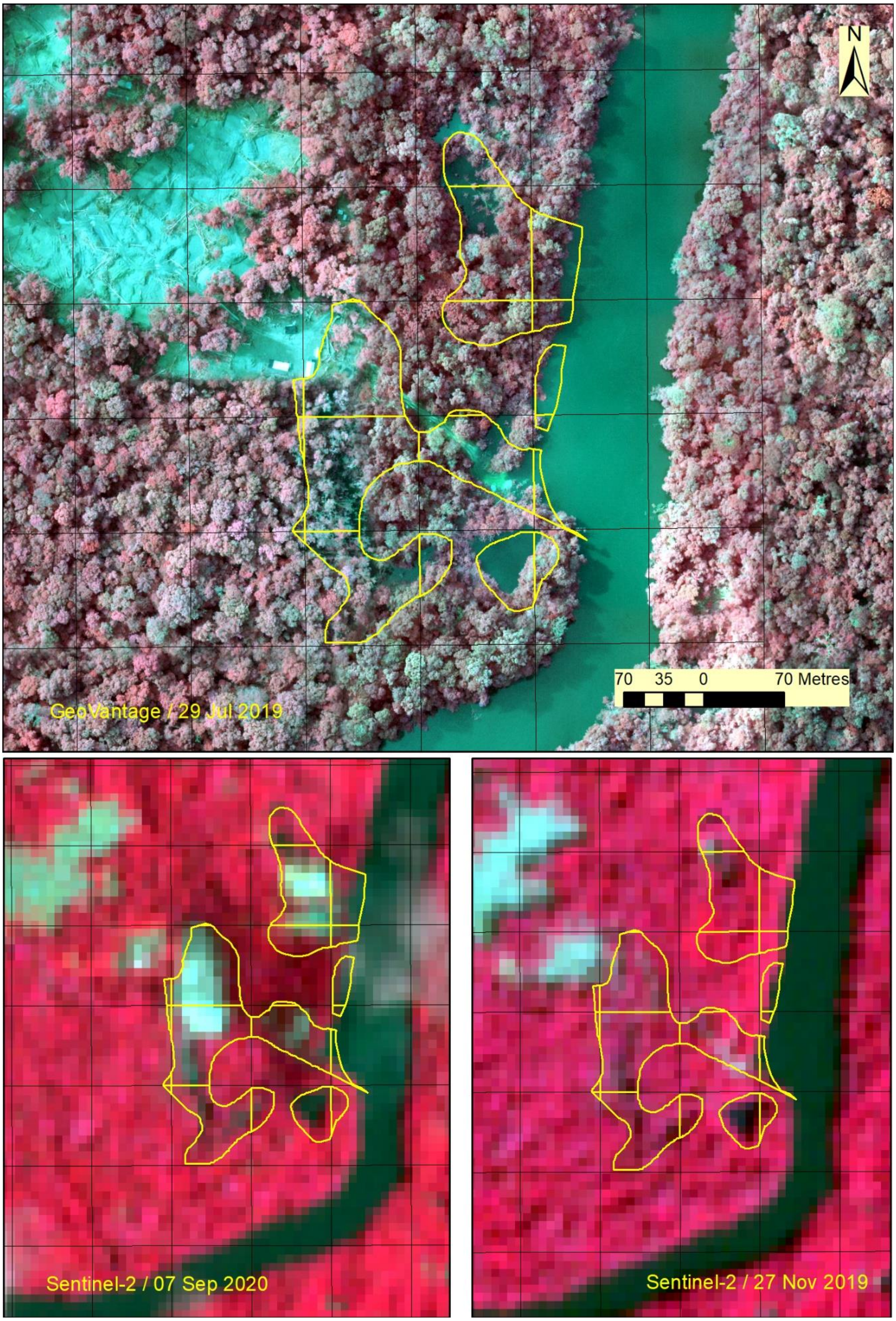

Figure 7.3 – The yellow lines show the deforestation area as it was mapped by the GFC mapping team. Without the GeoVantage, it is easy to consider the 2019 Sentinel-2 image as showing mostly forest. However, as GeoVantage shows, this is a degraded area where deforestation has mostly already occurred in 2019 with exception of the top right polygon.

7.2 Drivers of forest loss

The results from the stratified sample estimates confirm GFCs conclusion that mining and mining-related infrastructure, including settlements, is the overwhelming driver for deforestation, see Table 7.1.

The stratified sample-based estimates of deforestation show that 8,480 ha of loss are attributed to mining activity which represents 79.5 % of all forest loss for year 10. Fire and unknown change drivers account for 1,208 ha (12.2 %), infrastructure accounts for 465 ha (4.4 %), and agriculture 419 ha (3.9 %) of forest loss. These estimates are compared with GFC's forest loss data derived from systematic wall-to-wall mapping, see table 7.1. Both sets of statistics show that mining and mining-related infrastructure, including settlements, are the overwhelming drivers for deforestation in Guyana in Y10 (2020), see Table 7.1.

Table 7.1 Deforestation disaggregated by driver for sample-based estimate and Guyana Forestry Commission wall-to-wall mapping

	Change Sample-based estimate			GFC Mapping
Change Driver	Deforestation area in ha	Standard Error of deforestation in ha	Percentage of total de-forestation	Deforestation area in ha
Agriculture	419.3	298	3.9 %	489
Mining	8,480	1,438	79.5 %	6,452
Infrastructure Roads / Forest Roads / log landings / Settlements	465	329	4.4 %	360
Fire / unknown	1,303	535	12.2 %	2,993
Total forest loss (ha)	10,667	1,597		10,235

7.3 All years mapping accuracy

The assessment for accuracy for the up-to-date MRVS map covering all landcover change from 1990 to 2020 is presented in the form of an error matrix. When assessed against the independent accuracy assessment sample data for 2020 the MRVS map is 99.16% accurate. Breaking down the error by land cover type, the error of omission for forest land is 0.49% and for the non-forest land cover class is 5.56%. The latter error demonstrates that some forest loss is being missed and so there is scope for some improvement in the precision of the MRVS mapping. The reasons for forest loss being missed have already been outlined in section 7.1 above. However, it is worth noting that landcover in 1990 and in Periods 1-3 was mapped using Landsat data with 30 m pixel size and there are differences in the mapping methodologies between the sample-based change assessment where each sample hectare is treated independently and the GIS-based mapping where exact areas of change are mapped providing the total area of each polygon meets the threshold of forest loss greater or equal to one hectare. Overall, the level of accuracy is high and better that would be expected from automated classification of remote sensing data.

