REDD+ FOR THE GUIANA SHIELD

Second Working Group Meeting
February 27th and 28th, 2014
Paramaribo, Suriname

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Second Working Group Meeting

Context

The Guiana Shield is one of the largest blocks of primary tropical forest worldwide. Covered with around 90% of intact rainforest, it plays a critical role in mitigating climate change and in water regulation of Amazon and Orinoco basins. This eco-region also has very high biodiversity levels. Until a decade ago, the Guiana Shield forests were under little threat in comparison with other tropical forests. However, countries are burgeoning economically and demographically, leading to increasing pressures on natural ecosystems. The governments are keen to drive their development in a sustainable manner and in that perspective, they have shown strong interest in REDD+ as a mechanism that would enable to financially value their efforts, thanks to carbon revenues.

The project ***REDD+ for the Guiana Shield*** was initiated by Guyana, Suriname and France, at the occasion of the UNFCCC's fourteenth Conference of Parties, held in 2008 in Poznan. Shortly afterwards the state of Amapá in Brazil joined. The project aims at providing information and tools to be used by countries to establish sound science-based policies and measures to tackle deforestation and degradation, in the framework of REDD+ mechanism. The project is funded by the Regional Development European Fund (FEDER) through the Interreg IV Caraïbes program (1.26 M€), the French Global Environmental Facility (FFEM – 1 M€), the French Guiana Region (90 000 €), as well as by the project partners own contributions. Financing Agreements with donors have been signed late 2012 and the project officially started in January 2013.

Cooperation and capacity-building are key strategic components of the project. While in the same eco-region, Guiana Shield countries have different histories and have developed their own priorities. There is therefore high opportunity for lessons learning in the region starting through information and good practices sharing. The project encourages **cooperation** between neighboring countries on REDD+, thanks to a **technical and regional platform** that will focus on inventory of the resources (carbon stocks and forest surfaces), improvement of the quantified understanding of drivers of deforestation and forest degradation, as well as on modeling forest cover evolution. The platform includes four channels for **capacity building**: training and technology transfer; country/state-level support; regional discussions in the framework of Steering Committee meetings; as well as regional **Working Group** meetings.

This document contains the report of the **Second Working Group meeting**, which was held in Paramaribo, Suriname on 27-28 February 2014. As part of the *REDD+ for the Guiana Shield* project, the event was organized by ONFI, hosted by Suriname's Foundation for Forest Management and Production Control (SBB), and funded by FFEM, European Commission and Région Guyane. Contributing to the project's Component 1, the topic of the working group meeting was **"Mapping for REDD+: Tools and classification methods for forest cover monitoring"**.

Objectives

The aim of the Second Working Group Meeting was to compare methodologies that have been developed and are used within or outside the region and discuss specific technical topics in order to enhance a common understanding of REDD+ MRV through training and technology transfer.

Specific objectives included:

- Initiating regional dialogue to identifying gaps (data and methodologies) at national and regional level (i.e. in the perspective of a common view of REDD+ MRV);
- Build capacity (through lessons learnt and sharing of good practices);

- Discuss the development of a Regional cooperation platform;
- Prepare technical inputs and feed into Steering Committee decision making.

The two days of work were divided in four sessions, each one developing a specific sub-topic and counting with the contribution from experts in order to enrich the discussion. The meeting enabled technicians from the partner organizations to discuss the following relevant topics:

- Use of optical imagery for MRV;
- Use of radar imagery for MRV;
- Defining classes of land use;
- Dealing with shifting cultivation in forest monitoring.

Agenda

The meeting followed the Agenda below:

27th February 2014

8h30 – 9h	**Welcome remarks**
9h – 12h30	**Session 1: Use of optical imagery for MRV**
	09h00-09h15 – *Introduction to the session*
	09h15-10h15 – *Presentation by expert + discussion*
	10h15-10h30 – *Coffee Break*
	10h30-11h15 – *Country roundtable*
	11h15-12H30 – Discussion
12h30 – 13h30	**Lunch**
13h30 – 17h	**Session 2: Use of radar imagery for MRV**
	13h30-13h45 – *Introduction to the session*
	13h45-14h45 – *Presentation by expert + discussion*
	14h45-15h30 – *Country roundtable*
	15h30-15h45 – *Coffee Break*
	15h45-17H00 – Discussion

28th February 2014

8h30 – 12h	**Session 3: Defining classes of land use**
	09h00-09h15 – *Introduction to the session*
	09h15-10h15 – *Presentation by expert + discussion*
	10h15-10h30 – *Coffee Break*
	10h30-11h15 – *Country roundtable*
	11h15-12H30 – Discussion
12h – 13h	**Lunch**
13h – 16h30	**Session 4: Dealing with shifting cultivation in forest monitoring**
	13h30-13h45 – *Introduction to the session*
	13h45-14h45 – *Presentation by expert + discussion*
	14h45-15h30 – *Country roundtable*
	15h30-15h45 – *Coffee Break*
	15h45-17H00 – *Discussion*
16h30 – 17h	**Conclusion and approval of a position paper**

