

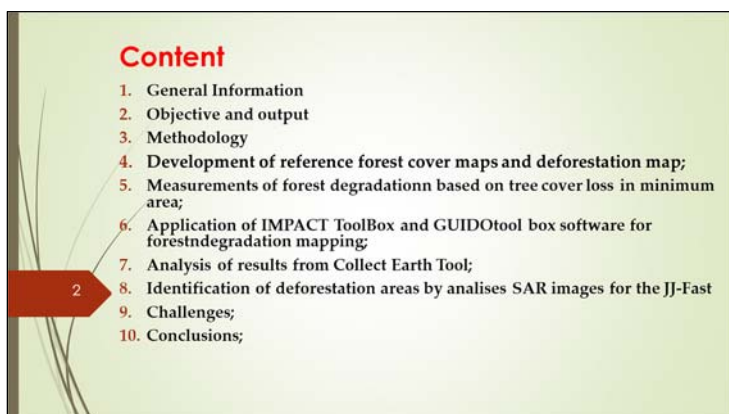
Development of Forest Monitoring Systems Methods and Forest Degradation Issues in Mozambique

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Before I start my presentation, I would like to thank FFPRI for inviting me to come and share our experience in Mozambique.

Objectives and Inputs



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General information

- Area ~ 801,590 Sq km;
- Population ~ 27,216,000 (2017 census projection);
- Economy ~ Agro-based (cashew nuts, cotton);
- Resources: Water, Wood Products, Shrimps, Natural Gas, Coal, Hydro-energy;
- Tropical climate with two seasons:
 - wet season from October to March, and
 - dry season from April to September;
- Institution responsible for Forest: National Directorate of Forestry under Ministry Land, Environment and Rural Development.
- Deforestation rate: 0.79%/year with 34 Million ha of forest (NFI, DINAF 2018);
- Supported by JICA and technical assistance of JOFCA & KOKUSAI KOGYO CO. LTD within 5 years project;
- Supported by JAXA in K&C#3 -K&C#4 initiatives.

2013 based forest map (DINAF, 2018)

Mozambique is a small country with almost 800,000 sq km. Our recent forest national inventory showed the deforestation rate to be 0.79% and 39 million hectares of forest.

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Objectives

To develop potential improved methodologies for satellite monitoring of tropical dry forest landscape, focusing on deforestation and forest degradation assessment for national forest monitoring system for REDD+ in the country.

The assessment aims the following output:

- ✓Enhance forest national monitoring;
- ✓Up-to-date forest monitoring products;
- ✓Building a relationship for forest monitoring;
- ✓Contribution to existing country projects and programs;

My objective is to show the development of potential improved methodologies for satellite monitoring of tropical dry forest and focusing on issues of deforestation and forest degradation in order to do assessment of monitoring of forest for REDD+. The aim of our output is enhancing national monitoring, updating forest monitoring, building relationship between forest management, and contributing to existing country project and other problems.

Specific Objectives?

- Identify the land affected by deforestation (xha)
- Identify the **land area affected** by forest degradation? (xha)
- Measure the **intensity** of deforestation and forest degradation? (x %, C/yr)
- Define the **nature** of deforestation and forest degradation? (**logging, overgrazing, small scale forest clearing for farming for subsistence purposes which include livelihood cash income, tree harvesting for firewood and charcoal, constructions, fire...**)

Proposed operational definition is based on forest definition

Forest definition:		Forest degradation 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, IPCC (2003a)
Minimum tree height	:3 m	
Minimum tree cover	: >30 %	
Minimum area	: 1 ha	

Forest degradation : Change in Forest land remaining forest land
 ⇒ Mask out Non Forest land and measure change in remaining forest land
 ⇒ **Decrease of tree cover but not < 30% in a minimum area of 1 ha**
 Suitable for small scale forest clearing type of forest degradation

The specific objective is to differentiate the effects of deforestation, the land area affected by degradation, define the nature of deforestation looking at the drivers of deforestation. For that, we had to select among many definitions of forest degradation, and we picked up the IPCC definition.