8. SUMMARY & CONCLUSIONS

8.1. We conclude that the estimates of deforestation based on the mapping undertaken by GFC based mainly on the interpretation of Sentinel-2 MSI imagery are consistent with sample-based estimation.

8.2. The methods used by GFC 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 October-December 2020 (Year 10).

8.3. The estimate of the total area of change in the 12-month Year 10 period from forest to non-forest and degraded forest to non-forest is 10,667 ha, with a standard error of 1,513 ha and a 97.5% confidence interval (7,433 ha; 14,972 ha).

8.4. The estimate of the annual rate of deforestation that occurred over the Year 9 (12 months) period is 0.0645% with a standard error of 0.00789% and a 97.5% confidence interval (0.0491%; 0.0800%).

8.5. The overall accuracy of the MRVS mapping over the period 1990-2020, when assessed against the independent accuracy assessment sample data for 2020 is 99.16%. The error of omission within the non-forest land cover class is 5.56%.

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10. STATISTICAL TABLES

Table 10.1 – ANALYSIS OF 2019 Hectares OF ALL CLASSES

	Hectares	SE	2.50 %	97.50 %
2019 Degradation	201110.1	6906.255	187574.1	214646.1
2019 Forest	19174193.5	19232.221	19136499.1	19211888.0
2019 NonForest	1568870.2	18265.348	1533070.8	1604669.7

Table 10.2 - ANALYSIS OF 2018 Hectares OF ALL CLASSES BY STRATUM

	Hectares	SE	2.50 %	97.50 %
HR:2019 Degradation	114092.3	5087.4	104121.2	124063.5
LR:2019 Degradation	31589.9	2426.4	26834.3	36345.5
MR:2019 Degradation	55427.9	3990.9	47605.9	63249.9
HR:2019 Forest	3916549.9	12916.2	3891234.7	3941865.2
LR:2019 Forest	10145218.2	8309.9	10128931.2	10161505.2
MR:2019 Forest	5112425.4	11575.7	5089737.4	5135113.3
HR:2019 NonForest	764953.0	12223.1	740996.1	788909.8
LR:2019 NonForest	351788.1	7972.5	336162.3	367414.0
MR:2019 NonForest	452129.1	10984.4	430600.0	473658.2

Table 10.3 - ANALYSIS OF 2019 Proportions OF ALL CLASSES

	Mean	SE	2.50%	97.50%
2019 Degradation	0.0096	3e-04	0.0090	0.0102
2019 Forest	0.9155	9e-04	0.9137	0.9173
2019 NonForest	0.0749	9e-04	0.0732	0.0766

Table 10.4- ANALYSIS OF 2019 Proportions OF ALL CLASSES BY STRATUM

	Mean	SE	2.50%	97.50%
HR:2019 Degradation	0.0238	0.0011	0.0217	0.0259
LR:2019 Degradation	0.0030	0.0002	0.0025	0.0035
MR:2019 Degradation	0.0099	0.0007	0.0085	0.0113
HR:2019 Forest	0.8167	0.0027	0.8114	0.8220
LR:2019 Forest	0.9636	0.0008	0.9620	0.9651
MR:2019 Forest	0.9097	0.0021	0.9057	0.9137
HR:2019 NonForest	0.1595	0.0025	0.1545	0.1645
LR:2019 NonForest	0.0334	0.0008	0.0319	0.0349
MR:2019 NonForest	0.0805	0.0020	0.0766	0.0843

Table 10.5 - ANALYSIS OF 2020 Hectares OF ALL CLASSES

	Hectares	SE	2.50%	97.50%
2020 Degradation	206987.4	7012.346	193243.5	220731.4
2020 Forest	19155790.1	19313.673	19117936.0	19193644.2
2020 NonForest	1581396.3	18323.685	1545482.6	1617310.1

Table 10.6 - ANALYSIS OF 2020 Hectares OF ALL CLASSES BY STRATUM

Stratum / Class	Hectares	SE	2.50%	97.50%
HR:2020 Degradation	116880.7	5147.7	106791.5	126970.0
LR:2020 Degradation	31776.8	2433.5	27007.2	36546.4
MR:2020 Degradation	58329.9	4093.0	50307.8	66352.0
HR:2020 Forest	3903537.4	12989.8	3878077.8	3928996.9
LR:2020 Forest	10144470.5	8317.7	10128168.2	10160772.8
MR:2020 Forest	5107782.2	11623.2	5085001.1	5130563.4
HR:2020 NonForest	775177.1	12288.9	751091.3	799262.9
LR:2020 NonForest	352348.9	7978.7	336711.0	367986.8
MR:2020 NonForest	453870.3	11003.7	432303.4	475437.2

Table 10.7 - ANALYSIS OF 2020 Proportions OF ALL CLASSES

	Mean	SE	2.50%	97.50%
2020 Degradation	0.0099	3e-04	0.0092	0.0105
2020 Forest	0.9146	9e-04	0.9128	0.9164
2020 NonForest	0.0755	9e-04	0.0738	0.0772

