

# State of the Malaysian Rainforest 2024

Timber plantations and oil palm expansion remain primary threats to rainforests.



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## Executive Summary

This supplement report supports the general findings of the original State of the Malaysian Rainforest 2023 Study. This report uses three baselines to predict a future reduction in forest cover; using the Vancutsem et al., 2021, Official Data, 2020 and Gaveau, 2022 forest cover statistics as baselines, compared to concession boundaries collated by RimbaWatch.

This report finds that between 3.2 and 2.1 million hectares of natural forest are under threat, which represents between 14-16% of our remaining forests. Forest cover will drop below 50% in all three baselines, ranging between 49% to 40%. In particular, the Gaveau dataset estimates that forest cover has already fallen below 50%, and stands at 46.97% as of 2022.

The supplement further reinforces that timber plantations and oil palm are the primary threats to natural forests. Timber plantations represent more than 76% of total threats to forests, and the majority of these concessions are located in intact forests. However, oil palm and timber plantation concessions overlap. Other threats include hydropower projects and degazettements of forest reserves.

The report reiterates the problem of encroachments of the traditional territories of Indigenous communities by concessions, where nearly 250,000 ha of concessions, mostly timber plantations, encroach on a sample of customary land boundary data. Finally, it finds that forests will drive significant carbon emissions, that data on forests continue to be non-transparent, and the majority of future deforestation will be unreported as such by Malaysian authorities due to loopholes in definitions.

## Part I: Context

Malaysia has internationally and domestically committed to maintain 50% of its land cover as forest, which is further enshrined in a number of national policies. However, performance on this claim has not been independently verified, until RimbaWatch published the State of the Malaysian Rainforest 2023 Study which found that forest cover in Malaysia was estimated to decrease to 47.35% in the future.

### 1.1 Objectives

The purpose of this report supplement is to update the findings of the existing study to take into account new concession boundaries, new forest cover datasets, refinements to the methodology, and climate data.

This supplement features the following updates:

1. Re-tracing of existing concession boundaries using an updated georeferencing policy
2. Addition of updated dataset on palm oil concessions
3. Addition of updated timber plantation concessions
4. Re-calculation of remaining forest areas within known concessions
5. Classifications of forest conditions within known concessions
6. Calculation of carbon vulnerable to release when concessions are cleared

Further, this supplement predicts Malaysia's total forest cover after conversion of forests within concessions using three baselines:

1. Baseline 1: Vancutsem et al., 2021

- a. This baseline assumes the natural forest cover extent and condition of forests as defined by the Vancutsem et al., 2021 dataset<sup>1</sup> from the EU's Tropical Moist Forest (TMF) cover dataset, which is a tool used to support the implementation of the EU Deforestation Regulation (EUDR), and subtracts the remaining forested areas in known concessions as defined by the same dataset.

2. Baseline 2: Official Data, 2020

- a. This baseline assumes the forest cover officially reported by Malaysia as of 2020, which is 18.1 million hectares<sup>2</sup>. In lieu of geospatial data to support this claim, this baseline subtracts the remaining forested areas in known concessions as defined by the Vancutsem et al., 2021 dataset from the officially reported numbers to make the prediction. For this baseline, the Vancutsem dataset was chosen over the Gaveau dataset as the total forest cover is the most similar to Malaysia's official reporting.

3. Baseline 3: Gaveau, 2022

- a. This baseline assumes the Forest Area extent as defined by the Gaveau 2022 dataset, and subtracts the remaining forested areas in known concessions as defined by the same dataset<sup>3</sup>.

## 1.2 Assumptions

This supplement is based on the following assumptions:

1. All forested areas within concession boundaries are assumed to be under threat from deforestation, as data on areas set aside for conservation, etc. are not known.
2. Concessions are defined as any areas which have been set aside for development, with a focus on identifying areas which will be converted from natural forests (as delineated in the Noon et al., 2021 and Vancutsem et al., 2021 datasets) to non-natural tree cover or other land uses.
3. Vulnerable carbon is defined by the Noon et al., 2021 dataset from "Mapping the irrecoverable carbon in Earth's ecosystems". This is with reference to the assumption that 100% of aboveground biomass and 21.3% of soil carbon is vulnerable during conversion events.

It must be noted that due to continued limitations in data availability, the findings of this report must be taken as estimates only, within the confines of the methodology used.

## Part II: Key Findings

### **Key Finding 1: In all baselines, Malaysia's forest cover will drop below 50%**

#### Baseline 1: Vancutsem et al., 2021

In Baseline 1, the Vancutsem et al. dataset identifies 14,632,271.25 ha of undisturbed forest and 5,060,024.881 ha of degraded forest in Malaysia, resulting in a total forest cover of 19,692,296.131 ha in 2021, which is 59.63% of its total land area<sup>4</sup> (map 1).

<sup>1</sup> This dataset is based on classifications of undisturbed and disturbed forests from remote sensing, and is published here: <https://forobs.jrc.ec.europa.eu/TMF>.

<sup>2</sup> Which includes protected areas, permanent forest reserves and state land forests as reported by Peninsular Malaysia, Sarawak and Sabah here: <https://www.mdpi.com/2071-1050/15/2/1385>.

<sup>3</sup> This dataset is published here: <https://map.nusantara-atlas.org/>, and is a combination of various existing datasets derived from modeling of landsat imagery, adjusted to remove plantations, agroforestry and forests recently degraded.

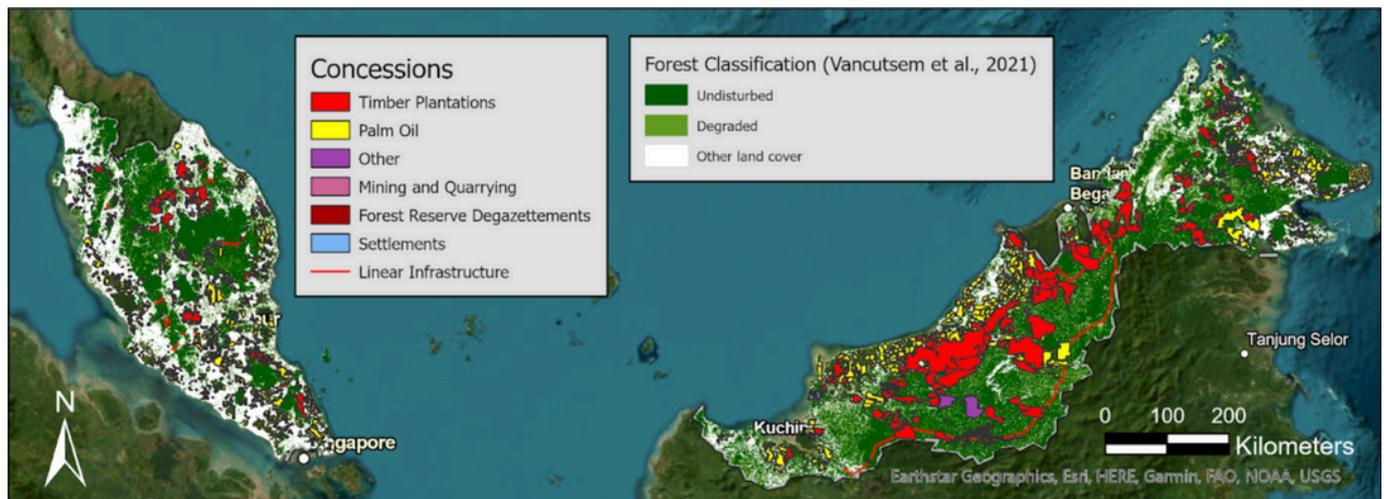
<sup>4</sup> With reference to a total land area of 330,241km<sup>2</sup> as reported in [https://unfccc.int/sites/default/files/resource/MY%20BUR4\\_2022.pdf](https://unfccc.int/sites/default/files/resource/MY%20BUR4_2022.pdf).

**Map 1: Forest Cover Classification of Malaysia (Vancutsem et al., 2021)**



The Vancutsem et al. dataset identifies 2,046,805.82 ha of remaining undisturbed forest and 1,199,903.71 ha of disturbed forest within known concessions, resulting in 3,246,709.53 ha of remaining forests in known concessions (map 2).

**Map 2: Forest Cover Classification (Vancutsem et al., Global Forest Watch) and Concessions (RimbaWatch, 2023) in Malaysia**



In this baseline, 3,246,709.53 ha is 16.48% of Malaysia's remaining forests. If all these forests within known concessions are cleared, Malaysia's forest cover will decrease to 16,445,586.6 ha, which is 49.79% of its total land area.

#### Baseline 2: Official Data, 2020

In Baseline 2, Malaysia's forest cover in 2020 is 18.1 million hectares, which is 54.81% of its total land area.