Methodology Used

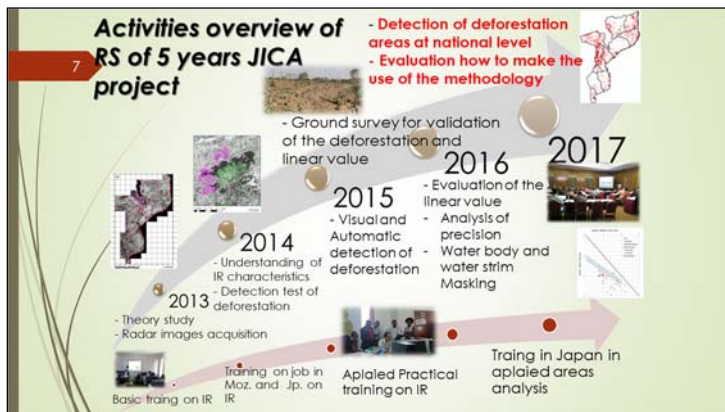
Methodology

- ✓ Boundary mapping and pixel based detection of deforested and forest depredated areas;
- ✓ Ground Truth survey in unsurvey area of Plantations and natural forest to support JICA project and national forest monitoring;
- ✓ Obtain the samples data that are insufficient for the threshold setting;
- ✓ Comparison of different values (-3, -4, -5 dB) between the images before and after 1 year for deforestation including Non-forest area (Thicket) in order to identify the threshold between forest/non-forest;
- ✓ Measuring forest degradation based on tree cover loss in a minimum area;
- ✓ Ground Truth survey to support LTS International alongside the University of Edinburgh with European Space and WB for utilising Radar and Optical (sentinel 1 and 2 data with developed toll for cloud free) of dense time series for continuous change monitoring and proxies of forest changes, and degradation using ALOS PALSAR mosaic in tropical dry forest;
- ✓ Ground Truth survey to support JICA- JAXA, for data calibration of JJ-FAST system (analysed by SAR imagery) with technical support of Tokyo Denky University.

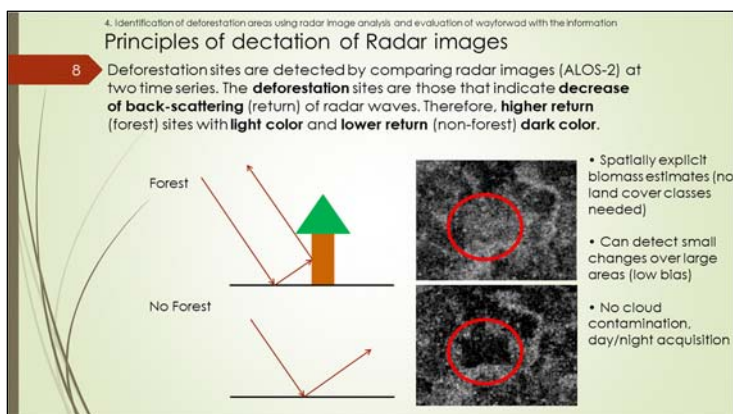
In terms of methodology, we followed boundary mapping and pixel-based detection, and did lot of Ground Truth survey test of all of methodologies in order to find the best threshold. We also did support of institutions like Tokyo Denki University¹ and to improve the JJ-FAST² methodology. We were also supported by the LTS International³ alongside Edinburgh University⁴ and European Space⁵.

¹ <https://www.dendai.ac.jp/en/>
² <https://www.eorc.jaxa.jp/jjfast/>
³ <https://www.ltsi.co.uk/>
⁴ <https://www.ed.ac.uk/>
⁵ <https://www.esa.int/ESA>