Table 10.8 - ANALYSIS OF 2020 Proportions OF ALL CLASSES BY STRATUM

Stratum / Class	Mean	SE	2.50%	97.50%
HR:2020 Degradation	0.0244	0.0011	0.0223	0.0265
LR:2020 Degradation	0.0030	0.0002	0.0026	0.0035
MR:2020 Degradation	0.0104	0.0007	0.0090	0.0118
HR:2020 Forest	0.8140	0.0027	0.8087	0.8193
LR:2020 Forest	0.9635	0.0008	0.9620	0.9651
MR:2020 Forest	0.9089	0.0021	0.9048	0.9129
HR:2020 NonForest	0.1616	0.0026	0.1566	0.1667
LR:2020 NonForest	0.0335	0.0008	0.0320	0.0350
MR:2020 NonForest	0.0808	0.0020	0.0769	0.0846

Table 10.9 - ANALYSIS OF 2019-2020 TOTALS OF CLASS CHANGES

	Hectares	SE	2.50 %	97.50 %
2019-2020 Degradation.Degradation	199251.2	6876.4	185773.7	212728.7
2019-2020 Forest.Degradation	7736.3	1398.4	4995.4	10477.1
2019-2020 Forest.Forest	19155790.1	19313.7	19117936.0	19193644.2
2019-2020 Degradation.NonForest	1858.9	657.1	571.0	3146.9
2019-2020 Forest.NonForest	10667.2	1597.0	7537.1	13797.3
2019-2020 NonForest.NonForest	1568870.2	18265.3	1533070.8	1604669.7

Table 10.10 - ANALYSIS OF 2019-2020 TOTALS OF CLASS CHANGES BY STRATUM

Stratum / Class	Hectares	SE	2.50%	97.50%
HR:2019-2020 Degradation.Degradation	112233.4	5046.8	102341.8	122124.9
LR:2019-2020 Degradation.Degradation	31589.9	2426.4	26834.3	36345.5
MR:2019-2020Degradation.Degradation	55427.9	3990.9	47605.9	63249.9
HR:2019-2020 Forest.Degradation	4647.3	1038.7	2611.5	6683.2
LR:2019-2020 Forest.Degradation	186.9	186.9	-179.4	553.3
MR:2019-2020 Forest.Degradation	2902.0	917.5	1103.8	4700.2
HR:2019-2020 Forest.Forest	3903537.4	12989.8	3878077.8	3928996.9
LR:2019-2020 Forest.Forest	10144470.5	8317.7	10128168.2	10160772.8
MR:2019-2020 Forest.Forest	5107782.2	11623.2	5085001.1	5130563.4
HR:2019-2020 Degradation.NonForest	1858.9	657.1	571.0	3146.9
LR:2019-2020 Degradation.NonForest	0	0	0	0
MR:2019-2020 Degradation.NonForest	0	0	0	0
HR:2019-2020 Forest.NonForest	8365.2	1393.0	5635.0	11095.5
LR:2019-2020 Forest.NonForest	560.8	323.8	-73.8	1195.3
MR:2019-2020 Forest.NonForest	1741.2	710.7	348.2	3134.2
HR:2019-2020 NonForest.NonForest	764953.0	12223.1	740996.1	788909.8

LR:2019-2020 NonForest.NonForest	351788.1	7972.5	336162.3	367414.0
MR:2019-2020 NonForest.NonForest	452129.1	10984.4	430600.0	473658.2

Table 10.11 - ANALYSIS OF 2019-2020 proportions OF CLASS CHANGES

	Mean	SE	2.5	%
2019-2020 Degradation.Degradation	0.00951	0.00033	0.00887	0.01016
2019-2020 Forest.Degradation	0.00037	0.00007	0.00024	0.00050
2019-2020 Forest.Forest	0.91461	0.00092	0.91280	0.91642
2019-2020 Degradation.NonForest	0.00009	0.00003	0.00003	0.00015
2019-2020 Forest.NonForest	0.00051	0.00008	0.00036	0.00066
2019-2020 NonForest.NonForest	0.07491	0.00087	0.07320	0.07662

Table 10.12 - ANALYSIS OF 2019-2020 proportions OF CLASS CHANGES BY STRATUM

Stratum / Class	Mean	SE	2.50%	97.50%
HR:2019-2020 Degradation.Degradation	0.02340	0.00105	0.02134	0.02547
LR:2019-2020 Degradation.Degradation	0.00300	0.00023	0.00255	0.00345
MR:2019-2020 Degradation.Degradation	0.00986	0.00071	0.00847	0.01125
HR:2019-2020 Forest.Degradation	0.00097	0.00022	0.00054	0.00139
LR:2019-2020 Forest.Degradation	0.00002	0.00002	-0.00002	0.00005
MR:2019-2020 Forest.Degradation	0.00052	0.00016	0.00020	0.00084
HR:2019-2020 Forest.Forest	0.81398	0.00271	0.80867	0.81929
LR:2019-2020 Forest.Forest	0.96352	0.00079	0.96197	0.96506
MR:2019-2020 Forest.Forest	0.90886	0.00207	0.90481	0.91291
HR:2019-2020 Degradation.NonForest	0.00039	0.00014	0.00012	0.00066
LR:2019-2020 Degradation.NonForest	0	0	0	0
MR:2019-2020 Degradation.NonForest	0	0	0	0
HR:2019-2020 Forest.NonForest	0.00174	0.00029	0.00118	0.00231
LR:2019-2020 Forest.NonForest	0.00005	0.00003	-0.00001	0.00011
MR:2019-2020 Forest.NonForest	0.00031	0.00013	0.00006	0.00056

HR:2019-2020 NonForest.NonForest	0.15951	0.00255	0.15452	0.16451
LR:2019-2020 NonForest.NonForest	0.03341	0.00076	0.03193	0.03490
MR:2019-2020 NonForest.NonForest	0.08045	0.00195	0.07662	0.08428