List of Participants

Name	Organization	Name	Organization
Rene SOMOPAWIRO	SBB, Suriname	Haidy LEPELBLAD	NIMOS, Suriname
Sarah CRABBE	SBB, Suriname	Gaelle VERGER	ONF Guyane, French Guiana
Mark DJOJODIKROMO	SBB, Suriname	Nicolas DEGARNE	ONF Guyane, French Guiana
Charlene SANCHES	SBB, Suriname	Thiago ZAMPIVA	IEF, Amapá
Cindyrella KASANPAWIRO	SBB, Suriname	Lana OLIVEIRA	IEF, Amapá
Reshma JANKIPERSAD	SBB, Suriname	José Maria ROSÁRIO	SEMA, Amapá
Consuela PALOENG	SBB, Suriname	Patrick FARIAS	SEMA, Amapá
Seth PANKA	SBB, Suriname	Eleneide Doff SOTTA	EMBRAPA, Amapá
Consuela PALOENG	SBB, Suriname	Marie CALMEL	ONF International
Valentien MOE SOE LET	SBB, Suriname	Sérgio MILHEIRAS	ONF International
Pearl JULES	SBB, Suriname	Sara SVENSSON	ONF International
Maureen PLAYFAIR	CELOS, Suriname	Sabá LOFTUS	ONF International
Anwar HELSTONE	CELOS, Suriname	Anne-Cécile CAPEL	ONF International
Razia TAUS	CELOS, Suriname	Anoumou KEMAVO	ONF International

Access to support materials

All presentations made during the 2nd Working Group Meeting can be downloaded, together with other relevant materials, at http://reddguianashield.com/working-groups/working-group-2/

Sessions Summary

February 27th, 2014

Introduction

The objective is to gather expertise from different countries to help forestry services in the Guiana Shield EcoRegion deal with MRV implementation by sharing experiences, methodologies, challenges, ideas, practises, experiences and work on collaborating regionally.

On behalf of the project team, Marie Calmel thanked Suriname for the support in organizing the event, and noted all those present are experts working on the same type of tools, facing same obstacles with imagery and software, therefore joint working can contribute to solve problems, identify new questions, and highlight aspects where there can be synergies. The working group is a chance to explore other methodologies. The format will be a presentation by an expert, Q&A based on the presentation itself and then a roundtable of discussion on national processes. The project team welcome suggestions to improve working group meetings.

On behalf of SBB, Rene Somopawiro welcomed the project partners and highlighted the value of partnership, sharing experiences and collaboration within the region during this learning opportunity. He noted that SBB's aim is to have sustainable use of forest and as a result strong monitoring tools are needed.

Session 1 – Use of Optical Imagery for MRV

Optical images are used due to their range potentiality that circumvents accessibility issues and enables comparisons over time. It allows for the study of complex phenomenon (e.g. changes in coastal lines) and provides reliable surface data for land use analysis and understanding of territory. This includes historical land use, land cover and monitoring over time. There are many different ways of using images, which raise several questions on quality requirements. The two uses of imagery for REDD+, historical LULCC analysis, monitoring of forest cover evolution and assessment of REDD+ performance were focused on during the Working Group. The introduction to Session 1 was given by Marie Calmel, ONFI[1].

The presentation that followed on optical images for MRV[2] by Anne-Cecile Capel, ONFI, included guidance on selecting amongst the different types of data sensors available based on needs including resolution or price and processing time. High resolution data is quite expensive and it may not necessarily be the best option since bands can compensate for low resolution. Low/medium resolution is better for the global scale because there is less noise (high variability of greens and more details), it is less expensive and has a shorter processing time. The process to decide on image use is dynamic. The costs from different sensors were summarised in a comparative table[3] .

[1] The presentation can be found at: http://reddguianashield.files.wordpress.com/2014/03/introduction-session-1.pdf
[2] The presentation can be found at: http://reddguianashield.files.wordpress.com/2014/03/acc-optical-images-for-mrv.pdf
[3] The table can be found at: http://reddguianashield.files.wordpress.com/2014/03/inventory-satellite-images-20140224.pdf

- Optical data is by nature heterogeneous because it is sensible to the season or time of the day. Pre-processing is needed if the images are to be compared with each other (e.g. as is the case with atmospheric correction). There is no magic way to exclude cloud cover. It is possible to classify clouds into a specific class and extract them to continue the process. Inclusion of other types of data like radar can help. It is important to identify what is needed during data preparation and field experience will be important to calibrate the eyes of the expert.
- Based on uses in the region, the different processing methods were introduced (starting with the pixel based method, which aims to extract specific classes from all different pixels in the image). The more bands the better the result, so there needs to be a balance between resolution and spectral bands. The segmentation method is possible with algorithms which are freely available. Classification can be done manually or automatically is it implies defining objects through vectorization of each part of the image.
- Most software provides a post-processing option. For example, additional GIS data can be inserted to add extra information on roads, rivers, etc. which may otherwise prove difficult to extract from the images alone. Filtering can be done to apply the Minimum Mapping Unit linked with the forest definition. Optical data is very useful for accuracy assessment and is a benefit which results from the use of high resolution images.
- It was noted that assessing changes is not an exact science and in each case testing is needed to find the best method. Two wall-to-wall maps can be computed from different dates and compared to assess changes. In most cases there will be false alerts, so an articulated verification is needed to make sure that changes are real. A different option is to extract all changes by manually delineation and classification, which will provide better results, but this can be time consuming. Finally if two different raw data sets e.g. date 1 and date 2 are merged together into one image, it will result in a specific new class that represents the changes.
- The use of optical data has pros and cons. It has a long time series through available archives. In addition, it is possible to improve the resolution with added bands and the images are equal to what the human eye sees so they are easier to understand. Software is also accessible and easy to use. On the other hand, it requires substantial processing time and needs to take into consideration the presence of clouds. Data heterogeneity sometimes requires interpreting each data separately, and it is not always possible to have a global coverage available for this purpose.
- Software for processing optical data was introduced including some free and open source options. The difference between free software which includes no access to the source code (such as sentinel, TerraAmazon, SPRING) and open source software was discussed. The advantage of the later is that a large community keeps improving it by adding new functionality and tools e.g. QGIS has a lot of additional tools. Most available processing can be done on QGIS and is linked to OTB which allows for remote sensing processing. In terms of the data, it is necessary to be aware that free data that takes too much time to process might become more costly than to buy mid priced data with lower processing time.