In this baseline, the Vancutsem et al. dataset identifies 3,246,709.53 ha of remaining undisturbed and disturbed forests in known concessions, which is 17.93% of its remaining forests. If all these forests within known concessions are cleared, Malaysia's forest cover will decrease to 14,853,290.47 ha, which is 44.97% of its total land area.

### Baseline 3: Gaveau, 2022

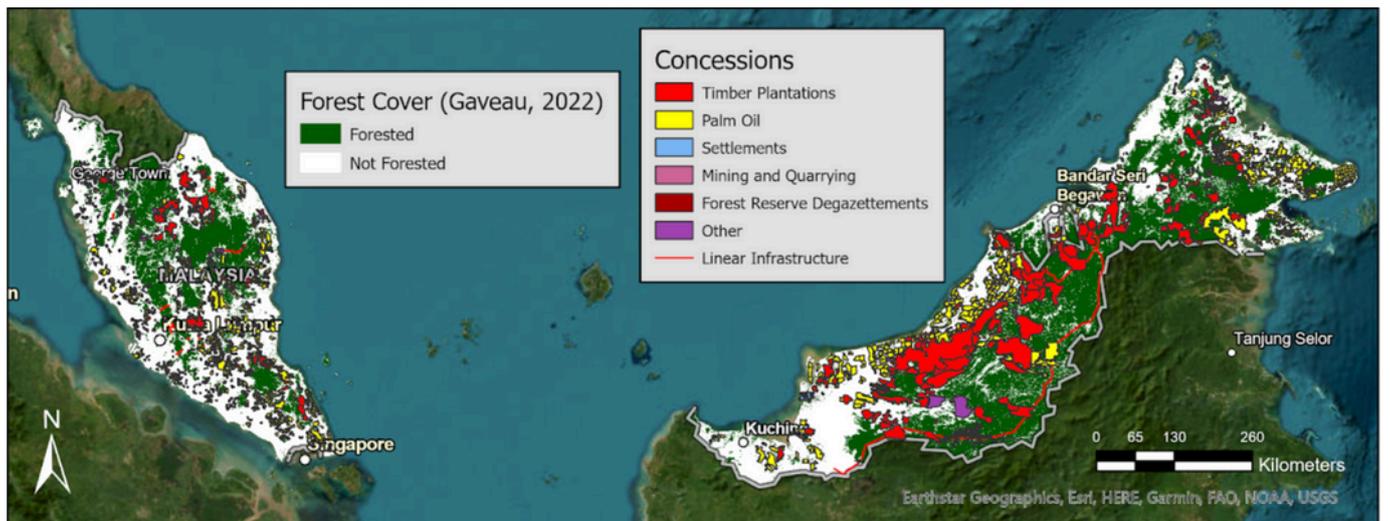
In Baseline 3, the Gaveau dataset identifies 15,512,694.75 ha of forest in Malaysia in 2022, which is 46.97% of its total land area<sup>5</sup> (map 3).

**Map 3: Forest Cover Classification of Malaysia (Gaveau, 2022)**



The Gaveau dataset identifies 2,185,208.4 ha of remaining forests within known concessions (map 4).

**Map 4: Forest Cover Classification (Gaveau, 2022) and Concessions (RimbaWatch, 2023) in Malaysia**



<sup>5</sup> With reference to a total land area of 330,241km<sup>2</sup> as reported in [https://unfccc.int/sites/default/files/resource/MY%20BUR4\\_2022.pdf](https://unfccc.int/sites/default/files/resource/MY%20BUR4_2022.pdf).

In this baseline, 2,185,208.4 ha is 14.08% of its remaining forests. If all these forests within known concessions are cleared, Malaysia's forest cover will decrease to 13,327,486.35 ha, which is 40.36% of its total land area.

### Discussion

In all three baselines, Malaysia's forest cover will drop below 50%. While Malaysia's forest coverage under the Vancutsem et al. dataset is 5% higher than officially reported figures, the clearance of remaining forests in known concessions will still result in an eventual forest cover which falls below 50%, particularly when taking into account that the concession data presented here is not comprehensive due to non-transparency of data. Conversely, the Gaveau dataset proposes that Malaysia's forest cover has already dropped below 50%, and therefore Malaysia has already reneged on its commitment to maintain 50% forest cover regardless of any predicted clearances in known concessions. Malaysia's officially reported number of 54.81% forest coverage sits between the Vancutsem et al. and Gaveau forest cover, however the lack of geospatial data supporting this statistic limits further analysis.

It is observed that the Vancutsem et al. dataset assumes a liberal interpretation of forest cover, and in some cases includes abandoned acacia or rubber plantations as degraded forest, and in limited cases interprets oil palm plantations as undisturbed forest. The Gaveau dataset, on the other hand, assumes a stricter interpretation of forest cover, and excludes large areas of tree cover which have been degraded through logging but have not been converted to plantations or settlements.

There is no singular definition of forest. However, taking into account the importance of large dipterocarp trees (which are removed through 'selective' logging) to ecosystem integrity and provision of services, including non-timber forest products and non-material, cultural and spiritual components of what constitutes a forest and which cannot be identified through remote sensing, we make the recommendation that the Gaveau dataset best represents Malaysia's forest cover as it excludes heavily logged forests and non-natural forests.

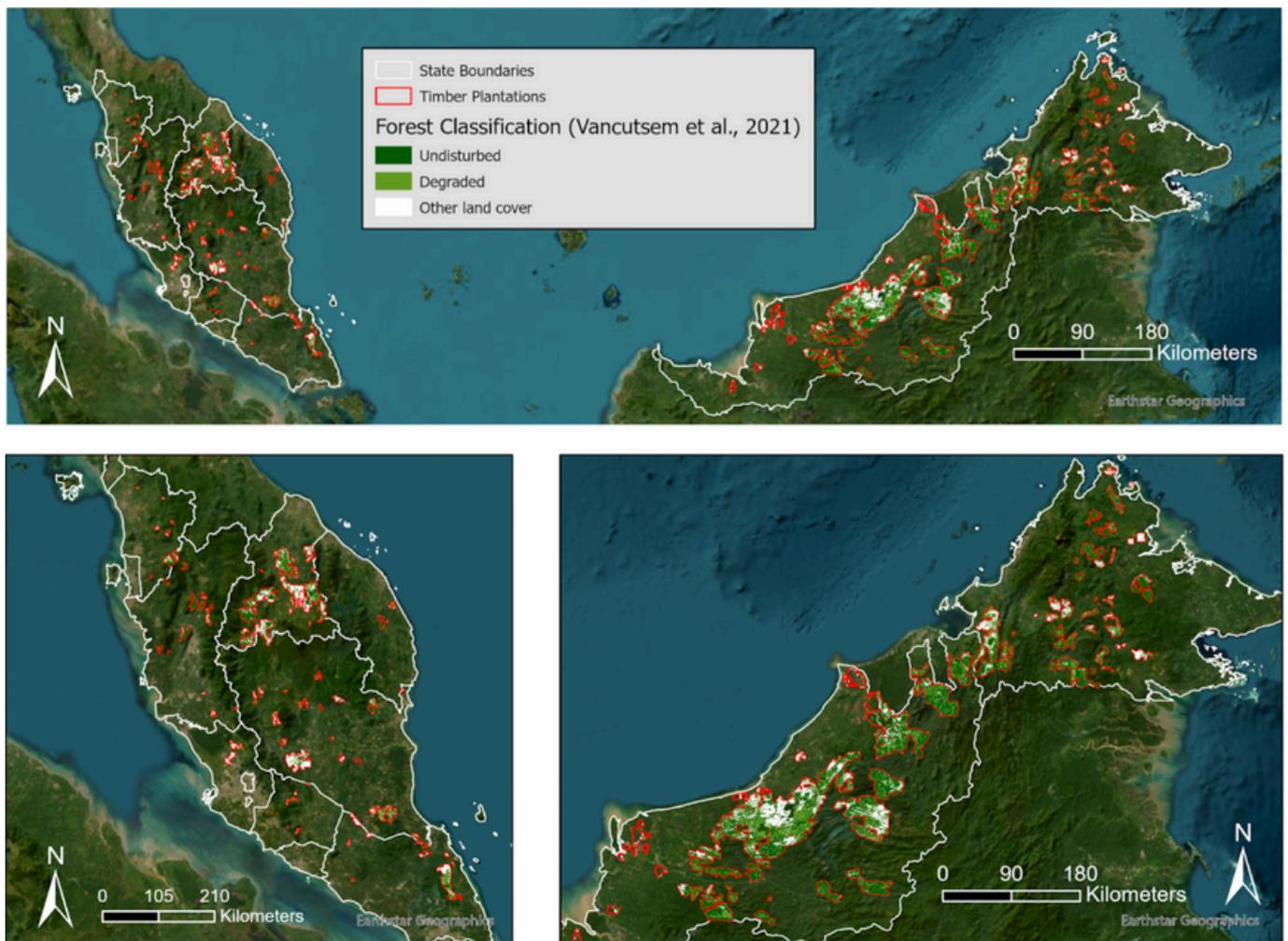
### ***Key finding 2: Timber plantations are the top threat to natural forests***

#### Baseline 1: Vancutsem et al., 2021

In Baseline 1, the Vancutsem et al. dataset identifies 1,556,191.68 ha of remaining undisturbed forests and 920,225.23 ha of degraded forests in known timber plantation concessions (map 5). Therefore, 62.84% of remaining forests in known timber plantation concessions are undisturbed forests.