Table 10.13 - ANALYSIS OF 2019-2020 TOTALS OF CLASS CHANGES FROM FOREST/DEGRADED

	Hectares	SE	2.50%	97.50%
2019-2020 Forest/Degraded.Degradation	206987.4	7012.3	193243.5	220731.4
2019-2020 Forest/Degraded.Forest	19155790.1	19313.7	19117936.0	19193644.2
2019-2020 Forest/Degraded.NonForest	12526.1	1726.5	9142.2	15910.0
2019-2020 NonForest.NonForest	1568870.2	18265.3	1533070.8	1604669.7

Table 10.14 - ANALYSIS OF 2019-2020 TOTALS OF CLASS CHANGES BY STRATUM FROM FOREST/DEGRADED

Stratum / Class	Hectares	SE	2.50%	97.50%
HR:2019-2020 Forest/Degraded.Degradation	116880.7	5147.7	106791.5	126970.0
LR:2019-2020 Forest/Degraded.Degradation	31776.8	2433.5	27007.2	36546.4
MR:2019-2020 Forest/Degraded.Degradation	58329.9	4093.0	50307.8	66352.0
HR:2019-2020 Forest/Degraded.Forest	3903537.4	12989.8	3878077.8	3928996.9
LR:2019-2020 Forest/Degraded.Forest	10144470.5	8317.7	10128168.2	10160772.8
MR:2019-2020 Forest/Degraded.Forest	5107782.2	11623.2	5085001.1	5130563.4
HR:2019-2020 Forest/Degraded.NonForest	10224.2	1539.7	7206.3	13242.0
LR:2019-2020 Forest/Degraded.NonForest	560.8	323.8	-73.8	1195.3
MR:2019-2020 Forest/Degraded.NonForest	1741.2	710.7	348.2	3134.2
HR:2019-2020 NonForest.NonForest	764953.0	12223.1	740996.1	788909.8
LR:2019-2020 NonForest.NonForest	351788.1	7972.5	336162.3	367414.0
MR:2019-2020 NonForest.NonForest	452129.1	10984.4	430600.0	473658.2

Table 10.15 - ANALYSIS OF 2019-2020 proportions OF CLASS CHANGES FROM FOREST/DEGRADED

Class	Mean	SE	2.50 %	97.50 %
2019-2020 Forest/Degraded.Degradation	0.00988	0.00033	0.00923	0.01054
2019-2020 Forest/Degraded.Forest	0.91461	0.00092	0.91280	0.91642
2019-2020 Forest/Degraded.NonForest	0.00060	0.00008	0.00044	0.00076
2019-2020 NonForest.NonForest	0.07491	0.00087	0.07320	0.07662

Table 10.16 - ANALYSIS OF 2019-2020 proportions OF CLASS CHANGES BY STRATUM FROM FOREST/DEGRADED

Stratum / Class	Mean	SE	2.50%	97.50%
HR:2019-2020 Forest/Degraded.Degradation	0.02437	0.00107	0.02227	0.02648
LR:2019-2020 Forest/Degraded.Degradation	0.00302	0.00023	0.00257	0.00347
MR:2019-2020 Forest/Degraded.Degradation	0.01038	0.00073	0.00895	0.01181
HR:2019-2020 Forest/Degraded.Forest	0.81398	0.00271	0.80867	0.81929
LR:2019-2020 Forest/Degraded.Forest	0.96352	0.00079	0.96197	0.96506
MR:2019-2020 Forest/Degraded.Forest	0.90886	0.00207	0.90481	0.91291
HR:2019-2020 Forest/Degraded.NonForest	0.00213	0.00032	0.00150	0.00276
LR:2019-2020 Forest/Degraded.NonForest	0.00005	0.00003	-0.00001	0.00011
MR:2019-2020 Forest/Degraded.NonForest	0.00031	0.00013	0.00006	0.00056
HR:2019-2020 NonForest.NonForest	0.15951	0.00255	0.15452	0.16451
LR:2019-2020 NonForest.NonForest	0.03341	0.00076	0.03193	0.03490
MR:2019-2020 NonForest.NonForest	0.08045	0.00195	0.07662	0.08428

Table 10.17 - ANALYSIS OF 2019-2020 TOTALS OF CLASS CHANGES FROM FOREST

Stratum / Class	Hectares	SE	2.50%	97.50%
2019-2020 Forest.Degradation	7736.3	1398.3	4995.6	10476.9
2019-2020 Forest.Forest	19155790.1	2121.3	19151632.5	19159947.8
2019-2020 Forest.NonForest	10667.2	1596.8	7537.5	13796.8

Table 10.18 - 2019-2020 TOTALS OF CLASS CHANGES FROM FOREST BY STRATUM

Stratum / Class	Hectares	SE	2.50%	97.50%
HR:2019-2020 Forest.Degradation	4647.3	1038.6	2611.7	6682.9
LR:2019-2020 Forest.Degradation	186.9	186.9	-179.4	553.3
MR:2019-2020 Forest.Degradation	2902.0	917.5	1103.8	4700.2
HR:2019-2020 Forest.Forest	3903537.4	1736.0	3900134.8	3906939.9
LR:2019-2020 Forest.Forest	10144470.5	373.8	10143737.8	10145203.2
MR:2019-2020 Forest.Forest	5107782.2	1160.3	5105508.1	5110056.4
HR:2019-2020 Forest.NonForest	8365.2	1392.8	5635.5	11095.0
LR:2019-2020 Forest.NonForest	560.8	323.8	-73.8	1195.3
MR:2019-2020 Forest.NonForest	1741.2	710.7	348.2	3134.2

Table 10.19 - ANALYSIS OF 2019-2020 proportions OF CLASS CHANGES FROM FOREST

Stratum / Class	Mean	SE	2.50%	97.50%
2019-2020 Forest.Degradation	0.00040	0.00007	0.00026	0.00055
2019-2020 Forest.Forest	0.99904	0.00011	0.99882	0.99926
2019-2020 Forest.NonForest	0.00056	0.00008	0.00039	0.00072