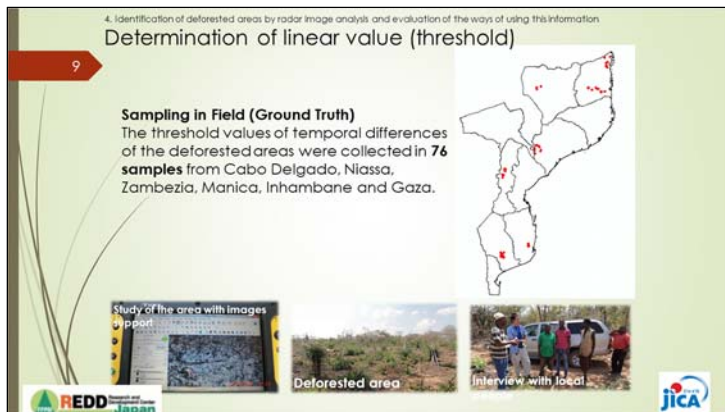
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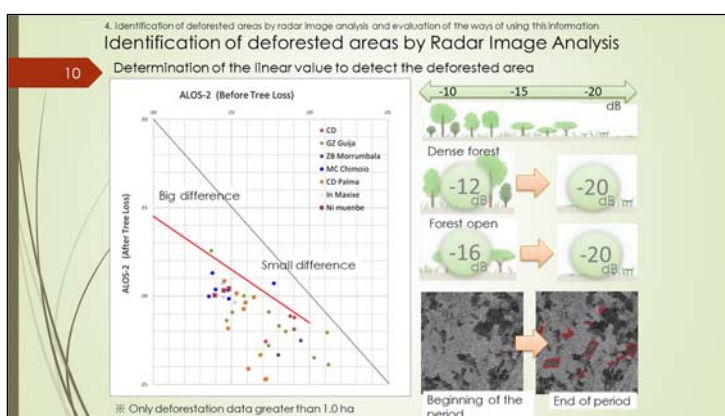
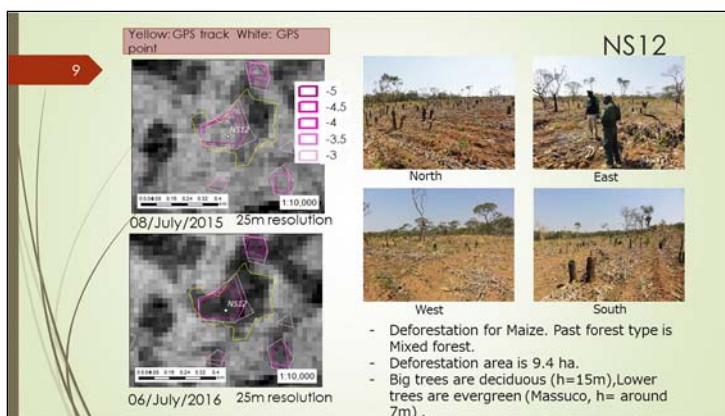
In terms of remote sensing activities, everything started from the theory to understand radar images acquisition. We went to the understanding of the constituents of the infrared, visual and automatic detections, Ground Truth for validation and evaluation of the linear value. We did all this work during job training exercises.



For those one of familiar with what it mean by the issue of reflectance of forests in order to detect the change. Here I just wrote a small picture of decrease of deforestation by doing plantation. The deforestation sites are those that indicate decrease of back-scattering of radar waves. Therefore, higher return sites with light color and lower return with dark color

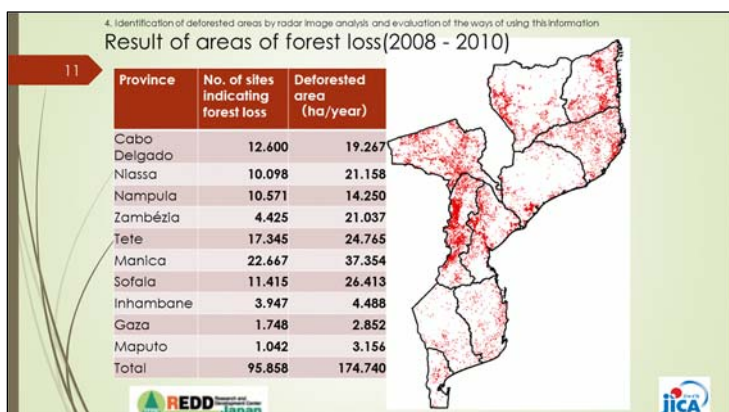


To get the results, we had to do field ground survey which considered 76 samples within 6 provinces as you can see in red.

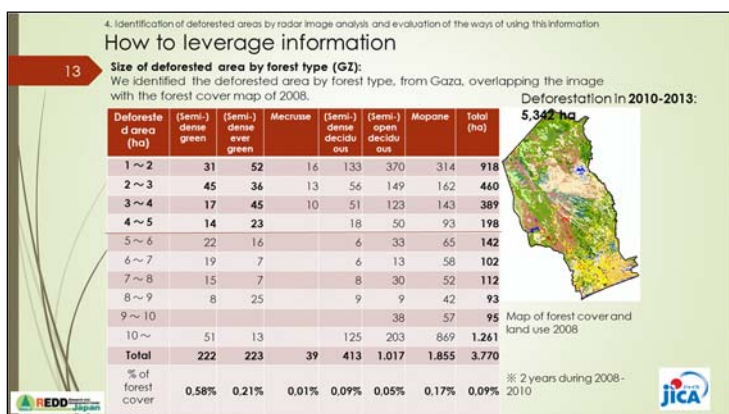
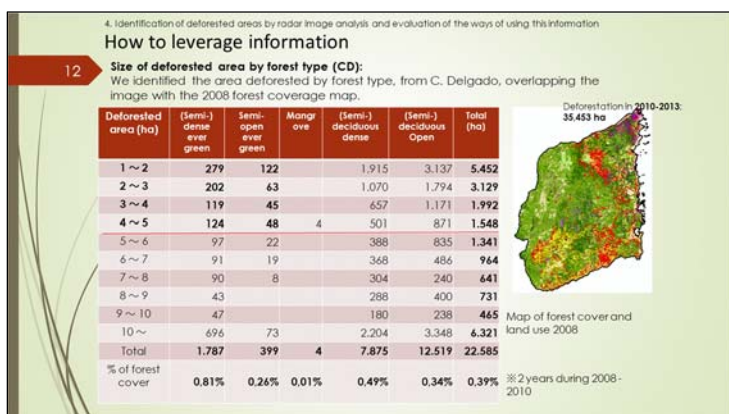


