RapidEye Imagery for REDD+ MRV Activities: Guyana

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Background

Guyana possesses one of the largest tracts of untouched rainforest in South America. In 2009, the Governments of Norway and Guyana embarked on one of the first national-scale REDD+ initiatives to preserve Guyana's forests. The bilateral agreement sets out how the two countries would work together to achieve the objective of Guyana conserving its forest stocks and helping reduce global carbon emissions.

The aim was to create a REDD+ MRV system with a solid methodology for the detection and reporting of national forest change. Potentially the methods employed could serve as a model that could assist other countries to progress their REDD+ MRV initiatives off the ground.

MRV
The most frequently discussed topic under forest carbon monitoring is Measurement, Reporting and Verification (MRV) of forest carbon stocks. The question is, how can the amount of forest carbon, including changes over time be reliably accounted for? This is the core monitoring challenge in REDD+, being the main efforts on the reporting to the UNFCCC at national level, with the subsequent accounting of valuable carbon credits for the country as a whole.

The Measurement Element
Measurement in REDD+ refers to i) forest area and area change, and ii) forest carbon stock and carbon stock changes (EF). Together, this information provides the grounds for creating a greenhouse gases (GHGs) inventory.

Initially, the Guyana Forestry Commission (GFC) found the wall-to-wall mapping and monitoring program to be a major undertaking, due to the size of the country (~215,000 km^2). It has since found a way to effectively establish processes to streamline operations and standardize outputs that enables annual reporting of forest change.

AAM, RapidEye's distributor in Australia and New Zealand, managed the supply of the imagery for this project.

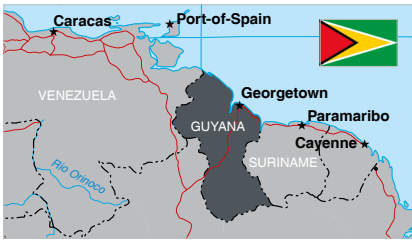
Challenge

As with all REDD+ MRV projects, the first step is to establish an historic trend to determine the rate of forest loss.

The GFC, as with most REDD participants, used Landsat data to establish the historic rate of forest loss and to determine the initial forest area. The forest cover was calculated for three points in time spanning from 1990 to 2009. This information was then used to calculate the rate of forest loss. Over this period about 3,800 hectares per year (0.02%) was deforested.

The 2009 Landsat dataset was set as the benchmark and provides a snapshot of the area of forested land in Guyana. The forest area as of 2009 has been set as the benchmark to which all future rates of deforestation and forest degradation are referenced against.

Image 1: Gold mining activity in Cuyuni District. Mining is one of the major activities contributing to deforestation in Guyana.



AAM Indufor

Background
In 2009 Guyana and Norway started working together in one of the first REDD+ MRV projects in the world at a country level. The main goal of this initiative was to establish the processes to monitor forest loss and degradation. In addition, this work also aimed to develop a solid methodology which could be applied and shared with other countries.

Challenge
Until 2009, the only cost-effective and reliable source of imagery to accomplish the goals of this project was Landsat. In order to maintain continuity and improve the quality of the detection the GFC/Indufor team evaluated RapidEye imagery. In 2011, RapidEye imaged 60% of Guyana over a four month period. In 2012, this was expanded to the entire country.

Results
Guyana has established an annual, nation-wide MRV system. The historical analysis (1990-2009) has shown that the country lost about 0,02% of its forest area every year. The incorporation of RapidEye and improved forest change routines into the MRV system have resulted in improved detection and classification of both deforestation and degradation events.

Validation
The University of Durham (England) ran an independent validation to verify these results. Their estimation of 2011 forest loss was the same as reported by the Guyana Forestry Commission using RapidEye imagery, with an accuracy level of 99.2%.

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Forest degradation was impossible to assess from the first year dataset due to the low resolution of the Landsat imagery. As a result, the degradation estimates for the first measurement year (2010) were based on the assumption that forest degradation radiates from deforested sites for a distance of 500 meters.

The GFC and Indufor team decided that high resolution imagery was required to improve the detection of small-scale degradation events. A methodology was developed using five meter RapidEye imagery. The method adopted considered the visual characteristics of degradation including, size, proximity and its spectral characteristics.

The team is now using one of the recognized analytical approaches as outlined in the GOFC GOLD Source Book (http://www.gofcgold.wur.nl/redd/). This approach requires land use changes to be monitored spatially at a minimum mapping unit (MMU) of one hectare, and they are using RapidEye imagery to do it.

An improved approach for year two

In 2011, the RapidEye constellation was tasked over a four month period to collect approximately 12 million hectares (120,000 km^2) of new imagery over all previously identified year one (2009-2010) forest loss areas.