Table 10.20 - ANALYSIS OF 2019-2020 proportions OF CLASS CHANGES FROM FOREST

Stratum / Class	Mean	SE	2.50%	97.50%
HR:2019-2020 Forest.Degradation	0.00119	0.00027	0.00067	0.00171
LR:2019-2020 Forest.Degradation	0.00002	0.00002	-0.00002	0.00005
MR:2019-2020 Forest.Degradation	0.00057	0.00018	0.00022	0.00092
HR:2019-2020 Forest.Forest	0.99668	0.00044	0.99581	0.99755
LR:2019-2020 Forest.Forest	0.99993	0.00004	0.99985	1.00000
MR:2019-2020 Forest.Forest	0.99909	0.00023	0.99865	0.99954
HR:2019-2020 Forest.NonForest	0.00214	0.00036	0.00144	0.00283
LR:2019-2020 Forest.NonForest	0.00006	0.00003	-0.00001	0.00012
MR:2019-2020 Forest.NonForest	0.00034	0.00014	0.00007	0.00061

Table 10.21 - Mean Deforestation (to Degraded/NonForest) per hectare

This analysis is restricted to hectares known to be forest in 2019.

	Mean	SE	2.50%	97.50%
loss	0.0954114	0.008406	0.078936	0.1118868

Table 10.22 - Mean Deforestation (to Degraded/NonForest) per hectare BY STRATUM

Stratum	Mean	SE	2.50%	97.50%
HR	0.3206764	0.0339975	0.2540425	0.3873103
LR	0.0071856	0.0030385	0.0012302	0.0131411
MR	0.0979168	0.0167101	0.0651655	0.1306680

Table 10.23 - Mean Area that is not Forest per hectare

This analysis is the amount of deforestation in the area sampled, using the actual area of deforestation per sample.

	Mean	SE	2.50%	97.50%
Area	0.08342259	0.02203252	0.04023964	0.1266055

Table 10.24 - Mean Area that is not Forest per hectare BY STRATUM

Stratum	Mean	SE	2.50%	97.50%
HR	0.2421212	0.0962298	0.0535143	0.4307281
LR	0.0570533	0.0218461	0.0142357	0.0998708
MR	0.0247126	0.0145237	-0.0037532	0.0531785

Table 10.25 – Analysis of 2019 - 2020 totals of class changes from forest

	Hectares	SE	2.50%	97.50%
Area	5760.5	1521.4	2778.6	8742.4

Appendix 2: IPCC Table

to: (end of year 10)	forest land	cropland (managed)	grassland (managed)	wetland (managed)	settlement	other land	end of year 10
from: (start of year 10)	*area (kha)*						
forest land (HPfC, MA)	4,529.42	0.2169	NO	NE	0.5794	4.1984	**4,524.42**
forest land (HPfC, LA)	2,235.93	0.2053			0.1924	2.3328	**2,233.20**
forest land (MPfC, MA)	1,225.73	0.0172			0.0719	0.4781	**1,225.16**
forest land (MPfC, LA)	4,315.51	0.0403			0.0645	1.4422	**4,313.97**
forest land (LPfC, MA)	200.36	0.0007			0.0018	0.0690	**200.29**
forest land (LPfC, LA)	5,504.26	0.0086			0.0045	0.3075	**5,503.94**
cropland (managed)	NE						**892.05**
grassland (managed)							**1,771.73**
wetland (managed)							**284.01**
settlement							**67.80**
other land							**97.12**
start of year 10	**18,011.21**	**891.56**	**1,771.73**	**284.01**	**66.88**	**88.29**	21,113.67
net change	10.23	-0.49			-0.91	-8.83	