During the country round table the following was raised:

- On the issue of cloud removal, Mark Djojodikromo, SBB, mentioned that they are testing new methods, such as an automatic tool (LEDAPS) from NASA, but they do not have results yet. Sarah Crabbe, SBB, added that before they used TerraAmazon for cloud detection which worked fairly well, but they are now passing to LEDAPS which might be better as it includes filling the clouds and coming to a mosaic. Eleneide Doff Sotta, Embrapa, indicated that IMAZON developed a tool that tried to extract pixels without clouds. It is not a good tool to classify land use but the results allow the user to distinguish between forested and non-forested areas.
- Gaelle Verger, ONF Guyane, highlighted that in regard to the regional context, medium resolution data is probably the best to balance results and cost. She noted that some high resolution data can be used as a complement or to control the quality or in specific areas that are still unclear after using the first approach.
- Is moving to high definition data definitive or possible to retract? Is it comparable with different resolution images? Anne-Cecile Capel, ONFI, explained that it depends on what you want to do with the data. It is better to start with low resolution data that is free and available, but sometimes it will be difficult to

extract information from it alone. For example, in a study in Cambodia, there was confusion between deciduous forest (no leaves) and soil, so in this case low resolution data was not enough, data was gathered in the field to improve the process and it was then decided that SAR data would be used. Gaelle Verger, ONF Guyane, stressed that it is possible to work with both methods, as it depends on the areas (more homogenous areas require less defined data, while in mosaic areas more definition is required). She noted that the high cost of HD images is also linked with the time that it will take to interpret the data. Anoumou Kemavo, ONFI, added that it is important to know what you want to detect, for example, in a project in central Africa where a type of forest compostеd of red leave trees, medium resolution data was not detecting this tree, and even with HD data there was confusion, so manual detection on HD data was required.

- And how do you combine systems (HD and medium resolutions)? Gaelle Verger, ONF Guyane, said that manual segmentation enables linkage of different images. As for linking classes, this is done differently because of availability of vector information. Anne-Cecile Capel, ONFI, confirmed that it is possible to combine two types of data. Lower resolution pixels can be cut into smaller parts and then merged with HD data. The opposite approach is also possible, but if HD data is degraded, its benefits will decrease. This depends on the results, in which case it is different and therefore difficult to generalize.

After the presentation on optical images for MRV, Gaelle Verger from ONF Guyane presented Monitoring Land Use and Land Use Changes in French Guiana by Optical Remote Sensing[4].

- The objective of the project is to complement existing inventories made for 1990, 2006 and 2008 time points which are elaborated within the Kyoto Protocol framework and provide surface data for 2012, feeding the last French GHG inventory.
- SPOT-5 satellite images were used to create a mosaic for French Guiana in 2012, while 8 Landsat images were used for 1990 along with SPOT 2, SPOT 4 & SPOT 5 for 2008. Different strata, each one with a specific sampling method, was defined based on several existing studies and on expert knowledge. French Guiana adapted the 6 land use categories according to IPCC guidelines. For example, class forests have mangroves as a subclass, while gold mining is a subclass of settlements.
- The results indicated that the 3 main causes of human deforestation in French Guiana are conversions from forest to settlements (including gold mining), forest to cropland and forest to wetland. From 1990/2006 to 2006/2008, the total annual deforestation rose from 3500 ha/year to 5900 ha/year. Nevertheless a large majority (98 %) of the forest is unchanged.
- The methodology selected was used for the NFI and had been validated by the IPCC for France, so it maintained coherence with the rest of national territory. It also does not require alot of expertise, saves digitization time and bias. There is also an ArcGIS extension for the analysis. Quality control was integrated within the statistical process. One important fact is that it can estimate the flow, which is not possible with the stock or surface approach, i.e., there are the same number of points in the category in 1990 and 2006, and are therefore needed to calculate the difference. On the other hand the methodology does not provide information about where deforestation is located and is dependent of availability of high resolution satellite imagery. France is not eligible for REDD+ but has submitted to Kyoto and as such needs a carbon inventory. The efficiency of the method to monitor deforestation has been demonstrated, with monitoring of forest degradation requiring further investigations.
- It enables analysis of the whole territory in a short period of time (annual monitoring process). While wall to wall analysis might not be feasible every year. It is an example of a method that can be used as complement to wall to wall. In REDD+ framework, it does not answer all expectations for land use and land cover maps. To estimate the flow Gaelle Verger thinks it is the easiest and most interesting method in terms of the time it takes to interpret results. There is no map to validate as it includes the photo interpretation process itself and also the statistics. The risk of mistakes is much lower than those which may occur in the segmentation process.

[4] The presentation can be found at: http://reddguianashield.files.wordpress.com/2014/03/guyane-lucf-paramaribo_27022014.pdf

The roundtable then continued discussing relevant issues on the use of optical images for MRV within REDD+ framework in the Guiana Shield.