» RapidEye imagery...turned out to be of excellent radiometric quality and of a spatial resolution ideally suited to the task of deforestation mapping. We strongly suggest that RapidEye data are used to target the High Risk stratum to help validate the year two REDD+ mapping «

– Guyana Forestry Commission (GFC)

Using the higher resolution RapidEye imagery as opposed to strictly Landsat, a higher level of accuracy in the mapping was achieved. This is particularly apparent in determining the cause and the extent of both forest loss and degradation.

While the overall change identification process was consistent from year 1 to year 2, modifications were made to accommodate the shift from 30 m Landsat to 5 m RapidEye imagery. The most notable change was the two stage evaluation approach that was implemented for year two.

For the first stage, a grid the size of a RapidEye data tile (25 x 25 km) was used to manually screen for change. The second stage used a combination of automated and manual processes to detect change. Each change event was systematically evaluated by casting a 1 x 1 km grid over the image. The outcome showed that changes could easily be identified in stage one, while accurately quantifying and attributing a cause to the change was carried out in stage two.

Results

Guyana has now established a MRV that allows annual reporting of forest area change at a national level. The historical twenty year (1990 and 2009) trend showed that Guyana lost approximately 3,800 hectares or 0.02% of its forests every year to deforestation. Subsequent annual assessments covering 2010-12 show the rate of change as approximately 10,000 hectares/year (about 0.05%). While these numbers are greater than the historical trend, the FAO 2010 sourcebook shows that Guyana has a deforestation rate which is less than 10% of the average rate for the rest of the South American continent.

Using RapidEye the GFC/Indufor team also quantitatively assessed the extent of forest degradation around deforested areas. The improved detection methodology enabled the arbitrary 500 m degradation buffer placed around deforestation events to be replaced. When reassessed the

Driver	Historical period			Year 1 (2009 - 10)	Year 2 (2010 - 11)	
	1990 - 2000	2001 - 2005	2006 - 2009		Deforestation	Degradation
	Area (ha)					
Forestry (includes forestry infrastructure)	6,094	8,420	4,784	294	234	147
Agriculture	2,030	2,852	1,797	513	72	
Mining (includes mining infrastructure)	10,843	21,438	12,624	9,384	9,205	5,287
Infrastructure	590	1,304	195	64	149	5
Fire (deforestation)	1,708	235		32	136	28
Area Change	**21,267**	**34,249**	**19,400**	**10,287**	**9,796**	**5,467**
Total forest area in Guyana	18,473,394	18,452,127	18,417,878	18,398,478	18,388,190	
Total remaining forest area in Guyana	18,452,127	18,417,878	18,398,487	18,388,190	18,378,394	
Deforestation (%)	0.01%	0.04%	0.02%	0.06%	0.05%	

Table1: Forest Change Area by Period & Driver from 1990 to 2011. Source: GFC and Indufor.

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RadidEye-based process resulted in a dramatic reduction in the area of degradation, falling from 92,000 hectares to 5,600 hectares.

A more precise methodology used to assess degradation, coupled with accurate identification of change areas due to the better spatial resolution (Landsat vs. RapidEye) were all factors contributing to the reduction of forest degradation values.

Precise identification of forest loss and degradation are critical components of any MRV system. High resolution satellite imagery enables systematic, repeatable, transparent and robust measurements of forest resources. This information can be used to monitor compliance (forestry or mining), inform policy and importantly in Guyana's case prove that Guyana has met or exceeded the performance-based targets established in the bilateral agreement with the government of Norway.

Validation

Since 2010 an independent in-country validation of the forest change estimates has been conducted by the University of Durham, England. The review process evaluates the accuracy of the mapping by scrutinizing the methodology and developing a statistical sampling approach to verify the results. Their audit concluded that the estimation of the 2011 forest loss was the same as reported by the GFC/Indufor team's analysis. The overall map accuracy (for both deforestation and forest degradation) was 99.2%.

The University of Durham attributed the extremely high accuracy rate to the manual multi-stage methods when validating forest loss, the five meter high resolution RapidEye imagery and the meticulous work of the GFC/Indufor team.

In the University's recommendations and comments, they strongly suggested that RapidEye data be used to image the entire country of Guyana in future years, as it is "of excellent quality and ideally suited for the task". They also stated that RapidEye data was "...of sufficient spatial resolution to identify deforestation and the main drivers of deforestation."

The Guyana Forestry Commission and Indufor team have already received RapidEye coverage over all of Guyana for 2012. This data will also be used to continue the REDD+ MRV of assessing forest loss and degradation. These measurements are used to prove that Guyana has met or exceeded the forest management benchmarks established with the government of Norway that trigger incentive payments.