NE – not estimated
NO – not occurring

Appendix 3: Year 10 Image Catalogue

Stack Name	Satellite/ Instrum.	Data Pro-vider	Res (m)	Acqu. Year	Acqu. Month
20200803T142739_20200803T142734_T20NRL.tif	Sentinel	ESA	10	2020	August
20200803T142739_20200803T142734_T20NRM.tif	Sentinel	ESA	10	2020	August
20200803T142739_20200803T142734_T21NTG.tif	Sentinel	ESA	10	2020	August
20200803T142739_20200803T142734_T21NTJ.tif	Sentinel	ESA	10	2020	August
20200813T142739_20200813T142734_T21NTE.tif	Sentinel	ESA	10	2020	August
20200820T141739_20200820T141738_T21NUB.tif	Sentinel	ESA	10	2020	August
20200823T142739_20200823T142734_T20NRN.tif	Sentinel	ESA	10	2020	August
20200823T142739_20200823T142734_T21NTJ.tif	Sentinel	ESA	10	2020	August
20200823T142739_20200823T142734_T21NUJ.tif	Sentinel	ESA	10	2020	August
20200902T142739_20200902T142734_T20NRN.tif	Sentinel	ESA	10	2020	September
20200904T141741_20200904T142011_T21NUG.tif	Sentinel	ESA	10	2020	September
20200905T143729_20200905T143729_T20PRQ.tif	Sentinel	ESA	10	2020	September
20200907T142741_20200907T142927_T21NTG.tif	Sentinel	ESA	10	2020	September
20200907T142741_20200907T142927_T21NUE.tif	Sentinel	ESA	10	2020	September
20200907T142741_20200907T142927_T21NUF.tif	Sentinel	ESA	10	2020	September
20200907T142741_20200907T142927_T21NUG.tif	Sentinel	ESA	10	2020	September
20200909T141739_20200909T141737_T21NUC.tif	Sentinel	ESA	10	2020	September
20200909T141739_20200909T141737_T21NUD.tif	Sentinel	ESA	10	2020	September
20200909T141739_20200909T141737_T21NUE.tif	Sentinel	ESA	10	2020	September
20200909T141739_20200909T141737_T21NUF.tif	Sentinel	ESA	10	2020	September
20200909T141739_20200909T141737_T21NUG.tif	Sentinel	ESA	10	2020	September
20200909T141739_20200909T141737_T21NVB.tif	Sentinel	ESA	10	2020	September
20200909T141739_20200909T141737_T21NVF.tif	Sentinel	ESA	10	2020	September
20200912T142739_20200912T142733_T20NQL.tif	Sentinel	ESA	10	2020	September
20200912T142739_20200912T142733_T20NQM.tif	Sentinel	ESA	10	2020	September
20200912T142739_20200912T142733_T20NRH.tif	Sentinel	ESA	10	2020	September
20200912T142739_20200912T142733_T20NRK.tif	Sentinel	ESA	10	2020	September
20200912T142739_20200912T142733_T20NRL.tif	Sentinel	ESA	10	2020	September
20200912T142739_20200912T142733_T20NRP.tif	Sentinel	ESA	10	2020	September
20200912T142739_20200912T142733_T21NTC.tif	Sentinel	ESA	10	2020	September
20200912T142739_20200912T142733_T21NTE.tif	Sentinel	ESA	10	2020	September
20200912T142739_20200912T142733_T21NTF.tif	Sentinel	ESA	10	2020	September
20200912T142739_20200912T142733_T21NTH.tif	Sentinel	ESA	10	2020	September
20200912T142739_20200912T142733_T21NUD.tif	Sentinel	ESA	10	2020	September
20200912T142739_20200912T142733_T21NUE.tif	Sentinel	ESA	10	2020	September
20200912T142739_20200912T142733_T21NUF.tif	Sentinel	ESA	10	2020	September
20200912T142739_20200912T142733_T21NUG.tif	Sentinel	ESA	10	2020	September
20200912T142739_20200912T142733_T21NUH.tif	Sentinel	ESA	10	2020	September
20200912T142739_20200912T142733_T21NUJ.tif	Sentinel	ESA	10	2020	September
20200912T142739_20200912T142733_T21PTK.tif	Sentinel	ESA	10	2020	September
20200914T141741_20200914T141739_T21NUH.tif	Sentinel	ESA	10	2020	September
20200914T141741_20200914T142123_T21NUD.tif	Sentinel	ESA	10	2020	September
20200914T141741_20200914T142123_T21NUE.tif	Sentinel	ESA	10	2020	September

20200914T141741_20200914T142123_T21NUF.tif	Sentinel	ESA	10	2020	September
20200914T141741_20200914T142123_T21NWC.tif	Sentinel	ESA	10	2020	September
20200917T142741_20200917T142735_T21NTJ.tif	Sentinel	ESA	10	2020	September
20200919T141739_20200919T141737_T21NUF.tif	Sentinel	ESA	10	2020	September
20200919T141739_20200919T141737_T21NUG.tif	Sentinel	ESA	10	2020	September
20200919T141739_20200919T141737_T21NUH.tif	Sentinel	ESA	10	2020	September
20200919T141739_20200919T141737_T21NVF.tif	Sentinel	ESA	10	2020	September
20200919T141739_20200919T141737_T21NVG.tif	Sentinel	ESA	10	2020	September
20200919T141739_20200919T141737_T21NVH.tif	Sentinel	ESA	10	2020	September
20200919T141739_20200919T142117_T21NTB.tif	Sentinel	ESA	10	2020	September
20200919T141739_20200919T142117_T21NTC.tif	Sentinel	ESA	10	2020	September
20200919T141739_20200919T142117_T21NUB.tif	Sentinel	ESA	10	2020	September
20200919T141739_20200919T142117_T21NUC.tif	Sentinel	ESA	10	2020	September
20200919T141739_20200919T142117_T21NUD.tif	Sentinel	ESA	10	2020	September
20200919T141739_20200919T142117_T21NUE.tif	Sentinel	ESA	10	2020	September
20200919T141739_20200919T142117_T21NUF.tif	Sentinel	ESA	10	2020	September
20200919T141739_20200919T142117_T21NVB.tif	Sentinel	ESA	10	2020	September
20200919T141739_20200919T142117_T21NVC.tif	Sentinel	ESA	10	2020	September
20200919T141739_20200919T142117_T21NVD.tif	Sentinel	ESA	10	2020	September
20200919T141739_20200919T142117_T21NVE.tif	Sentinel	ESA	10	2020	September
20200919T141739_20200919T142117_T21NWC.tif	Sentinel	ESA	10	2020	September
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20200920T143731_20200920T143732_T20NPN.tif	Sentinel	ESA	10	2020	September
20200920T143731_20200920T143732_T20NQL.tif	Sentinel	ESA	10	2020	September
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20200922T142739_20200922T142733_T20NQN.tif	Sentinel	ESA	10	2020	September
20200922T142739_20200922T142733_T20NRG.tif	Sentinel	ESA	10	2020	September
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20200922T142739_20200922T142733_T21NUH.tif	Sentinel	ESA	10	2020	September
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20200924T141741_20200924T141740_T21NUB.tif	Sentinel	ESA	10	2020	September
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20200929T141739_20200929T141738_T21NVB.tif	Sentinel	ESA	10	2020	September
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20200929T141739_20200929T141738_T21NVG.tif	Sentinel	ESA	10	2020	September
20200929T141739_20200929T141738_T21NVH.tif	Sentinel	ESA	10	2020	September
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20200930T143731_20200930T144000_T20NQM.tif	Sentinel	ESA	10	2020	September
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20201010T143731_20201010T143733_T20NQN.tif	Sentinel	ESA	10	2020	October
20201010T143731_20201010T143733_T20NQP.tif	Sentinel	ESA	10	2020	October
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20201012T142739_20201012T142947_T21NTG.tif	Sentinel	ESA	10	2020	October
20201012T142739_20201012T142947_T21NUD.tif	Sentinel	ESA	10	2020	October
20201014T141741_20201014T141741_T21NVC.tif	Sentinel	ESA	10	2020	October
20201014T141741_20201014T141741_T21NVF.tif	Sentinel	ESA	10	2020	October
20201014T141741_20201014T141741_T21NVH.tif	Sentinel	ESA	10	2020	October
20201015T143729_20201015T143730_T20NQP.tif	Sentinel	ESA	10	2020	October
20201017T142741_20201017T142736_T20NQL.tif	Sentinel	ESA	10	2020	October
20201017T142741_20201017T142736_T20NRG.tif	Sentinel	ESA	10	2020	October
20201017T142741_20201017T142736_T20NRH.tif	Sentinel	ESA	10	2020	October
20201017T142741_20201017T142736_T20NRJ.tif	Sentinel	ESA	10	2020	October
20201017T142741_20201017T142736_T21NTE.tif	Sentinel	ESA	10	2020	October
20201017T142741_20201017T142736_T21NTH.tif	Sentinel	ESA	10	2020	October
20201017T142741_20201017T142736_T21NUD.tif	Sentinel	ESA	10	2020	October
20201017T142741_20201017T142736_T21NUE.tif	Sentinel	ESA	10	2020	October
20201017T142741_20201017T142736_T21NUF.tif	Sentinel	ESA	10	2020	October
20201017T142741_20201017T142736_T21NUH.tif	Sentinel	ESA	10	2020	October

