Quantifying tropical deforestation driven by oil palm cultivation: a case study for Borneo Island, Indonesia

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Group: 10

1. Context and Objective

Palm oil is found everywhere in our daily lives, whether in food products, cosmetics, cleaning products or agrofuels. Almost 90% of total global oil palms are cultivated in Southeast Asia, dominated by Indonesia and Malaysia [1]. In these regions, practices of oil palm cultivation are considered unsustainable: clearing the primary forests and its buffer zones [2].

While helping the economy to thrive, this approach is deeply impacting the forest ecosystems, biodiversity and significantly contributing to climate change by releasing stored carbon. In that context, the objective of our study is to map the deforestation induced by palm oil cultivation in Borneo island, Indonesia.

2. Study area

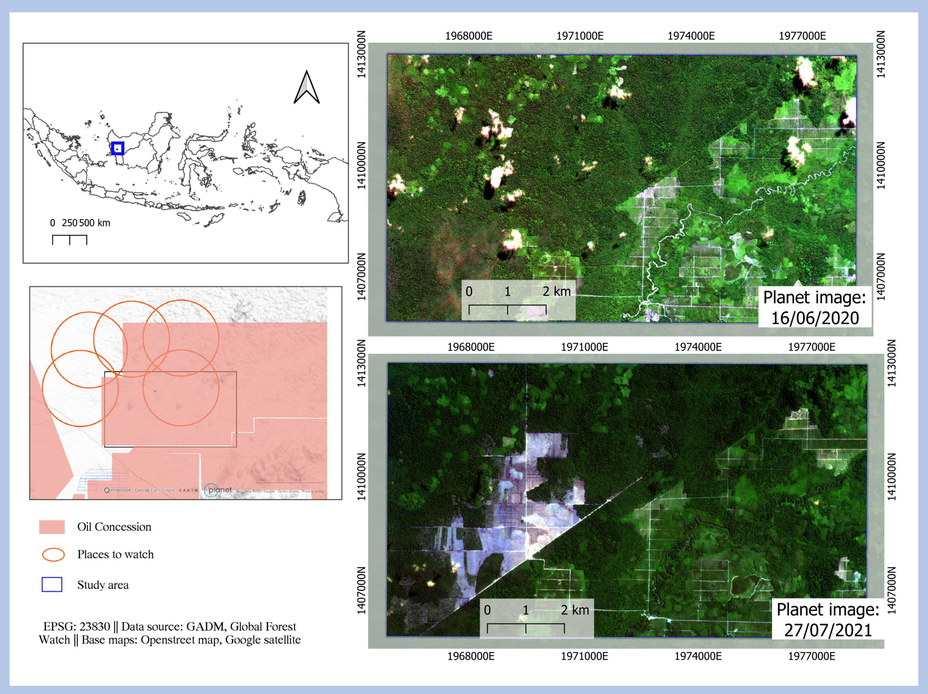


Fig. 1 Study area

Our study area is located in the western part of Borneo island, West Kalimantan, Indonesia (84 sq. km). This area was chosen for several reasons:

- It is in the region where there is the most deforestation on the island;
- It is part of a palm oil concession and therefore we can directly deduce that deforestation in this area is for the purpose of palm oil culture;
- This area is considered a high priority places from GLAD alert in Global Forest Watch platform.

3. Data sources

The study area is in persistence cloud cover zone. Therefore, 10 m resolution SAR data from Sentinel 1 was processed and analyzed for 2020 to 2021 in Google Earth Engine (GEE) platform, which can penetrate the cloud . The orbit number and direction used are 149 descending. The two Planet mosaics (3.125 m resolution) for the study area was downloaded from planet.com .

We want to detect the monthly changes, therefore monthly median composite of S1 were used. The images were normalized with two previous years' images to avoid radiometric variations and noise. The required images were therefore:

- 12 images per year between 2020 and 2021 in both VV and VH to detect the change.
- 12 images per year between 2018 and 2019 for the normalization of the 2020 images also in both VV and VH.

In total 96 monthly composite were required to detect the change between 2020 and 2021.