- José Rosario, SEMA, indicated that the state uses images from Landsat and since 2011, images from RapidEye. In addition they will be acquiring radar images during this year. RapidEye images, which will be available until 2015, have a large cloud cover which poses a problem. At the moment they are working on a new map of deforestation using manual segmentation. An automatic approach was tried but it did not work well. A new methodology to process the images is being developed, which will have its point zero in 2015. In 2016 high resolution images might not be available anymore, so they may then need to continue with Landsat. There are 240 RapidEye scenes needed to cover the whole state. There is a difference in the deforestation rate detected by RapidEye and Landsat because RapidEye has more problems with cloud cover.
- Mark Djojodikromo, SBB, remarked that in Suriname the forest cover monitoring unit was created in 2012 within an ACTO project to produce a regional map 2000 and 2000-2010. The methodology used was similar to INPE's PRODES in Brazil but was adjusted to national conditions, e.g. the minimum mapping unit is 1ha instead of 6.25ha. The images for 2010 were too cloudy, so images from 2009 were used. In Peru in 2012 we agreed to have 4 classes on the maps -- forest, non forest, deforestation and clouds. The software used was TerrAmazon with support from INPE. Other software used was SPRING, PostgreSQL and ArcGIS. To deal with the cloud cover issue, clouds were detected and filled up with images of the same scene from another period. SBB is now in the process of validating maps from 2000 and 2009 and looking at other regional approaches for this issue to produce better maps in the future.
- Next Consuela Paloeng, SBB, added details about the NASA project LEDAPS (Landsat Ecosystem Disturbance Adaptive Processing System). She indicated that last November SBB received training from CI USA on cloud masking using LEDAPS pre-processing tool. After that gap filling can be performed using different tools, such as MosaicPro tool or an IDL-VM script. SBB is testing the IDL-VM script that was developed by CI. This involves going manually over the shape files and adjusting them accordingly while TerrAmazon is used to classify. It works with Landsat-5 and 7 and is being adapted to Landsat-8. It includes semi-automatic processing with manual adjustments when needed and is an open source tool available on the NASA website. (Note: Max Wright from Conservation International, the original presenter, authorized us to share this presentation on the project website[5] - see below for link).

Session 2 – Use of Radar Imagery for MRV

During the second Session, Anne-Cécile Capel, ONFI, presented[6] the differences between optical and radar data. Radar for example does not require sunlight. The signal passes through clouds is and receives it back. Since the same signal sent is always sent, this makes changes from different land/soil interactions easier to identify. It is clear enough for identification between a plain surface (where the signal rebounds and none returns to the sensor) or irregular soil (the signal will be spread with a little part returning). The signal that comes back can be analysed differently (for example it is dark when the signal does not return to the sensor and very bright when the all signal returns to the sensor, with lots of intermediate possibilities (e.g. forest)).

The session also discussed the following:

- The signal that returns might have different polarimetry (horizontal or vertical). This information can be exploited to know what is the use of the land; might help detect different land class wavelengths. We have about 4 different wavelengths (P; L; X; C bands), e.g., if wavelength is 5cm, only objects bigger than 5cm will be detected. X band (1cm) will interact with everything in the forest; C band (5 cm) will pass through the leaves but not the trunk; P,L bands (23 cm or more) will pass through all the trees if forest is very

[5] The presentation can be found at: http://reddguianashield.files.wordpress.com/2014/03/cloudmasking-sbb.pdf
[6] The presentation can be found at: http://reddguianashield.files.wordpress.com/2014/03/session-2-acc.pdf

dense (150 tons of carbon per ha). P,L bands will not go into the soil and the resolution will be lower if there is less signal coming back.

- Advantages of processing radar data includes homogeneity of the data (it is possible to reach a mosaic image quickly and there is no sensitivity to clouds) and interpretation (sensitive to water, humidity [possible to detect flooded forest, swamp forest] it is possible to detect deforestation, degradation; we can find very detailed information on deforestation, as a biomass map is possible, but there is no information after 150 tons of carbon and it is possible also to detect burnt areas in forest). Furthermore, digital elevation model also possible in tropical regions but only with high wavelength sensors.
- Disadvantages include its sensitivity to relief, as you can have weak interpretation and false positives; difficult to interpret; training needed.
- It is possible to use QGIS and PolSARPro for free and good quality. Images are quick to process once the right algorithm is found and large data sets can be processed with a good computer.
- Model elevation is easy to produce and there free option. It is very accurate. ALOS PALSAR is not very expensive (new sensor will be launched this year) and Sentinel1 will be free (launched this year). However, pre process the data needs to be done in a different way than optical data. It is sensitive to season, but you have to compare the same periods for it to be comparable.

A project that covers 600 000 km2 was then presented by Anoumou Kemavo, ONFI. The radar images are 185x185 km2 and therefore 18 images were needed to cover all the area. It took around 10 working days in Suriname to do the classification for one Landsat scene, which means approximately eight months to have a forest/non-forest map of the whole region. A Guiana Shield map shown as example was done in 2 hours, plus 1-2 hours for classification of the all of the region. It is not an easy process that requires training, but it definitely is much faster. The advantage is that you detect more things in radar than optical images. As it was explained:

- Coloured composing uses 3 bands and using the LandSat example, you will have different colours (green, blue, red) in different channels. It is the same thing for radar using different polametries (HH in red; HV in blue; for the green channel either you put the division HH/HV or the same HH+HV). For radar it is necessary to calculate stability (entropy) which is given by HH/HV or HH+HV -- everything that is stable, homogeneous, it is darker in colour; all areas with more variety will be light green.
- Radar data allows for precise monitoring of the evolution of the coastal line; yellow/orange parts will represent diffusion of the signal, so in the image being shown it is mangrove. In an optical image is complicated to discriminate between water and mukumuku, but in radar they are shown differently. It is possible to distinguish between mukumuku and mangrove by colour (e.g. longside rivers there are yellow areas which are flooded areas).
- With only one processing you can produce a classification for the whole region for processing using several logarithms, supervised classification with some manual addition, wall-to-wall, segmentation.