Special thanks to Pete Watt from Indufor for all his input

How RapidEye can contribute to REDD+

RAPIDEYE ADVANTAGES	CONTRIBUTION TO REDD
High Resolution Imagery (Five Meter Pixel Size)	Ideal for identifying both deforestation and forest degradation. Five meter pixel size is suitable for Minimum Mapping Units (MMU) of 0.5 ha or better
Largest High Resolution Collection Capacity From a Constellation of Five Identical Satellites	Wall-to-wall national coverages in short time frames; allowing for annual, same season coverages, critical for change detection
Multi Temporal	Daily revisit capability allowing for multiple imaging opportunities over the same point on earth. This allows for base and reference mapping, change detection over large areas and reliable acquisitions in cloudy areas
Multi-spectral Sensor With Five Bands (including Red Edge)	RapidEye's sensors were built with the visible bands of Blue, Green and Red as well as Near-Infrared and the Red Edge band, which provides Improved vegetation monitoring and analysis
Multiple Country Coverages Already Available	RapidEye continuously runs background imaging missions over all REDD countries assuring historical data for change detection EyeFind makes it easy to find out quickly! Visit eyefind.rapideye.com
Proven Track Record in Global REDD Efforts	Several current REDD projects rely on RapidEye for monitoring (Mexico, Guyana, Nepal, Costa Rica, Panama and more…)
Guaranteed Data Continuity	RapidEye is committed to providing a long-term data source. While it is assumed RapidEye's constellation will be operational into 2019 or beyond, plans for a second generation are currently underway