4. Method

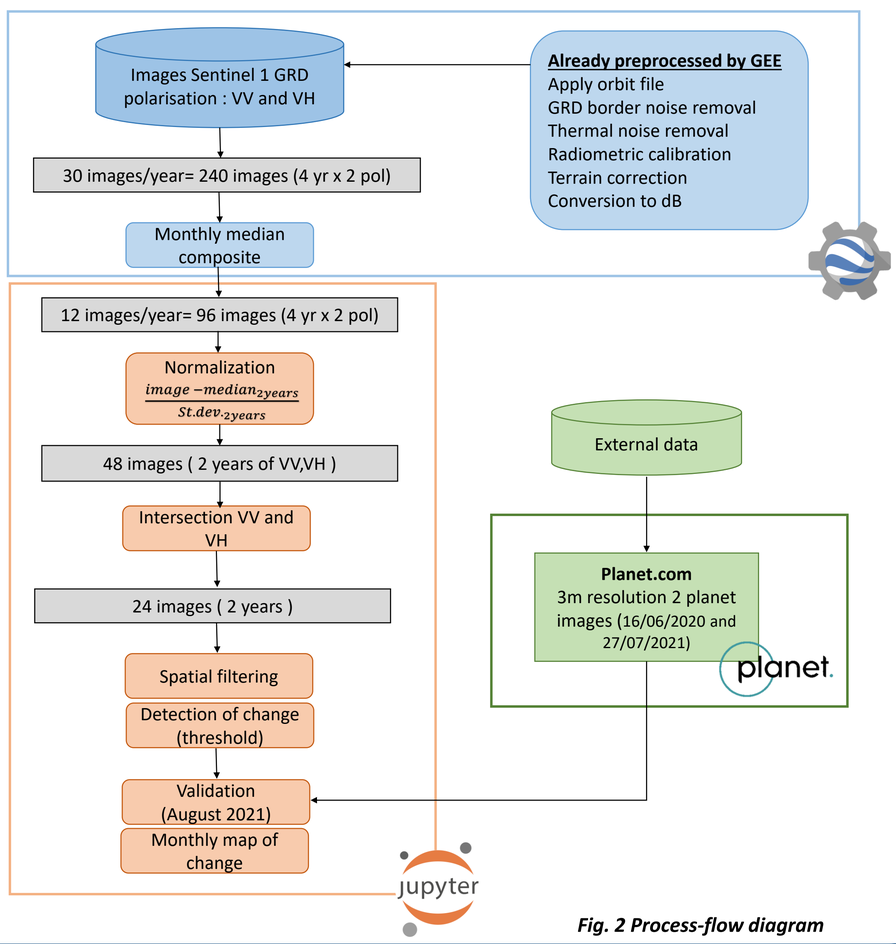


Fig. 2 Process-flow diagram

5. Results

A. Validation samples

From the comparison of the planet images, 20 polygons are drawn:

- 10 in the part deforested at that time
- 10 in the intact forest.

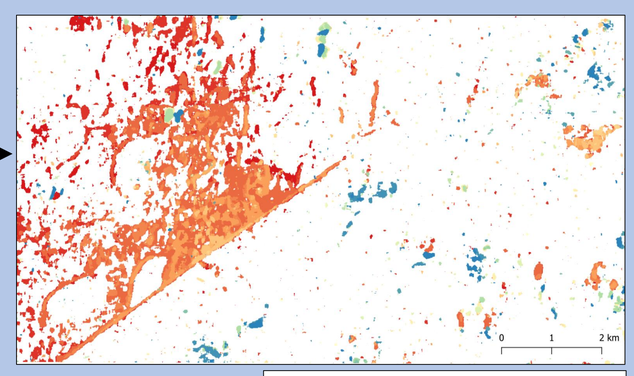
Fig. 3 Validation polygons

Based on these polygons, several combinations of filters and thresholds were tested with filters ranging from 1x1 to 9x9 and thresholds ranging from 0 to -1.5.

The overall acuracy of each combination is calculated, giving the table below. The maximum overall accuracy obtained is when a 9x9 filter is applied and the threshold is -0.25, it is 94.74%.

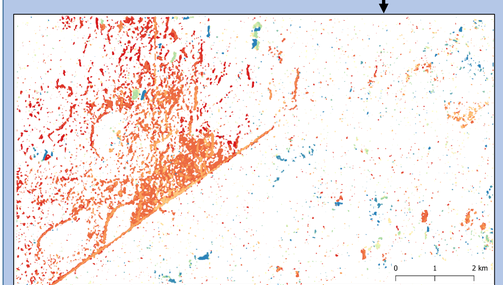
Threshold σ(dB)	Median filter: no filter	3x3	5x5	7x7	9x9
0	77,66	77,66	84,86	90,46	93,75
-0,25	76,45	83,83	90,49	93,53	94,74
-0,5	80,23	86,89	91	92,2	92,66
-0,75	82,33	87,15	88,77	89,35	89,72
-1	83,06	86,78	85,97	86,02	86,2
-1,25	82,53	83,51	83,15	82,9	82,88
-1,5	81,86	81,84	81,01	80,73	80,51