The roundtable then continued discussing relevant issues on the use of radar images for MRV within REDD+ framework in the Guiana Shield.

- José Maria Rosário, SEMA, stated that listening to the speaker it seems very easy to use radar. SEMA had had some images for Amapa and processed it. SEMA used Landsat to confirm and seemed satisfied but when land uses were increased (e.g. different savannah types) it became confusing. It is very difficult to validate when you have more classes without fieldwork.
- Anne-Cécile Capel, ONFI, noted that the c band discriminates this type of classes and is better for that, the image shown was L band
- Gaelle Verger, ONFG, thanked for the presentation on radar because it was the first time she understood a bit more about it; she noted that we are considering using radar in French Guiana, at the moment we don't use it.
- José Maria Rosário, SEMA, noted that they had partial radar work done in 2009 but need more training on it; since they are working out a potential agreement with the army to have new images. However, the P,X bands (the ones that Amapa might get) will not be enough for biomass calculation. They will have a zero

point of high quality with a mix of optical/radar images, but will need to keep using free images for deforestation

- SBB shared that they have a PhD student working on this who has a little experience looking at data but not on how to interpret it. Radar seemed promising with regard to illegal logging and SBB would like to use it for classification of land use/vegetation types, X band for illegal logging
- Nicolas Degarne, ONFG, noted that using radar needs different knowledge but it looked really easy to use radar so we are open to integrate it together with optical data; every 2 years we refresh the data and maybe in the next years we can integrate radar. If possible, we can have a radar working group for more information or a training session, it is important to get operational data to work in instead of abstract
- Anne-Cécile Capel, ONFI, noted that Radar images were used by ONFI because they were working in Central Africa (where cloud cover is also frequent) to monitor illegal logging in a concession. ONFI looked at different sources of data and all had too many clouds, so radar was used. Also in Cambodia there was a problem with deciduous forest, and it was impossible to differentiate two classes (comparing with soil) and the radar was the only way to get this result. Another study was done on a national forest cover of Central Africa, it was difficult to extract swamp and flooded forest (to distinguish them) but with radar it was easy. It was useful to calibrate the map and just by comparison with SAR data it was possible to see that water was producing a small change.
- Thiago Zampiva, IEF, noted that in Amapa forest concessions need to be monitored and the difficulty is to have continual monitoring of concessions. It is a small area which could make it easier to acquire, the problem is that it needs to be continuous, we need practical experiences where radar images where used for this kind of monitoring, these concessions are staring in 2015 with selective cutting starting in 2017 in a area of around 100000 ha, for classification.

February 28th, 2014

Session 3 – Defining Classes of Land Use

The first session of the day was moderated by Marie Calmel, ONFI, and focused on classification of land use. It should be noted that land cover and land use are not the same concepts. The first defines surface cover on the ground while the second is purpose the land serves. The two categories do not require producing different maps, most maps integrate both information.

- What LULUCF classes should be differentiated? IPCC GPG-LULUCF (2006) differentiates 6 classes to have a global standard, but sub categories are possible depending on the context and purpose the map is produced. Those 6 classes are forest, grassland, wetland, cropland, settlements, others.
- To assess deforestation in the context of REDD+ framework, forest/non-forest classes are enough. However, more details will be necessary for other purposes, such as assessing drivers of deforestation or for producing biomass maps in carbon stock assessment.
- Forest definition is a unsettled issue with a huge amount of literature and not clear addressed by any UN convention. Furthermore it is very relevant for REDD+, which has followed the definition developed in Marrakesh for Kyoto Protocol Clean Development Mechanism, more oriented for afforestation and reforestation activities. It sets 3 criteria for defining a forest: *minimum area of land of 0.05-1.0 hectares; tree crown cover of more than 10-30 per cent; trees with the potential to reach a minimum height of 2-5 meters at maturity in situ.* All plantations and areas un-stocked but expected to revert to forest are included in the definition, which is problematic for REDD+.
- The latest Warsaw Framework national forest monitoring text indicates the definition of forest includes but might not limited to natural forests and is defined by the country. There is no clear definition of forest throughout the text, only vague mentions.

- The 3 criteria mentioned (height of tree, surface area, tree crown cover) are the only guidance. But the decision between different value will depend on the context, the data available and political considerations. The definition selected will make national forest smaller or larger, a political decision connected to what there is intention to value or to be considered deforestation. For example, depending what region is being considered, people might be more or less sensible to the 30% tree cover threshold for forest definition (e.g. Africa more sensible due to huge areas of savannah, while the Guiana Shield is much less sensible). Therefore, the selection of the criteria are dependent on context.
- In the process to define land use/land cover classes it is relevant to collect knowledge from different sources (knowledge of the local forest, deforestation/degradation dynamics, etc.). Plus, the purpose/objectives of the map are relevant too. For example, discriminating gold mining might be relevant if the purpose of the map is to monitor deforestation. The classification is applied to a specific regional context and implies a dynamic process where different approaches might need to be tested before reaching the pretended outcome.