In the field, we identified the deforested area, and then with GPS we tried to work around the deforested area.

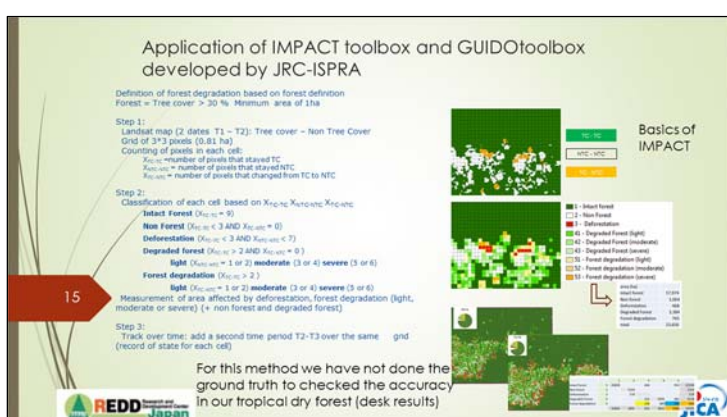
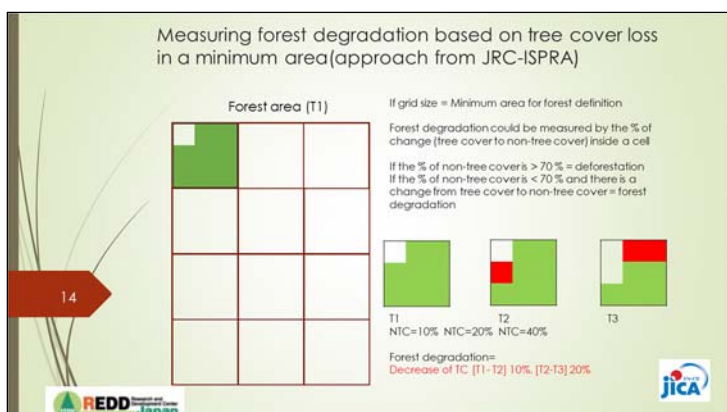
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Then back in the office we found the threshold and did statistical analysis to find the linear value of the deforestation area in Mozambique using 2008-2010 information of Mozambique.



For that, we had to align with wall to wall map to see the activity data in order to ascertain what contributes to forest deforestation. In the analysis of the target area, we found that shifting cultivation is the major contributor among many drivers of deforestation in Mozambique.



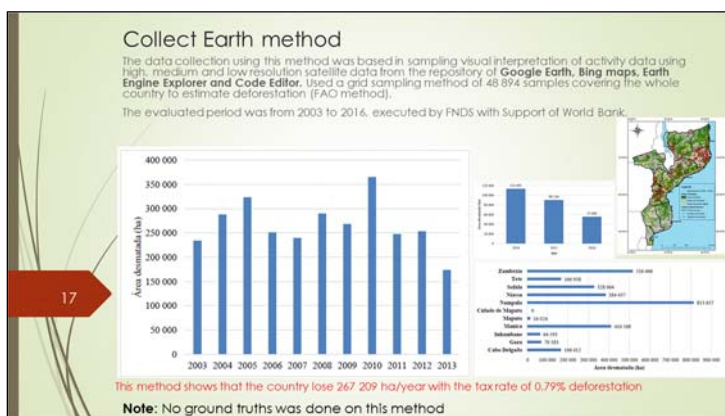
We used another method developed by JRC in Ispra⁶, Italy, which consist of grid interpretation using pixel 3x3, where we identified how many pixels changed/not changed within the interval of less than 70% or greater than 70% which has deforestation and forest degradation. The methodology is applied using the IMPACT tool and GUIDOS. We were not familiar with these tools, but we tried to use it to ascertain their precision. Unfortunately, we did not get financial source to go to the field to recheck this, so it remained as one of the challenges.