In this baseline, there is a combined 2,476,416.91 ha of remaining forests in known timber plantation concessions, which represents 76.27% of all remaining forests in known concessions.

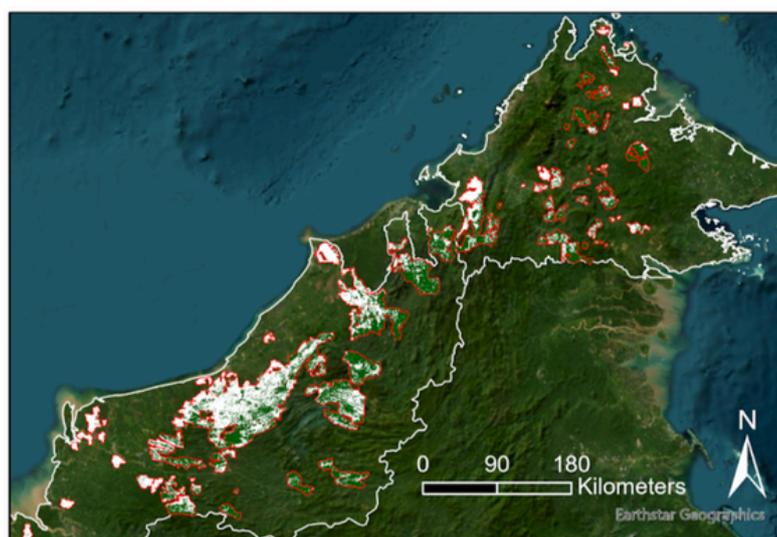
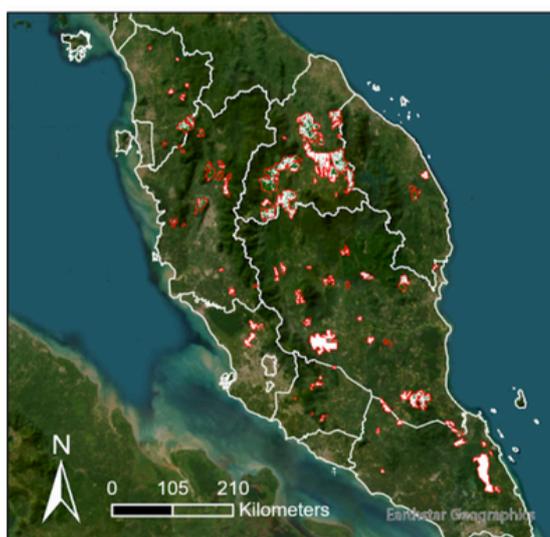
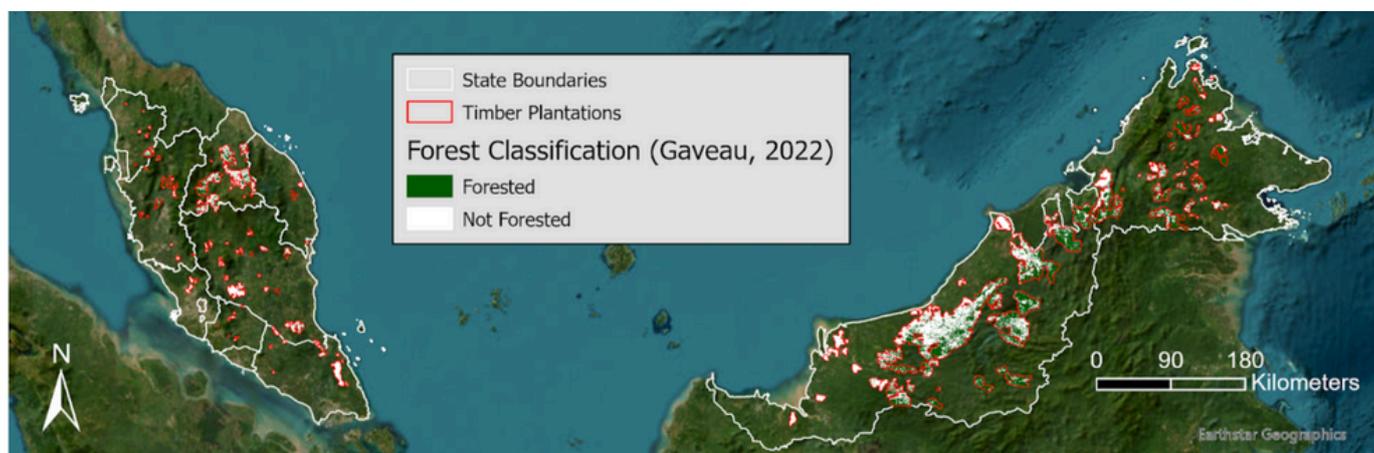
**Map 5: Forest Cover Classification (Vancutsem et al., 2021) of Timber Concessions (RimbaWatch, 2023) in Malaysia**



Baseline 3: Gaveau, 2022

In Baseline 3, the Gaveau dataset identifies 1,731,187.47 ha of remaining forests in known timber plantation concessions, which represents 79.2% of all remaining forests in known concessions (map 6).

**Map 6: Forest Cover Classification (Gaveau, 2022) of Timber Concessions (RimbaWatch, 2023) in Malaysia**



## Discussion

In both baselines, timber plantations will be the top driver of deforestation in Malaysia in the future. Since their inception as the 'Ladang Hutan Kompensatori' program in the early 1980s, the official position of the Peninsular Malaysia<sup>6</sup>, Sarawak<sup>7</sup> and Sabah<sup>8</sup> authorities is that timber plantations are a method of rehabilitating degraded forests which reduces pressure on natural forests.

<sup>6</sup> Forest Plantation Development Sdn Bhd, *Background History* (2022) (<https://www.fpd.com.my/backgroundhistory>) [accessed 8 February 2023].

<sup>7</sup> Forest Department Sarawak, *ISSUES AND CHALLENGES* (2022) (<https://forestry.sarawak.gov.my/page-0-245-1010-tid.html>) [accessed 8 February 2023].

<sup>8</sup> Anjumin, E., *Tree Plantations way forward in forestry*, *New Straits Times*, (2022) (<https://www.nst.com.my/news/nation/2022/07/811532/tree-plantations-way-forward-forestry>) [accessed 8 February 2023].

These authorities refer to timber plantations as 'Forest Plantations', 'Planted Forests' and 'Forest Farms' respectively, which in reality are monoculture plantations of rubberwood, acacia and other species in forest reserve land.

Both baselines show that, at a minimum, more than 1.5 million ha of timber plantation concessions are located in intact forests which are not degraded. The majority of timber plantation concessions are in Sarawak, while Kelantan takes the lead for Peninsular Malaysia (see table below).

State	Area (ha)	Area as % of total timber concessions
Negeri Sembilan	3616.26	0.10%
Selangor	11060.26	0.30%
Kedah	18712.09	0.51%
Perak	46760.39	1.28%
Johor	52665.12	1.44%
Terengganu	55210.10	1.51%
Pahang	151459.48	4.14%
Kelantan	233880.24	6.40%
Sabah	588735.98	16.11%
Sarawak	2493471.89	68.21%