Next, Anoumou Kemavo, ONFI, demonstrated how to process optical satellite images to reach an unsupervised and a supervised classification of land use/land cover on QGIS, a free and open source software for processing remote sensing images. A tutorial with screenshots of all the steps shown during the demonstration are available for download at the meeting's web page[7].

- What are the implications of the 3 criteria defining forest (minimum surface, tree cover, height of tree at maturity) for remote sensing analysis of LandSat images (30m resolution)? If definition is 1 ha, 11 pixels need to be analysed (minimum map unit – MMU), patches of forest smaller than that will not be considered. As for 0.05 ha minimum surface, the MMU will be less than 1, so not possible with LandSat (MMU= S/(spR*spR), S=minimum surface, spR= resolution).
- As for the second criteria, tree crown coverage of 10%-30%, it is a bit abstract because the difference cannot be discriminated in the images. It needs addition information, namely field work or aerial images, which are too expensive to obtain at national level.
- Tree height cannot be confirmed only with LandSat images. Furthermore is not a question in tropical regions where 5m are expected to always be reached. However, in for example Morocco forest the case is different, therefore they will use a lower threshold.
- QGIS has extensions for remote sensing processing. For an unsupervised classification KMEANS is needed. It will enable to select different criteria (such as validity mask, number of classes, max number of iterations, etc). Unsupervised classification can be used when it is difficult to distinguish between classes. More details available in the tutorial.
- For a supervised classification the extension used is named OTB, which is integrated in the newer version of the software. The most relevant step in this method is the selection of training polygons for each class, where the polygons need to be enough to represent well the spectral variation of the land use in the correspondent class within the image. After the result is obtained, it is possible to run a tool to validate the processed image using a accuracy assessment plugin that creates a confusion matrix indicating possible overlap between classes. More details available in the tutorial.

Marie Calmel, ONFI, and Anne-Cecile Capel, ONFI, then continued discussing the available methodologies to refine classification and the risks and consequences of discriminating between several classes.

- There are options for improving the results, depending on the desired outcome. For example, classes can be added or combined together to modify the final result. Additional layers of data from aerial images or field work can be inserted, as well as combine optical and radar data. If you were working with LandSat and then get higher resolution data, you will need to degrade the high resolution data before integrating it on your baseline map. Different satellite bands can also add information (e.g. Landsat-8 has 11 bands), although bands have to be converted to the same spatial resolution first. A buffer area can be created to

[7] The tutorial can be found at: http://reddguianashield.com/working-groups/working-group-2/

deal with degradation highlighting where forests are under anthropogenic pressures. This requires defining degradation drivers and good field knowledge, including extra plots of carbon stock measurements.

- When classifying different types of degradation that may introduce noise and lead to misleading results. The choice of training polygons is the most important step to avoid it. There are also some statistical analysis to make sure that there are no overlaps between the classes that you are trying to analyse.
- Therefore, once a classification is reached there are existing ways to add more classes, which might improve accuracy. However, the more classes are inserted, the more validation work is required. That can be complicated and subsequent merging and reduction of some classes might be needed. Having many classes is a long-term commitment because all classes need to be monitored, except for classes with stable data. It will increase the duration of the process and its cost due to more images, more field work, more human resources needed. A more detailed classification should be a decision that reflects a specific purpose, and not only because it is possible.

The session progressed to a round table format, moderated by Sara Svensson, where participants had the opportunity to share the work that is being developed in their countries and learn from other similar experiences in the region concerning the session's topic. The moderator presented different questions to the participants, namely regarding the forest definition used and why it was selected, what classes are being used, and if improvements to that system are being equated.

- For Amapá, Eleneided Doff Sotta, Embrapa, clarified that for Brazil the definition of forest and its classes used were defined by IBGE (Instituto Brasileiro de Geografia e Estatística) and there is no specific criteria on minimum tree height, minimum tree cover, minimum area. IBGE has a report describing the biophysical characteristics of each class, forest classes are defined for species composition, soil type, topography, etc. Major classes used in Amapá are flooded forest, savannah, mangrove, upland forest, transition forest, flooded fields.
- Gaelle Verger, ONFG, indicated that for French Guiana the definition of forest used is 10% of tree cover, 0.5 ha of minimum area, 5 meters minimum tree height, plus the areas have to be free of agricultural practices. The definition is the same for all France and in mainland France the forest is more fragmented therefore the 0.5 ha minimum area. In French Guiana is very rare to find forest at that small scale. There are 11 different forest classes being used. A problem is that local agricultural practices do not fit the classes set, so agroforestry will not be considered as a forest.
- Sarah Crabbe, SBB, mentioned that in Suriname forest is defined in the forest management act. It is difficult to use for monitoring purposes and therefore SBB is looking for a new definition. It will set a 1 ha minimum area, 5 meters of tree height and percentage of tree cover still being decided but leaning towards 30%. This discussion will enrich that process of decision making. SBB is also working on an improved forest classification system. For example, there are potential classes that are small in area and might not be worth the effort to classify them.