Table 1 Overall accuracy of each combination



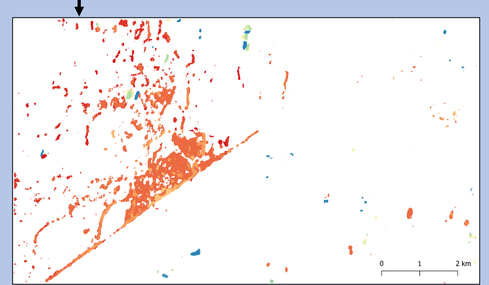
Filter : 9x9 , Threshold : -0,25, O.A. : 94,74%

Fig. 4 Map of change 1



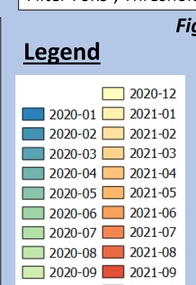
Filter : 5x5 , Threshold : -0,75, O.A. : 88,77%

Fig. 6 Map of change 3



Filter : 9x9 , Threshold : -0,75, O.A. : 89,72%

Fig. 5 Map of change 2



The 3 maps of change follow the same trend regarding date of the deforestation. However, it can be observed that it is necessary to use a large median filter to limit the noise (Fig.5), The map with a 5x5 filter still shows a lot of noise (Fig. 6). It can also be seen that, with the threshold (-0.25) we detected both high and low confidence deforested areas (Fig.4)

B. Map statistics

2020		2021	
Month	Deforested area (sq. km)	Month	Deforested area (sq. km)
January	0,6214	January	0,2513
February	0,3598	February	0,1255
March	0,1504	March	0,1163
April	0,0407	April	0,5087
May	0,0546	May	0,2362
June	0,0379	June	1,4787
July	0,2996	July	1,5398
August	0,0363	August	4,92
September	0,077	September	0,3254
October	0,1651	October	2,1288
November	0,0454	November	1,1191
December	0,0712	December	/
Total deforested area :		14,7092 km^2	

Table 2 Deforested area by month

This table shows the deforested areas per month. This table confirms the observations made from the deforestation map. All periods where deforestation exceeds 1 km^2 are highlighted in red and most of the deforestation takes place in the second half of 2021 with a peak in August at 4,92 km^2.

Before June 2021, deforestation is very low, with almost 80% of the deforestation observed in 2020 and 2021 taking place after June 2021. According to our detection with Sentinel1, the total deforested area from 2020 to 2021 is 14.7092 km^2, which corresponds to 17.3% of our study area.

C. Limitations

Although our most accurate map of change has an overall accuracy of 94.74%, our deforestation detection using Sentinel-1 has limitations. Figure 8 shows our deforestation detection in red and close Planet image, showing actual deforestation in blue. Even if both follow the same trend, our detection overestimates deforestation in some places while it underestimates it in others.

To have a more representative overall accuracy, a more demanding validation should be done, by adding more polygons or by enlarging them or by adding points. Figure 7 show the deforestation in our study area between 2020 and 2021 from GFW. According to GFW, the actual deforested area in this period is of 17.3 km^2.

Fig. 7 Tree cover loss for 2020-2021, GFW [3]

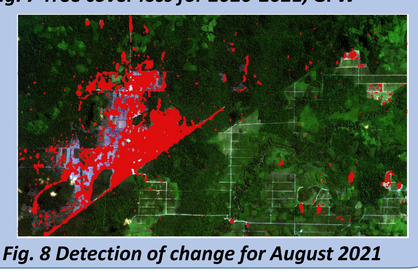


Fig. 8 Detection of change for August 2021

6. Conclusion

In this study we used Sentinel 1 time series to detect the deforestation caused by oil palm cultivation. We used different median filter and threshold level to detect the monthly deforestated areas within 2020 to 2021. Our methodology made it possible to detect the changes where no cloud-free Sentinel 2 image were found during the study duration. Therefore, with some improvements, Sentinel 1 can be useful in a densely cloud cover region for the detection of forest cover changes. As this area located in oil palm cultivation area, this study highlights the significant environmental impact of this industry in widespread deforestation and urgent need for sustainable practices in the oil palm industry.

7. References

1. Danylo, Olha, et al. "Satellite reveals age and extent of oil palm plantations in Southeast Asia." *arXiv preprint arXiv:2002.07163* (2020).
2. Dauvergne, P. (2018). The Global Politics of the Business of "Sustainable" Palm Oil. Global Environmental Politics, 18(2), 34–52. https://doi.org/10.1162/glep_a_00455
3. Global Forest Watch (globalforestwatch.org) Data source: Hansen/UMD/Google/USGS/NASA