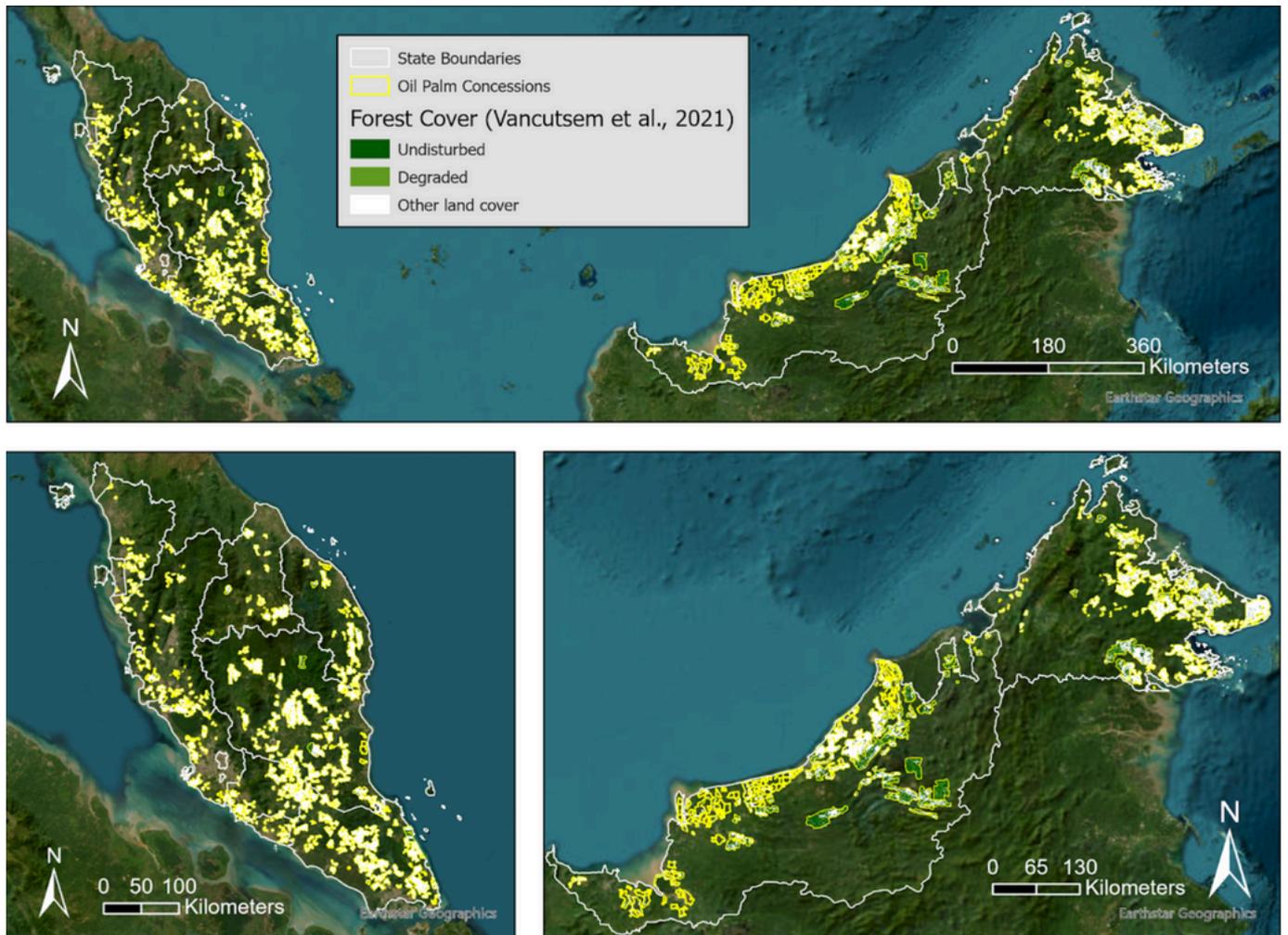
### **Key finding 3: Oil palm expansion remains a threat**

Baseline 1: Vancutsem et al., 2021

In Baseline 1, the Vancutsem et al. dataset identifies 452,009.59 ha of remaining undisturbed forests and 298,933.18 ha of degraded forests in known oil palm concessions.

In this baseline, there is a combined 750,942.78 ha of remaining forests in known oil palm concessions, which represents 23.13% of all remaining forests in known concessions (map 7).

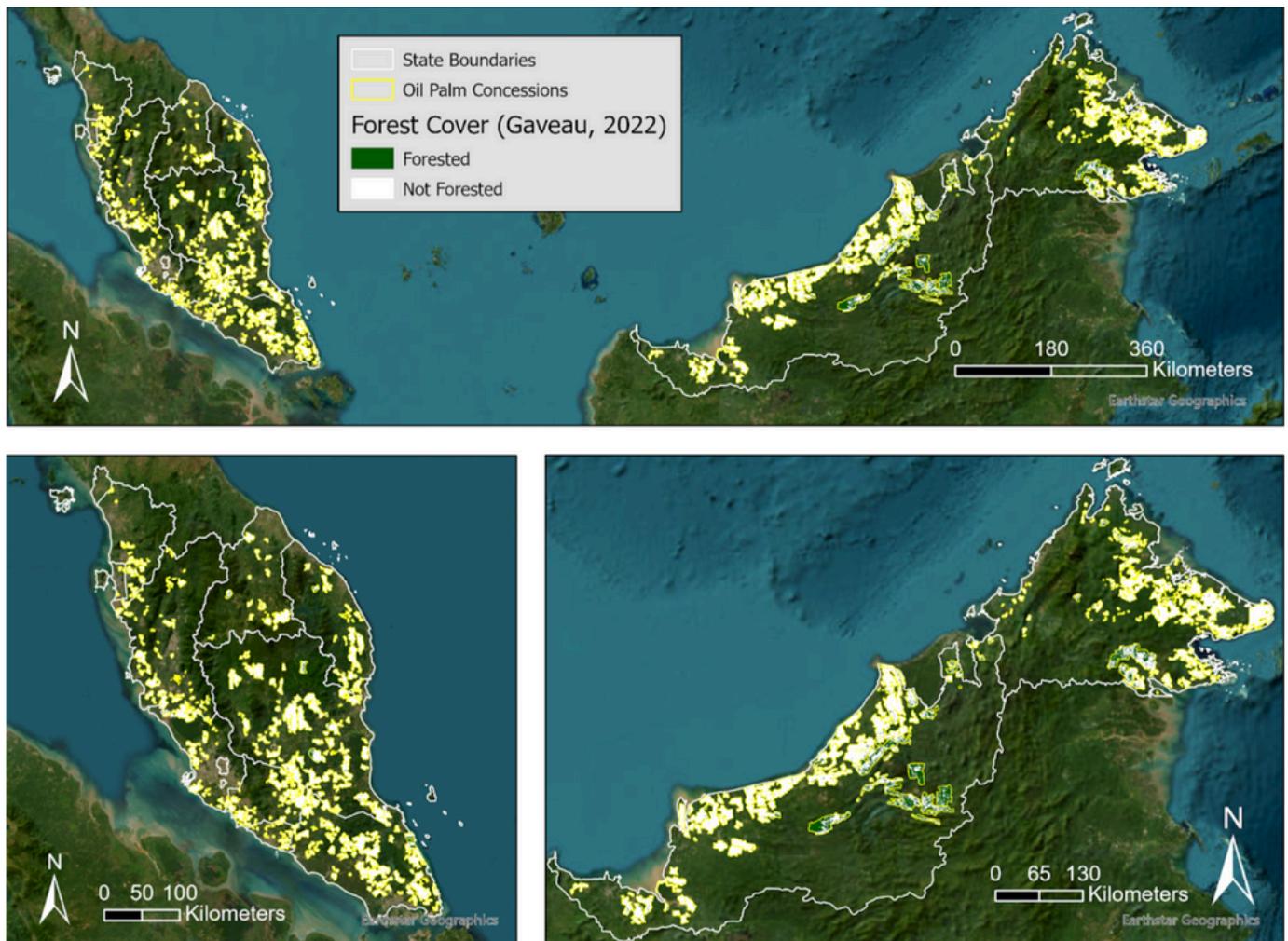
**Map 7: Forest Cover Classification (Vancutsem et al., 2021) of Oil Palm Concessions (RimbaWatch, 2023) in Malaysia**



Baseline 3: Gaveau, 2022

In Baseline 3, the Gaveau dataset identifies 466,751.76 ha of remaining forests in known oil palm concessions, which represents 27.17% of all remaining forests in known concessions (map 8).

**Map 8: Forest Cover Classification (Gaveau, 2022) of Oil Palm Concessions (RimbaWatch, 2023) in Malaysia**



### Discussion

In both baselines, oil palm plantations could remain as a driver of deforestation in Malaysia in the future, despite Malaysia's stated commitment to achieve 100% MSPO certification, which would expose plantations to a cut-off date of 31st December 2019. However, oil palm plantations are no longer the top driver of deforestation in Malaysia.