The participants from French Guiana, Gaelle Verger and Nicolas Degarne, presented the project "Expertise Littoral - Land use and land use changes on coastal band in French Guiana":

- The coastal area of French Guiana, where this work was developed, represents only 8% of the territory but concentrates 90% of the population. Therefore it is where conflict between human occupation and nature conservation is higher.
- Four time points were used: 2001, 2005, 2008, 2011. For the first two years high resolution (0.5m) aerial images were available, while for the other two the resolution was lower (20m and 10m). Those images allowed to create 2.5m multispectral degraded images built on ArcGis. The methodology was wall to wall mapping, manual segmentation approach, with MMU of 5ha except for high interest areas where it was 2.5ha.
- In order to fit with the French typology of land use, they used an adapted CORINE classification, which is not fitted for tropical forest habitats so had to be refined. In the end there was 41 categories analysed within 5 main classes (artificial land, agricultural land, forest and degraded ecological environment,

wetland, water surfaces), the one more changed in relation to the previous version was forest. Degraded ecological environment are areas were under human pressure but are now recuperating. The choice of the number of classes will depend on the data available, in this study there were aerial images available so it was possible to get further detail and detail 41 classes, plus it was not for all French Guiana, since for all French Guiana only the 6 IPCC classes are used.

- Coastal line dynamics were a issue, with 11 700 ha of territory lost between 2005 and 2011. The area used for analysis was the part present in all dates, i.e., the surface of the previous years is also changed if in the following year the area has retracted, therefore the coastline is not reported to be changing. When reporting to UNFCCC the total area of the country is updated each time. Sarah Crabbe clarified that SBB applies a buffer of 3 kms to deal with this issue, but that improvements are required.
- The results show that 7 500 ha of forest, or 1.5% of forest cover, were lost between 2005-2011, and if mangroves are excluded from the forestry class the value rises to 11 500 ha. In the meanwhile urbanised areas won 4 557 ha during that period, representing a 18.05% increase and the two main classes of agricultural land (heterogeneous agricultural areas and prairie) gained 75.06% and 52.74% to a total of 11 191 ha and 9 005 ha, respectively.
- The analysis of the dynamics of land cover by municipality from 2005 to 2011 has shown that deforestation is more intense along roads. The team is now working on maps of agricultural potential for biomass. New information can also be crossed and added to the results.

Session 4 – Dealing with Shifting Cultivation in Forest Monitoring

The session began with a presentation from Anwar Helstone, CELOS, initiating the discussion on shifting cultivation:

- Shifting cultivation is a food crop system with a social value for local communities. According to the definition from FAO, it is not categorized as forest. CELOS research on the topic pretends to understand that type of land use and develop baseline socio-economic data in different districts and villages, both Amerindian and Maroon. This research involves participatory work with local communities.
- According to research from CELOS satellite imagery shows that in 2008 about 240 000 ha of land were under shifting cultivation. That use is divided in short and long fallow systems, with parcels of 0.08-4 ha, that are abandoned when soil fertility decreases or weed development. Maximum cultivation period will normally be 2 years. The main crops are rice, tannia (root crop), cassava, pine apple. During the fallow period, the land also has some benefits to the farmers, as they collect building materials or palm fruits, plus by being the first logger they gain right to the land. From a local farmer perspective fallow land not accepted as cropland.
- Answering a question on what motivates the dynamics of different shifting cultivation types, Anwar Helstone clarified that basically those dynamics reflect social choices, in some areas after 2/3 years the forest is cut again in same place because there is lack of capacities to deforest new areas, plus people are becoming more sedentary and less willing to work on locations distant from home.

After the presentation the participants were able to share their own perspectives on the topic, with moderation of Marie Calmel, ONFI.

- Thiago Zampiva, IEF, said that agrosilvopastoral systems with recovery and reuse, sometimes with cattle, are more sustainable than simple slash and burn. The dynamics of cutting forest, introducing animals and then leaving the soil rest is not so devastating as a clear cut, due to the rotating cycle. For example divide area into five plots, one used per year and then go back to area from first year. There is an alternation of land uses so the area is simultaneously agriculture and forest. Plus maintaining this system can decrease pressure on pristine forest. If farming communities own the land that will avoid deforestation by others. Anwar Helstone responded that agrosilvopastoral systems are not yet implemented in Suriname, nobody has cattle. A few pilot projects were started to research how local communities can make use of trees in a productive way. The situation is different from Brazil.

- Eleneide Doff Sotta, Embrapa, pointed that shifting cultivation will not necessarily give time for soil to recover, while agroforestry keeps land always fertile. In the latter, we studied an area in the north of Amapá where people leave the land for recovery during 4 years (fallow time) and alternate it with 2 years of use (three 0.5ha plots used in rotation). Normally the cultivation is for cassava. There is preference for secondary forest because it is easier to clean and the soil is not considered worse than in primary forest. So they will not leave the land too long because it will then more difficult to clean it again. Most of the settlements doing this are there for 20 years and they keep the same production. There are people trying to intensify use but local communities are resistant due to bad experiences in the past. If secondary forest is part of the cycle of cultivation, it was to be considered agricultural land.
- Gaelle Verger, ONFG, mentioned that in French Guiana fallow time vary between 2 and 12 years with average of 10 years. There is tradition of agriculture but not shifting agriculture. Population will stay in the same village, so deforestation comes from an extension, not displacement to new locations, of the current field. However, there is high immigration to French Guiana and people open new fields, this situation is more common than shifting cultivation. In terms of classification of land use, either cultivated or during fallow period, it is still considered agricultural land. Shifting cultivation does not exist in Europe so the classes of land use in French Guiana are not prepared to deal with it, plus under the Kyoto Protocol these areas are also considered agricultural forest. In the study we presented today, all areas left long enough to be secondary forest are classified as forest.
- Maureen Playfair, CELOS, indicated that people manage areas of secondary palm forest that started as an area of shifting cultivation, but when they clear the plots, they leave the seeds of the palm trees to grow up again. To Maureen Playfair that should be considered secondary forest. Eleneide Doff Sotta, Embrapa, responded that in that situation it would be managed forest, a class included under forest. It is a grey area open to different interpretations.
- Marie Calmel, ONFI, highlighted that the question is linked to whether the shifting cultivation system is sustainable or not. If it is just merged with forest class, there is a risk of ignoring a threat that can become unsustainably higher and higher. In DRC some areas pressure is low and without long term deforestation, because people are moving frequently to areas where forest concessions open and maintain roads, leaving forest for 15 years to recover. However in other parts with high demographic pressure, the shifting cultivation practices are not sustainable anymore and forest land is being converted to grassland and other land uses. It can be classified as forest but discriminated within that class in order to keep monitoring how it changes over time.