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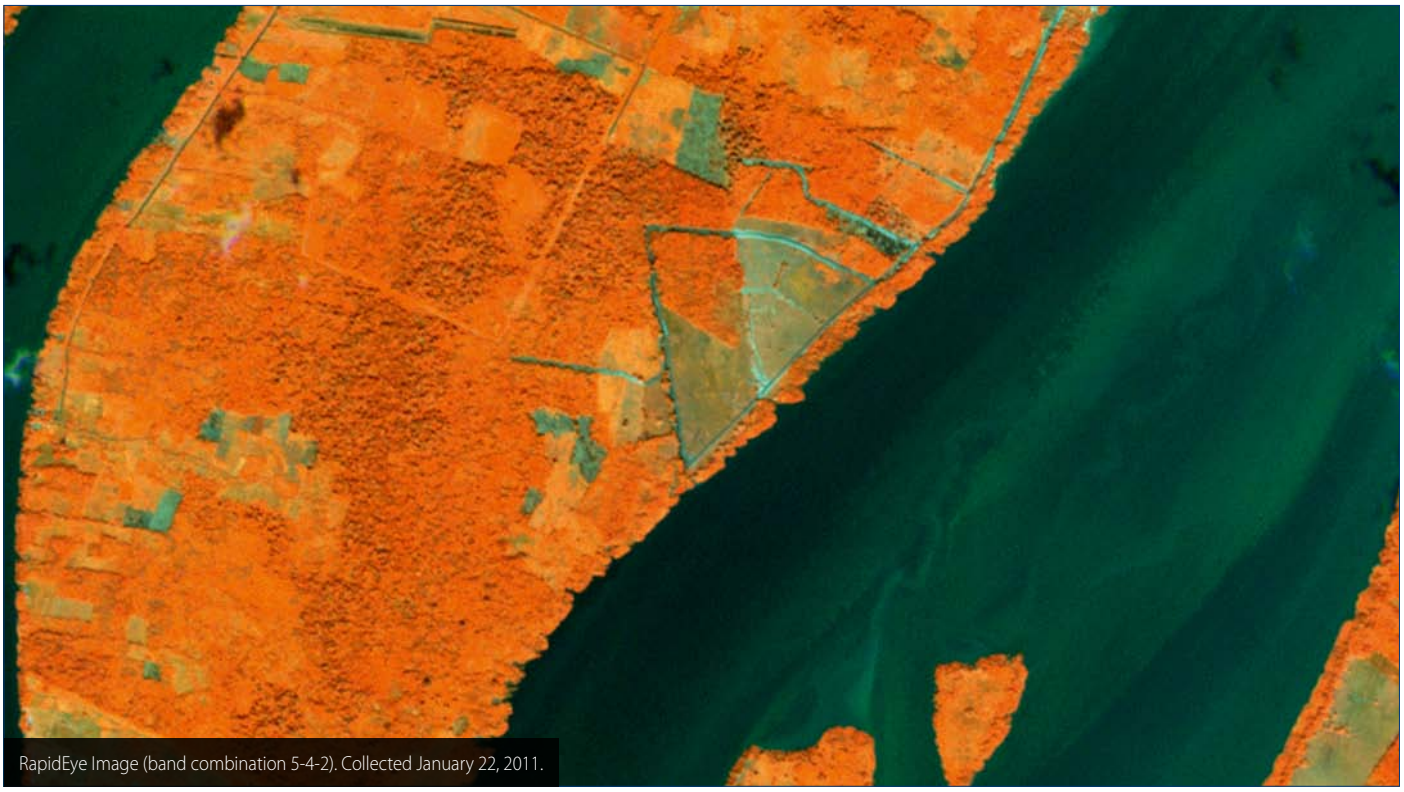
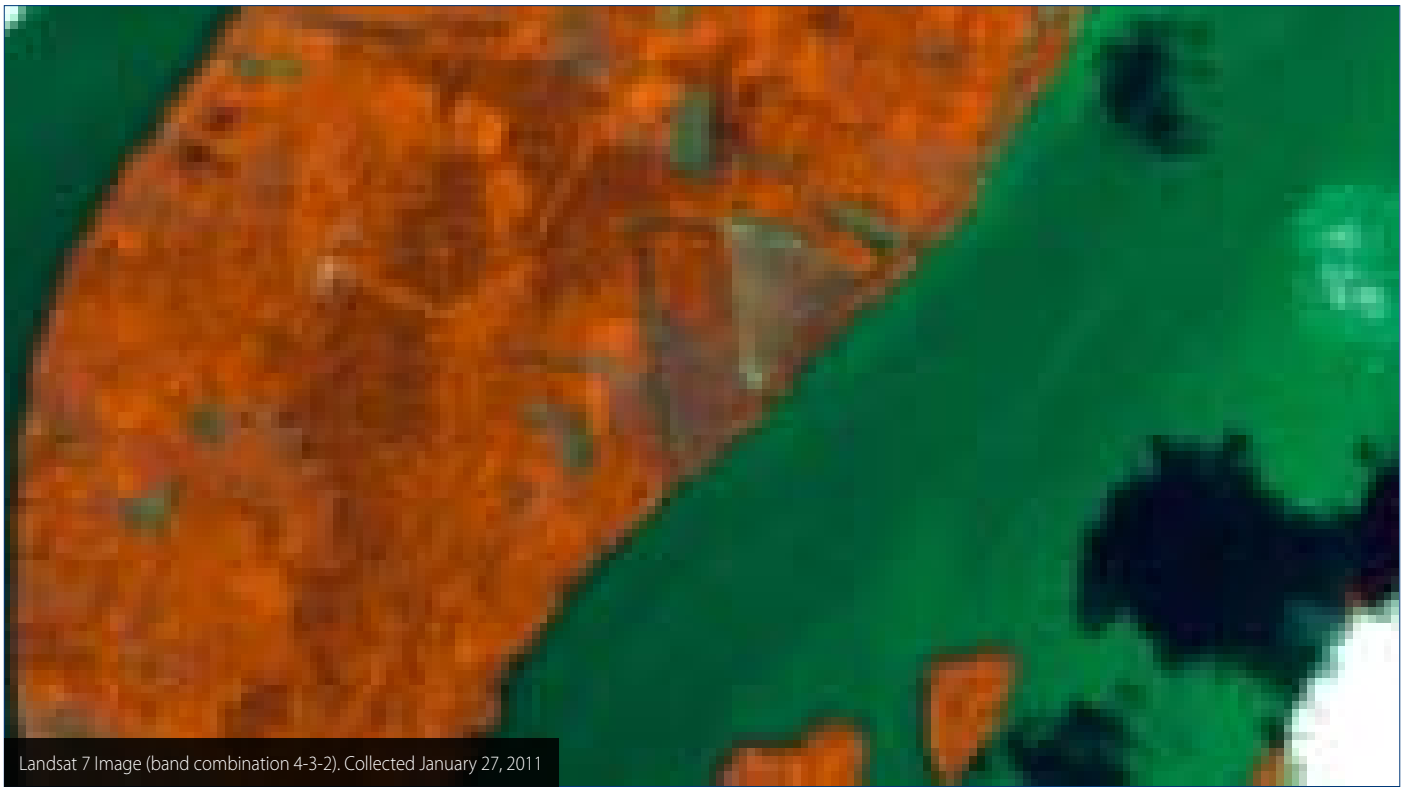


RapidEye Image (band combination 5-4-2). Collected January 22, 2011.



Landsat 7 Image (band combination 4-3-2). Collected January 27, 2011

Images 2 and 3: This example clearly shows how RapidEye imagery allows for detecting and delineating smaller features compared to Landsat 7