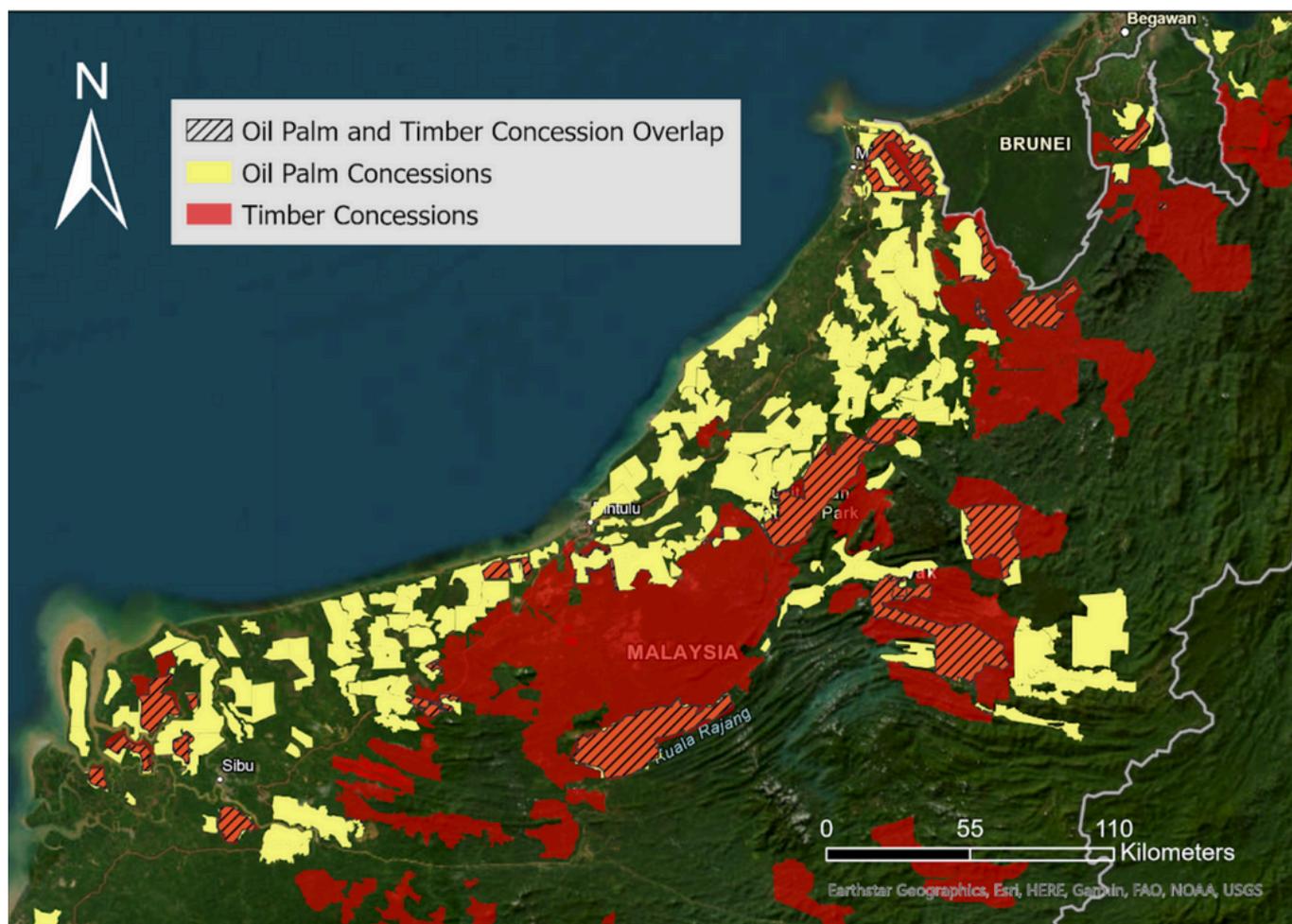
### **Key finding 4: Oil palm and timber plantation concessions overlap**

### Discussion

It must be noted that a number of known oil palm concessions overlap with known timber plantation concessions in East Malaysia. In the case of the Vancutsem et al. dataset, there is 526,249.7 ha of overlap. This can be attributed to the fact that the Sarawak Forestry Department permits the planting of up to 20% of the timber plantation concessions with oil palm for one cycle of 25 years.

However, it is not known in these cases whether the oil palm species or conventional timber plantation species such as acacia will take precedence after the conversion takes place (map 9). It must be noted that this overlap does not impact the analysis in Key Findings I.

**Map 9: Overlap of Oil Palm and Timber Concessions (RimbaWatch, 2023) in Sarawak, Malaysia**

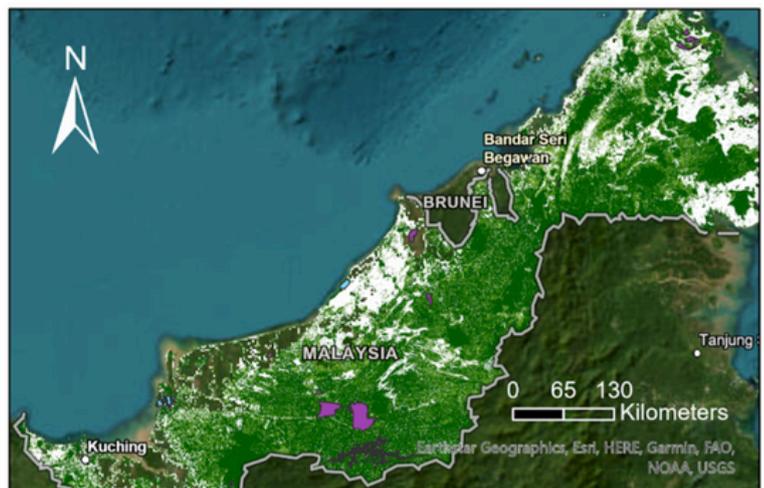


**Key finding 5: There is deforestation beyond timber and oil palm**

Baseline 1: Vancutsem et al., 2021

In Baseline 1, the Vancutsem et al. dataset identifies 280,868.37 ha of remaining forests in non-timber plantation or oil palm concessions (map 10). Of this, there are 7,233.72 ha of forest reserve degazettements, 71,687.85 ha of settlements (including the Baleh hydropower project), 5,480.2 ha of mining and quarrying and 196,466.6 ha of others (which includes forested areas advertised for sale online and undefined agricultural projects).

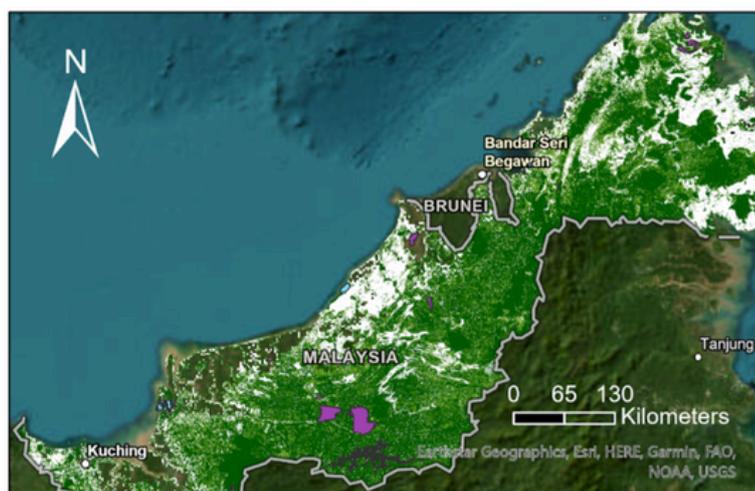
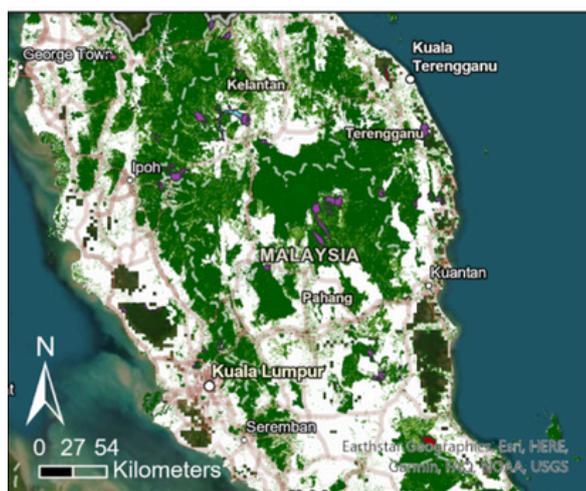
**Map 10: Forest Cover Classification (Vancutsem et al., 2021) of Non-Timber or Palm Concessions (RimbaWatch, 2023) in Malaysia**



### Baseline 3: Gaveau, 2022

In Baseline 3, the Gaveau dataset identifies 185,978.22 ha of remaining forests in non-timber plantation or oil palm concessions (map 11). Of this, there are 5,764.65 ha of forest reserve degazettements, 58,505.19 ha of settlements (including the Baleh hydropower project), 4,025.86 ha of mining and quarrying and 117,682.52 ha of others (which includes forested areas advertised for sale online and undefined agricultural projects).