The definition of shifting cultivation offers some room to interpretation depending on context, but how to classify it using remote sensing is also a technical challenge. Anne-Cecile Capel, ONFI, continued the meeting with a presentation with options to overcome that challenge that were discussed with the participants.

- The usual small size of the plots, with less than 5 ha, make it difficult to detect shifting cultivation using satellite images. Plus, plots have a particular spatial and temporal dynamics due to being heterogeneous and with short rotation cycle. The classification process is usually based on analysis of radiometry of the pixel and not adapted to detect that variation.
- An approach, although not tested, is to increase number of bands artificially by using images with different dates and merge all that information into one image. Each pixel will have information for each band, so it is possible to make a difference between forest and deforested pixels by analyzing each of them separately. A problem is that you need to have plenty of data, could be difficult to do at national level but at local level it can help.
- A second approach, detailed in a research study that will be shared with all participants[8], is to do a mosaic spatial analysis that might help to identify patterns at large scale. The analysis will centre the main pixel and see classes around this pixel with an algorithm decision tree. To detect a pixel in shifting cultivation class it will test assumptions (e.g. share of primary forest, of agricultural land) for the surrounding pixels

[8] The article can be found at: http://reddguianashield.files.wordpress.com/2014/03/tc3a9lc3a9dc3a9tection_swidden-agriculture.pdf

(in an area can be adapted depending on the context of the country). The algorithm is automatic and its rules/assumptions can be changed.

- The third approach, manual detection, is for the moment the most relevant, since the other are still being researched, although the first one can also be easily tested. It requires good field knowledge (plot size, type of crop, agroforestry, seasonal activities, location, etc). If the analyst knows well the data it can delineate it manually. Field knowledge is always necessary. This might be the best of the 3 approaches because the others are still at research level, however the first can be a very good opportunity.
- Sarah Crabbe, SBB, explained that SBB is discriminating shifting cultivation by analysing manually the spectral information. It looks bright in Landsat images and close to roads. And since Suriname is small SBB together with CELOS know more or less where it is located. It is not always easy to delineate it exactly, but the system itself is visible and possible to discriminate manually. Posterior validation is required.
- Gaelle Verger, ONFG asked if shifting cultivation is being merged in the forest class then what is the interest of detecting it at regional level. Furthermore, Gaelle commented that it is important to know what are the shifting cultivation practices, but not sure if an automatic way to discriminate it is useful, although a semi-automatic analysis can save some time by identifying areas with agricultural practices. Plus with a resolution of 20m there is confusion in optical images in terms of spectral information between primary and secondary forest, so defining it is very challenging and manual definition is required.
- Marie Calmel, ONFI, replied that there is an interest in monitor it since what sustainable today might not be so in the near future, it helps controlling if these practices are not causing deforestation. In that perspective, putting it in the forest class can be questioned many years later. Also, in the REDD+ context classifying it can contribute to refine the analysis of carbon stocks, if classified as degradation it will reduce carbon stocks. In terms of spectral interpretation this class can be similar in whole Guiana Shield.
- Eleneide Doff Sotta, Embrapa, questioned if a class of shifting cultivation is an abstraction because people are looking for different things depending on the context of agricultural practices in each place. The intensity of human pressure lead to different situations despite similar images. It is relevant if the purpose is to assess carbon stocks, but otherwise it might not be necessary to map it.

Conclusion and next steps

The list of updated possible topics for coming WGs was quickly presented and after discussion between participants it was decided that **next WG meeting** would be focused on "**Designing a multipurpose national forest inventory**". A proposed date was also agreed by the participants (TO BE CONFIRMED): **22nd and 23rd April 2014**. In case of objections, the project partners are welcome to express them by email to the coordinating team.

Marie Calmel, ONFI, stressed that the meeting allowed for experts from different countries to talk and share experiences, which was the main objective. It was a fruitful discussion due to the inputs from all participants. Two ideas that can be brought to the Steering Committee: organization of another WG on cloud cover issue and training session on Radar imagery. Finally, gratitude expressed to SBB for helping to organize the event, to Anne-Cecile Capel and Anoumou Kemavo for coming from Paris to share their expertise, to Celos for the presentation, to the translators, and the project team.

Pearl Jules, the director of SBB, finalized the meeting by thanking all for the participation. SBB technical people participated keenly and SBB was happy to have hosted the meeting in Suriname.