20201022T142739_20201022T142734_T20NRG.tif	Sentinel	ESA	10	2020	October
20201022T142739_20201022T142734_T21NTC.tif	Sentinel	ESA	10	2020	October
20201022T142739_20201022T142734_T21NTD.tif	Sentinel	ESA	10	2020	October
20201024T141741_20201024T141740_T21NVG.tif	Sentinel	ESA	10	2020	October
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20201111T142729_20201111T142732_T20NRL.tif	Sentinel	ESA	10	2020	November
20201111T142729_20201111T142732_T21NTF.tif	Sentinel	ESA	10	2020	November
20201121T142729_20201121T142731_T20NRJ.tif	Sentinel	ESA	10	2020	November
20201123T141741_20201123T141856_T21NVG.tif	Sentinel	ESA	10	2020	November
20201203T141731_20201203T141734_T21NVF.tif	Sentinel	ESA	10	2020	December
20201203T141731_20201203T141734_T21NVH.tif	Sentinel	ESA	10	2020	December
20201213T141731_20201213T141732_T21NVD.tif	Sentinel	ESA	10	2020	December
20201213T141731_20201213T141732_T21NVE.tif	Sentinel	ESA	10	2020	December
L8_P229R58_200809_U_O.tfw	Landsat 8 DCM	USGS Glovis	30	2020	August
L8_P229R59_200809_U_O.tfw	Landsat 8 DCM	USGS Glovis	30	2020	August
L8_P229R58_200910_U_O.tfw	Landsat 8 DCM	USGS Glovis	30	2020	September
L8_P229R59_200910_U_O.tfw	Landsat 8 DCM	USGS Glovis	30	2020	September
L8_P230R57_200906_U_O.tfw	Landsat 8 DCM	USGS Glovis	30	2020	September
L8_P230R59_200901_U_O.tfw	Landsat 8 DCM	USGS Glovis	30	2020	September
L8_P231R57_200908_U_O.tfw	Landsat 8 DCM	USGS Glovis	30	2020	September
L8_P231R57_200924_U_O.tfw	Landsat 8 DCM	USGS Glovis	30	2020	September
L8_P231R58_200924_U_O.tfw	Landsat 8 DCM	USGS Glovis	30	2020	September
L8_P231R59_200924_U_O.tfw	Landsat 8 DCM	USGS Glovis	30	2020	September
L8_P232R54_200915_U_O.tfw	Landsat 8 DCM	USGS Glovis	30	2020	September
L8_P233R55_200922_U_O.tfw	Landsat 8 DCM	USGS Glovis	30	2020	September
L8_P233R56_200922_U_O.tfw	Landsat 8 DCM	USGS Glovis	30	2020	September
L8_P229R58_201012_U_O.tfw	Landsat 8 DCM	USGS Glovis	30	2020	October
L8_P229R59_201012_U_O.tfw	Landsat 8 DCM	USGS Glovis	30	2020	October
L8_P230R56_201001_U_O.tfw	Landsat 8 DCM	USGS Glovis	30	2020	October
L8_P230R56_201003_U_O.tfw	Landsat 8 DCM	USGS Glovis	30	2020	October
L8_P230R58_201003_U_O.tfw	Landsat 8 DCM	USGS Glovis	30	2020	October
L8_P230R58_201007_U_O.tfw	Landsat 8 DCM	USGS Glovis	30	2020	October
L8_P230R59_201003_U_O.tfw	Landsat 8 DCM	USGS Glovis	30	2020	October
L8_P230R59_201019_U_O.tfw	Landsat 8 DCM	USGS Glovis	30	2020	October
L8_P231R55_201010_U_O.tfw	Landsat 8 DCM	USGS Glovis	30	2020	October
L8_P231R55_201026_U_O.tfw	Landsat 8 DCM	USGS Glovis	30	2020	October