**Map 11: Forest Cover Classification (Gaveau, 2022) of Non-Timber or Palm Concessions (RimbaWatch, 2023) in Malaysia**



### **Key finding 6: Deforestation threatens communities**

#### Discussion

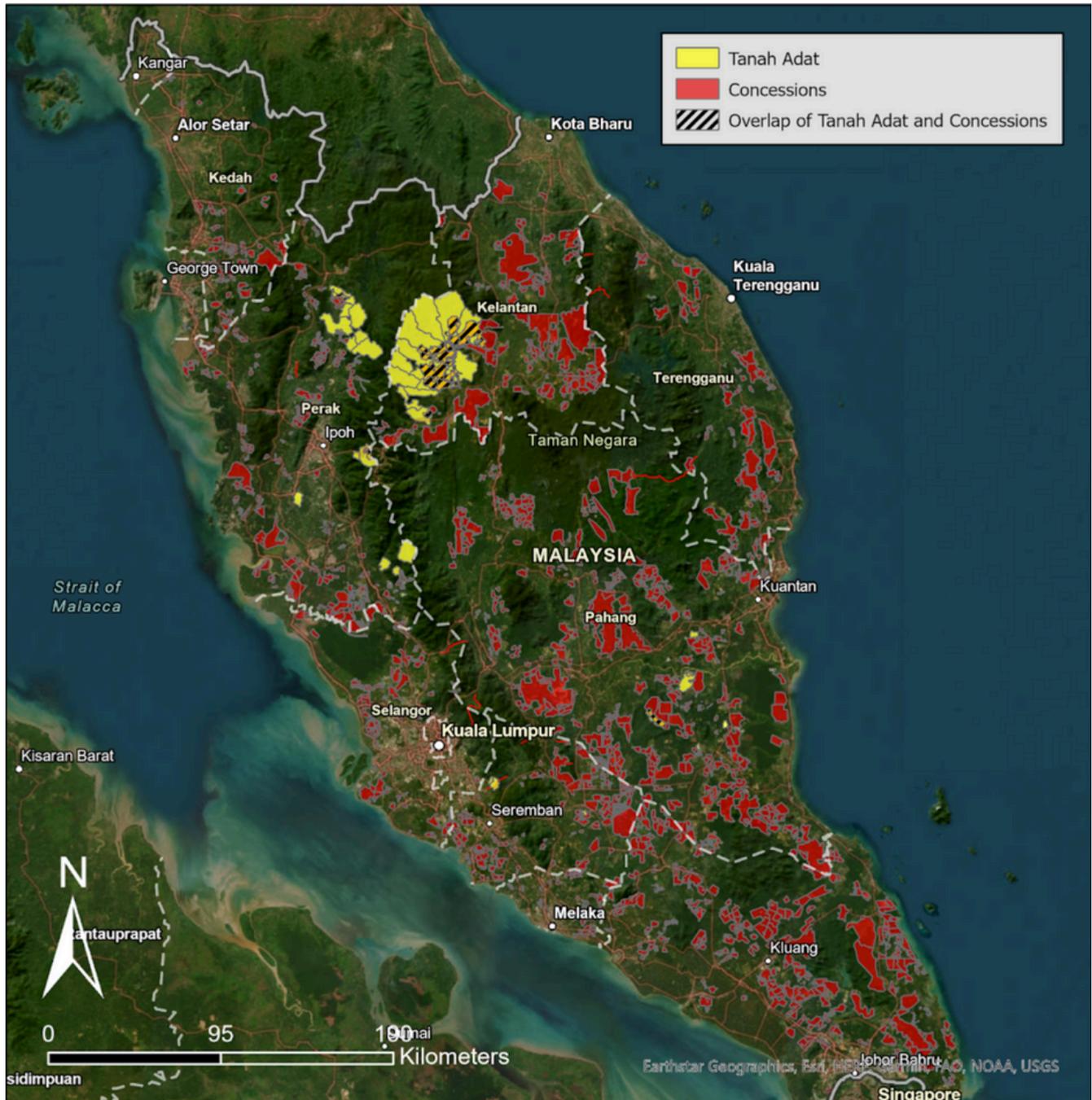
The Orang Asal comprise a diverse range of Indigenous groups in Malaysia. Their rights to their traditional territories receive limited recognition, despite Malaysia's endorsement of the United Nations Declaration on the Rights of Indigenous Peoples (UNDRIP).

Of the 1,060,142 ha of geospatial data for traditional territories which RimbaWatch possesses, which is in itself a small sample of all the lands claimed by Indigenous communities in Malaysia, 246,177 ha overlap with known concessions (map 12 and 13).

Of these concessions, 207,762 ha are timber plantations, 21,686 ha are oil palm plantations, and 16,729 ha are other.

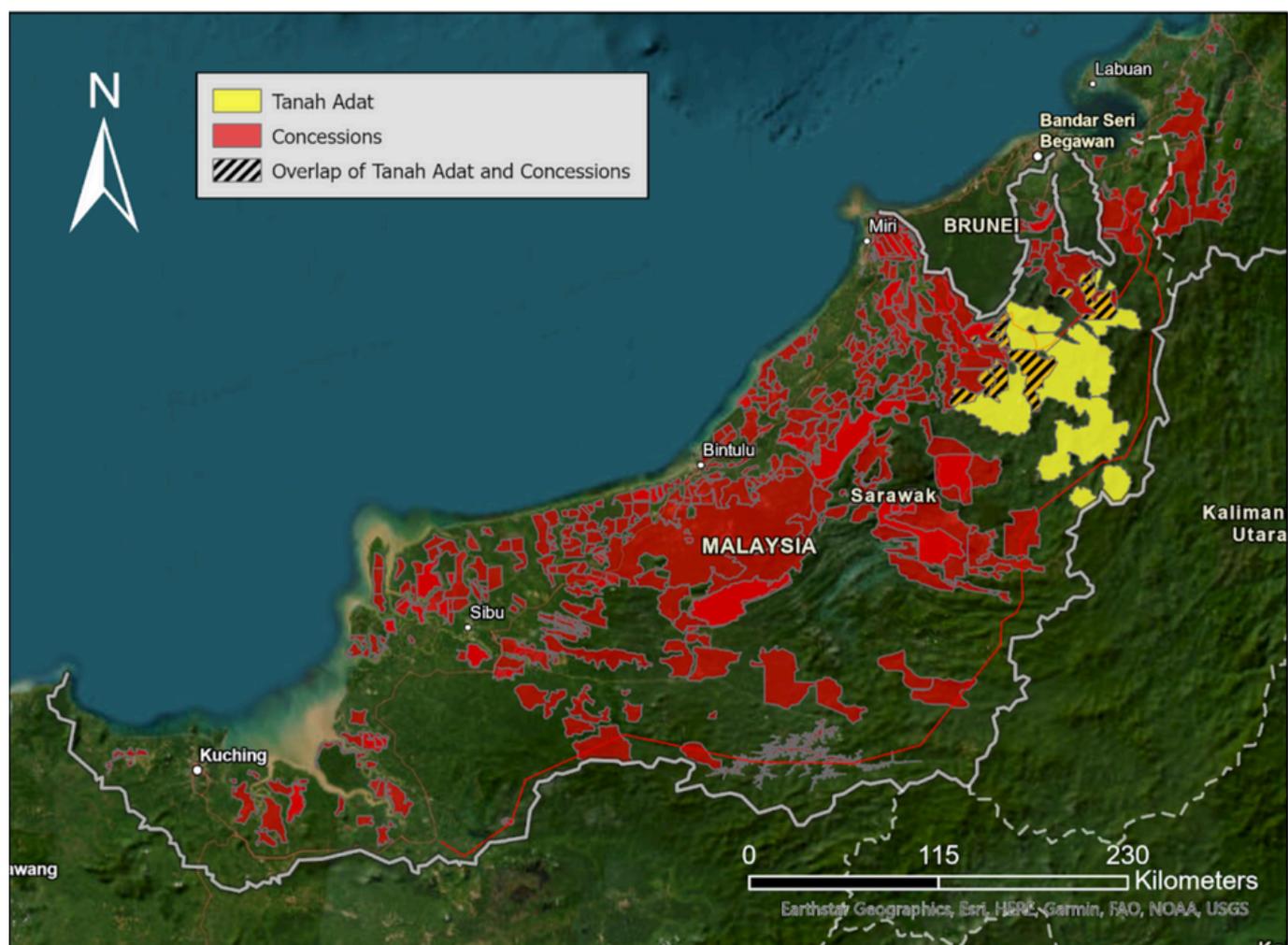
It must be noted that encroachments of traditional territories have continued since the publication of the initial report. In one case, a state-linked company commenced development of an oil palm plantation on peatland near the Jakun community of Air Hitam in Pekan, Pahang<sup>9</sup> which has impacted community gravesites, trees and other properties.