⁶ <https://ec.europa.eu/jrc/en/about/jrc-site/ispra>

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Recently, we had another Ground Truth to support JJ-FAST method developed by Tokyo Denki University in order to improve the system. This is because our major driver of deforestation is shifting cultivation in a very small area. We would like to see this method reflecting those small areas in order to evaluate the deforestation. We went to the field and left some instruments there to measure soil humidity and trees.



We used Collect Earth method extensively. This is a less costly method, which has a huge bunch of satellite data from Google Earth, Bing Map, Earth Engine Explorer, and Code Editor Repository. Using this method which is a statistical grid interpretation, we found that within the interval of 2003 and 2015, 2010 was the major year of deforestation. But we found that this deforestation is decreasing after 2014.

Key Challenges Faced

Challenges?

Long-term effects: How to differentiate between long-term decline or persistent decline and temporal variability due to normal/good management or annual variability? How to differentiate between forest degradation and sustainable management of forest (cf. Forest code of practice? National/at logging company?)

Exclusion of deforestation: How to be sure that forest degradation will not be reclassified as deforestation in the future (precursor to deforestation)? (long-term reduction of carbon stocks but tree cover, height and area are not under the threshold defined for forest land). How to define when the threshold for forest has been crossed?

Loss of forest carbon stock in forest land remaining forest land. The change should lead to a change in carbon stocks. Emissions due to forest degradation will depend on carbon stock available for release and degree/nature of the process (stem for removals).

Has to be operational, has quantifiable and measurable/detectable thresholds within a defined time frame, be part of the GHG inventory (must be human-induced, describe change in carbon stocks at least), can be applied consistently in the same biome, must be possible to quantify/verify the change.

Key challenges to implement and provision technologies and data sources of forest inventories using unmanned aerial vehicles (UAVs) or drone platforms to acquire both LiDAR and Very High Spatial Resolution (VHSR) imagery with high operational capacity to capture detailed data with less cost of hardware infrastructure, advanced techniques of large extracted amount of data and store.

Definition of the most precise, accurate method considering the consistency with the reliable results for data comparison in the country when forest management is being carried out. Full knowledge of the current ground field is needed to support Remote Sensing:

Radar signal saturates in dense tropical forests. Limited availability of long-wavelength radar data and Data cost:

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In terms of challenges, we found more challenge in degradations compared to deforestation. We see the issues of long-term effects; exclusion of deforestation; loss of the carbon stocks; and the issue of how to measure green gas inventory using those tools. We have seen that the provision of technology like unmanned aerial vehicles or drone platforms to acquire both LiDAR and VHSR image is needed to support this kind of information. Lastly, for small areas, we found drone is efficient at detecting changes in forest at low cost.

Conclusion

Conclusions

1. Use of ALOS data provided by wall to wall forest cover map resulted in forest base map (2013) of the country to estimation changes of the forest cover is a good methodology to detect a time series of deforestation, forest remaining forest and gains.
2. Deforested areas and forest degradation can be identified by RADAR image analysis and ScanSAR can be produced for any weather and sunlight independent. Penetrates through canopy, Signal 'scattered' from trunks and branches, interacts with woody biomass.
3. Measuring forest degradation based on tree cover loss in a minimum area methods require ground truth survey at large scale and biomass assessment and carbon estimation to confront the challenges aforementioned in the our dry tropical forest due to the existence of certain species with wide canopy cover (e.g. *Brachystegia* sp) in order to be avoid bias;
4. The use of Collect Earth Tool to get reliable results needs experienced technical staff with full knowledge of the ground to get accurate results with statistical sample approach to have a minimum acceptable error and the factor of expansion needs to be more elaborated and clear based in ecological area rather than administrative boundaries;
5. Scanning deforested areas using drone for small assessment and carbon of inaccessible areas is much efficient and less costly compared to large satellite data of low resolution;

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In conclusion, we found wall to wall as the best method to produce a deforestation map. We also found that to compare deforestation and forest degradation using RADAR and ScanSAR is possible, but it needs support of the Ground Truth. Collect Earth also needs a Ground Truth survey and it requires a good knowledge by the technicians who are doing this interpretation. Otherwise, they can misunderstand, say, crops with land use and call it as deforestation. Lastly, scanning of deforested area using drone is a good method for inaccessible areas compared to satellite data with low resolution.