L8_P231R56_201010_U_O.tfw	Landsat 8 DCM	USGS Glovis	30	2020	October
L8_P231R56_201026_U_O.tfw	Landsat 8 DCM	USGS Glovis	30	2020	October
L8_P231R57_201010_U_O.tfw	Landsat 8 DCM	USGS Glovis	30	2020	October
L8_P231R58_201010_U_O.tfw	Landsat 8 DCM	USGS Glovis	30	2020	October
L8_P231R58_201026_U_O.tfw	Landsat 8 DCM	USGS Glovis	30	2020	October
L8_P231R59_201026_U_O.tfw	Landsat 8 DCM	USGS Glovis	30	2020	October
L8_P232R54_201001_U_O.tfw	Landsat 8 DCM	USGS Glovis	30	2020	October
L8_P232R55_201001_U_O.tfw	Landsat 8 DCM	USGS Glovis	30	2020	October
L8_P232R55_201017_U_O.tfw	Landsat 8 DCM	USGS Glovis	30	2020	October
L8_P232R56_201001_U_O.tfw	Landsat 8 DCM	USGS Glovis	30	2020	October
L8_P232R56_201017_U_O.tfw	Landsat 8 DCM	USGS Glovis	30	2020	October
L8_P232R57_201001_U_O.tfw	Landsat 8 DCM	USGS Glovis	30	2020	October
L8_P232R57_201017_U_O.tfw	Landsat 8 DCM	USGS Glovis	30	2020	October
L8_P233R55_201008_U_O.tfw	Landsat 8 DCM	USGS Glovis	30	2020	October
L8_P233R55_201024_U_O.tfw	Landsat 8 DCM	USGS Glovis	30	2020	October
L8_P233R56_201008_U_O.tfw	Landsat 8 DCM	USGS Glovis	30	2020	October
L8_P233R56_201024_U_O.tfw	Landsat 8 DCM	USGS Glovis	30	2020	October
L8_P231R55_201127_U_O.tfw	Landsat 8 DCM	USGS Glovis	30	2020	November
L8_P231R56_201127_U_O.tfw	Landsat 8 DCM	USGS Glovis	30	2020	November
L8_P232R54_201118_U_O.tfw	Landsat 8 DCM	USGS Glovis	30	2020	November
L8_P232R56_201118_U_O.tfw	Landsat 8 DCM	USGS Glovis	30	2020	November
L8_P230R56_201210_U_O.tfw	Landsat 8 DCM	USGS Glovis	30	2020	December
L8_P230R57_201206_U_O.tfw	Landsat 8 DCM	USGS Glovis	30	2020	December
L8_P231R59_201213_U_O.tfw	Landsat 8 DCM	USGS Glovis	30	2020	December
L8_P232R55_201220_U_O.tfw	Landsat 8 DCM	USGS Glovis	30	2020	December
L8_P232R57_201220_U_O.tfw	Landsat 8 DCM	USGS Glovis	30	2020	December
116_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - December
121_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - December
127_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - December
129_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - December
133_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - December
135_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - December
136_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - December
141_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - December
142_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - December

143_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - December
144_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - December
147_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - December
153_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - December
157_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - December
161_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - December
164_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - December
167_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - December
168_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - December
169_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - December
171_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - December
174_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - December
177_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - December
178_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - December
179_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - December
17_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - December
181_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - December
182_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - December
183_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - December
185_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - December
186_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - December
187_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - December
190_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - December
195_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - December
196_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - December
198_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - December
200_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - December
202_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - December
203_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - December
205_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - December
208_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - December
209_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - December
212_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - December
213_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - December
219_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - December

220_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - De-cember
221_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - De-cember
222_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - De-cember
223_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - De-cember
225_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - De-cember
226_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - De-cember
227_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - De-cember
228_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - De-cember
235_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - De-cember
237_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - De-cember
239_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - De-cember
23_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - De-cember
240_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - De-cember
241_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - De-cember
243_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - De-cember
247_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - De-cember
249_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - De-cember
251_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - De-cember
252_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - De-cember
253_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - De-cember
257_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - De-cember
258_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - De-cember
259_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - De-cember
262_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - De-cember
263_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - De-cember
264_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - De-cember
267_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - De-cember
269_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - De-cember
26_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - De-cember
270_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - De-cember
271_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - De-cember
273_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - De-cember
276_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - De-cember
280_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - De-cember
282_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - De-cember

283_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - December
285_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - December
287_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - December
288_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - December
294_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - December
296_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - December
297_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - December
298_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - December
29_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - December
300_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - December
301_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - December
302_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - December
303_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - December
304_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - December
305_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - December
306_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - December
308_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - December
309_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - December
30_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - December
313_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - December
315_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - December
319_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - December
320_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - December
321_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - December
322_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - December
323_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - December
324_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - December
326_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - December
329_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - December
330_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - December
331_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - December
332_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - December
333_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - December
335_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - December
336_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - December

340_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - December
341_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - December
342_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - December
343_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - December
344_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - December
346_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - December
347_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - December
348_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - December
351_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - December
352_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - December
353_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - December
354_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - December
355_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - December
356_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - December
357_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - December
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360_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - December
361_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - December
362_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - December
363_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - December
364_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - December
365_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - December
366_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - December
367_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - December
368_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - December
370_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - December
372_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - December
373_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - December
374_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - December
378_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - December
381_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - December
385_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - December
387_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - December
388_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - December
389_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - December

390_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - December
392_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - December
393_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - December
395_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - December
398_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - December
399_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - December
39_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - December
402_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - December
403_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - December
406_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - December
407_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - December
408_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - December
410_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - December
414_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - December
416_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - December
419_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - December
422_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - December
423_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - December
424_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - December
426_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - December
427_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - December
428_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - December
429_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - December
430_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - December
431_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - December
433_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - December
436_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - December
43_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - December
45_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - December
47_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - December
49_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - December
50_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - December
52_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - December
54_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - December
60_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - December

62_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - December
64_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - December
65_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - December
66_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - December
70_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - December
71_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - December
72_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - December
75_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - December
79_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - December
7_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - December
80_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - December
85_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - December
86_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - December
88_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - December
89_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - December
8_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - December
90_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - December
93_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - December
96_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - December
97_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - December
98_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - December
99_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - December
9_S2_SR_2020_08_01_2021_01_01_median_S2Cloudless_RGB_NIR_8bit.tif	Sentinel	ESA	10	2020	August - December