**Map 12: Overlap of Concessions and Tanah Adat in Peninsular Malaysia**



<sup>9</sup> <https://www.freemalaysiatoday.com/category/nation/2023/07/05/revoke-approval-for-palm-oil-project-near-orang-asli-villages-govt-told/>

Map 13: Overlap of Concessions and Tanah Adat in Sarawak, Malaysia



### Key finding 7: Deforestation will drive emissions

#### Discussion

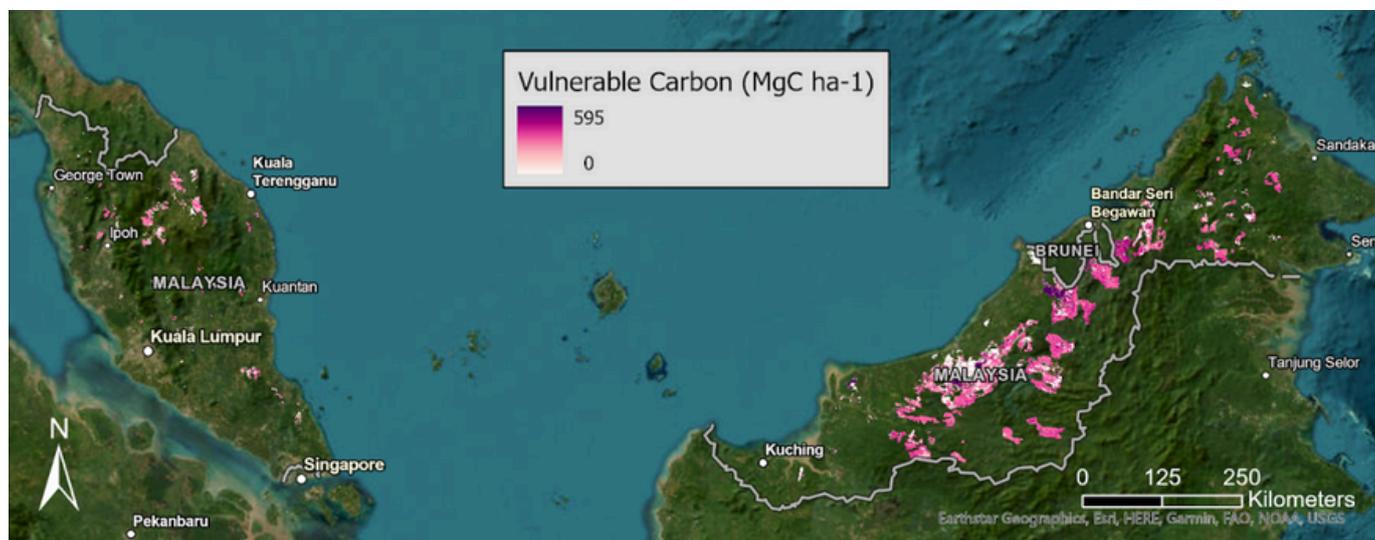
The Noon et al. dataset on vulnerable carbon estimates the amount of carbon that will be released into the atmosphere during the conversion of natural forests to non-forest usage, on the assumption that 100% aboveground biomass and 21.3% of soil carbon is vulnerable to release during conversion events.

Illustrating this, in the case of timber plantations alone, 368,615,839.92 MgC is expected to be released from the conversion of known concessions, which is roughly equal to the overall emissions of Petronas in 2022<sup>10</sup>. This data results in an average of 128.82 MgC ha<sup>-1</sup>.

<sup>10</sup>

[https://www.petronas.com/integrated-report-2022/assets/pdf/sustainability/9.%20PETRONAS%20Integrated%20Report%20\(PIR\)%202022%20-%20Our%20Sustainability%20Journey.pdf](https://www.petronas.com/integrated-report-2022/assets/pdf/sustainability/9.%20PETRONAS%20Integrated%20Report%20(PIR)%202022%20-%20Our%20Sustainability%20Journey.pdf)

**Map 14: Vulnerable Carbon (Noon et al., 2022) of Timber Plantation Concessions (RimbaWatch, 2023) in Malaysia**



**Key finding 8: There are loopholes in reporting mechanisms for deforestation**

Discussion

Malaysia adopts the Food and Agriculture Organisation's (FAO) definition of forest cover, which allows Malaysia to report any land classified as forest cover on paper by them, including empty land which has not yet been planted with trees and rubberwood plantations, as forest cover.

Recently<sup>11</sup>, the Minister of Natural Resources, Environment and Climate Change clarified that “generally, the total forest area is obtained from legal gazette notifications”, which means that any land gazetted by state governments as forest and subjected to the National Forestry Act are considered as forest cover. Further, the Minister has stated that based on Malaysia's reporting to international frameworks such as the Global Forest Resources Assessment protocol under the Food and Agricultural Organisation, that “there is hardly any deforestation from plantations”.

Timber plantations are exclusively located in areas gazetted in Peninsular Malaysia as Permanent Forest Reserves, in Sarawak as Permanent Forest Estates and in Sabah as Forest Reserves. As the land-use is not changed on paper when a natural forest in a gazetted estate or reserve is converted to monoculture, Malaysia does not consider any clearances for timber plantations as deforestation, regardless of physical changes to the ecosystem.

<sup>11</sup> <https://www.thestar.com.my/news/focus/2023/06/18/how-malaysia-is-trying-to-stay-green>.

Therefore, the 1,464,078.61 ha to 2,128,616.58 ha of degraded and undisturbed forests identified as under threat from conversion in the two baselines will not be recorded by Malaysia as deforestation; which is an inaccuracy calls into question the legitimacy of Malaysia's biodiversity and climate reporting mechanisms, and the possibility of Malaysia 'greenwashing' its deforestation due to this loophole.

### **Key finding 9: Basic data remains unavailable**

#### Discussion

The general findings of the original State of the Malaysian Rainforest (SMR) 2023 report on data non-transparency remain unchanged. Malaysia continues to restrict access to any geospatial data related to its official forest cover reporting, meaning that it does not share where its forests actually are. Maps of timber plantation concessions are grossly outdated and have not been updated to take into account new areas zoned for plantations in the ensuing years, such as Sabah's Forest Plantation Development Action Plan 2022-2036. Further, maps are not commonly available on Forestry Department websites.

The link to the map of License for Planted Forest Concessions from the Sarawak Forestry Department's website became inaccessible after the publication of the SMR 2023. The Ministry of Natural Resources, Environment and Climate Change has not yet delivered on promises to share EIA reports, which remain unavailable. There is still no publicly available list of EIAs for Sarawak. Further, the Malaysian Palm Oil Certification Council (MPOCC) stated that they would publish maps of oil palm concessions in Malaysia in 2019, but has yet to follow up on this.

## **Part III: Methodologies Used**

### **3.1 Georeferencing**

Where possible, concession boundaries are imported directly from existing datasets. If unavailable, maps are digitized to convert them from 2D images into geospatial data.

To digitize maps of concessions, these are georeferenced on Google Earth Pro according to forest reserve boundaries, geographical features (i.e rivers), or other other features (i.e boundaries of plantations). Once digitized, concessions are then traced at less than a 100km resolution for maps which are state level, 50km resolution for district level, and 20km for individual concessions. They are traced following the outer boundary of the concession, as a .1 point line.

It must be noted that the accuracy of concession boundaries are dependent on the resolution of the image used, and the data presented here is an estimate only.

### **3.2 Calculation of forest area and condition**

*System requirements for Section II-IV: To replicate this calculation, the user should download ArcGIS Pro 2.9, installed with a patch to fix existing bugs in the software. This methodology may be applicable with other Geographic Information Systems (GIS) such as QGIS, however the details below are based solely on calculations performed with ArcGIS Pro.*

Upon downloading the relevant data, the "Extract by Mask" raster tool and "Mosaic to New Raster" tool were applied to isolate and merge the data within Malaysia's administrative boundaries. This process generated a comprehensive layer representing the state of forests within Malaysian territory, categorized as [Undisturbed, Degraded, and Other] (Vancutsem et al., 2021) and [Forested, Not Forested] (Gaveau, 2022).

To integrate the concession boundaries data obtained from RimbaWatch into the analysis, the Keyhole Markup Language (KML) format of the concession boundaries (see Appendix II) was converted into a layer file using the tool available in ArcGIS Pro.

Further, classification of the polygons and lines in the RimbaWatch dataset (Appendix II) was conducted based on their respective attributes, such as timber plantations, palm oil areas, and settlements, utilizing the reclassify tool. This step enabled the differentiation of different types of concessions within the dataset.

Subsequently, the forest classification layer was overlaid onto the RimbaWatch dataset using the "Extract by Mask" tool. In this operation, the forest classification data served as the input data, and the RimbaWatch dataset functioned as the boundary, yielding forest classification information within the defined concession boundaries.

The attribute tables from the new layers provide data for the number of cells for each type of forest cover. Section IV describes how calculations on area are performed.

### 3.3 Calculation of vulnerable carbon

Three geospatial datasets were used. Firstly, the vector data of boundaries of interest, in this case the concession boundaries (see Appendix II) which were generated by RimbaWatch as per Section I above. Secondly, Malaysia administrative boundary shapefiles obtained from Stanford University and Tindak Malaysia, which are delineated by state to (a) provide a boundary for global datasets, and (b) to produce state analyses<sup>12</sup>. Thirdly, the Irrecoverable Carbon dataset, which includes carbon stocks from land-use change and forestry activities<sup>13</sup>. Specifically, the raster data includes information on vulnerable carbon, which refers to the carbon that would be released in a typical land-use conversion. This dataset is based on the conditions of forests at the time the base datasets were created (Spawn et al: 2010, Soilgrids: September 2019), and on the assumption that 100% of aboveground biomass is potentially vulnerable in a conversion event, and 21.3% of soil carbon is vulnerable during conversion.

The assessment of vulnerable carbon (VC) within concession boundaries (Appendix II) involved the utilization of various analytical tools within ArcGIS Pro. Initially, the VC raster layer was clipped to the target concession boundary or national administrative boundary using the "Extract by Mask" tool. This operation allowed for a focused examination of the regions of interest, and it could be applied iteratively to different or more specific boundaries, such as those associated with timber or palm oil.

Then, the attribute table of the new layer provides data on the values of Megagrams of Carbon per hectare and the number of cells for each value. Section IV describes how calculations on area are performed.

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<sup>12</sup> Hijmans, Robert J.. University of California, Berkeley. Museum of Vertebrate Zoology. (2015). Boundary, Malaysia, 2015. [Shapefile]. University of California, Berkeley. Museum of Vertebrate Zoology. Retrieved from <https://earthworks.stanford.edu/catalog/stanford-bd012vf3991>.

<sup>13</sup> Noon et al., "Mapping irrecoverable carbon", <https://zenodo.org/record/4091029#.ZDrmKOzMK3I>.

### 3.4 Calculating area from raster data in attribute tables

The layer properties of the raster data, available for each layer, provide the necessary information for this calculation. Specifically, the Raster Spatial Reference and Extent provided the necessary values for cell length (x) and cell width, which were instrumental in calculating the size of each cell. The cell length was squared to determine the cell size in square meters (m<sup>2</sup>), and this value was then converted to hectares (ha) by dividing it by 10,000.

The formula for calculating the cell size (ha) is as follows:

$$\text{Cell size (ha)} = \frac{x^2}{10000}$$

After obtaining the cell size, the attribute table of each layer was processed to extract pertinent information related to VC values and the corresponding number of pixels for each VC row. The total area of VC for each row in the attribute table was then determined by multiplying the number of cells by the previously calculated hectare value.

$$\text{Total VC area (ha)} = \text{Number of cells} \times \text{Cell size (ha)}$$

Finally, the total amount of carbon stored in a given area was determined by multiplying the total VC area (ha) by the corresponding VC value specific to that region.

$$\text{Total MgC (Megagrams of Carbon)} = \text{Total VC area (ha)} \times \text{Corresponding VC value}$$

#### Example

If cell width is 305.4067589 m, the area of one cell is  $\frac{93273.28841 \text{ m}^2}{10000}$  which is 9.327328841 ha.

Value (MgC ha <sup>-1</sup> )	Count (# of cells)	Area (ha)	VC (MgC)
0	47748	445361.2975	0
1	903	8422.577943	8422.577943
2	713	6650.385464	13300.77093
3	540	5036.757574	15110.27272
4	466	4346.53524	17386.14096
5	433	4038.733388	20193.66694
6	391	3646.985577	21881.91346
7	412	3842.859482	26900.01638
8	444	4141.334005	33130.67204
9	471	4393.171884	39538.54696
10	426	3973.442086	39734.42086

### 3.5 Disclaimer

It is important to standardise projection systems specific to the boundary of analysis to ensure accuracy of calculations. For the calculations in this report, the Projection Coordinate System (PCS) used was Kertau 47N and Kertau 48N, depending on whether analysis was performed on Peninsular Malaysia or Sabah and Sarawak. Differences in PCS can yield marginally different values.

## Appendix A: Data Sources

### 1.1 Physical data

Name	Citation	Link
European Union Tropical Moist Forest	Vancutsem, C., Achard, F., Pekel, J.-F., Vieilledent, G., Carboni, S., Simonetti, D., Gallego, J., Aragão, L. E., & Nasi, R. (2021). Long-term (1990–2019) monitoring of forest cover changes in the humid tropics. <i>Science Advances</i> , 7(10). <a href="https://doi.org/10.1126/sciadv.abe1603">https://doi.org/10.1126/sciadv.abe1603</a>	<a href="https://forobs.jrc.ec.europa.eu/TMF/data">https://forobs.jrc.ec.europa.eu/TMF/data</a>
Gaveau	Gaveau, D. (2022). Forest Area 2022. <i>Nusantara Atlas</i> . <a href="https://map.nusantara-atlas.org/">https://map.nusantara-atlas.org/</a>	N/A (sent directly)
Vulnerable Carbon	Noon, M. L., Goldstein, A., Ledezma, J. C., Roehrdanz, P. R., Cook-Patton, S. C., Spawn-Lee, S. A., Wright, T. M., Gonzalez-Roglich, M., Hole, D. G., Rockström, J., & Turner, W. R. (2021). Mapping the irrecoverable carbon in Earth's ecosystems. <i>Nature Sustainability</i> , 5(1), 37–46. <a href="https://doi.org/10.1038/s41893-021-00803-6">https://doi.org/10.1038/s41893-021-00803-6</a>	<a href="https://zenodo.org/record/4091029">https://zenodo.org/record/4091029</a>

## 1.2 Concession Data

The geospatial concession data can be downloaded [here](#).

Timber Plantations		
Name	Source	Link
Timber Plantations, Terengganu	Map from Forest Plantation EIA	N/A
Timber Plantations, Selangor	Map from Proposed Restoration Project, Bukit Tarek EIA	N/A
Timber Plantations, Johor	Rancangan Pengurusan Hutan Johor 2016-2025	<a href="https://forestry.johor.gov.my/images/pdf/RINGKASAN%20EKSEKUTIF_RPH%202016-2025.pdf">https://forestry.johor.gov.my/images/pdf/RINGKASAN%20EKSEKUTIF_RPH%202016-2025.pdf</a>
Timber Plantations, Perak,	Raw data sent to	N/A
Timber Plantations, Sarawak, 2020	License for Planted Forest Concessions, Sarawak from Global Forest Watch, updated using map of Valid License for Planted Forests concessions, 2020 published on Sarawak Forestry Corporation website	<a href="https://data.globalforestwatch.org/datasets/gfw::sarawak-licenses-for-planted-forests-lpfs/explore">https://data.globalforestwatch.org/datasets/gfw::sarawak-licenses-for-planted-forests-lpfs/explore</a>  Link for updated map removed by Sarawak Forestry Corporation.
Timber Plantations, Sabah, 2022	Map prepared by GIS Unit of Sabah Forestry Department	<a href="https://www.forestry.gov.my/images/pengumuman/2022/MFC/MFC2022/paperwork/KK17.pdf">https://www.forestry.gov.my/images/pengumuman/2022/MFC/MFC2022/paperwork/KK17.pdf</a>
Timber Plantations, Negeri Sembilan, 2022	Map published in CFS Masterplan	<a href="https://myplan.planmalaysia.gov.my/www/admin/uploads_publication/pelan-induk-rangkaian-ekologi-central-forest-spin-e-pirecfs-2022-jilid-2-perecfs-2022-jilid-2-negeri-sembilan-my-16032023.pdf">https://myplan.planmalaysia.gov.my/www/admin/uploads_publication/pelan-induk-rangkaian-ekologi-central-forest-spin-e-pirecfs-2022-jilid-2-perecfs-2022-jilid-2-negeri-sembilan-my-16032023.pdf</a>

Settlements		
Name	Source	Link
Baleh Dam	Provided by Bruno Manser Fonds	N/A
Upper Padas Dam	Map from EIA titled: Special Environmental Impact Assessment for Upper Padas Hydroelectric Project, Sabah	Link removed from Environmental Protection Department Sabah
Proposed developments, Genting Highlands Special Area Plan	Genting Highlands Special Area Plan	Link removed
Pahang Technology Park	East Coast Economic Region Plan	<a href="https://www.mida.gov.my/wp-content/uploads/2020/07/20200304175911_02_ECER_DC.pdf">https://www.mida.gov.my/wp-content/uploads/2020/07/20200304175911_02_ECER_DC.pdf</a>
Westport	EIA titled: "Westports Phase II Development – Proposed Expansion of Container Terminal CT10-CT17 and Its Associated Works at Westports Pulau Indah Selangor"	<a href="https://westportsholdings.com/wp-content/uploads/files/Westports%20%20Volume%201/Westports%20Phase%20II%20EIA-ExecutiveSummary-F0.pdf">https://westportsholdings.com/wp-content/uploads/files/Westports%20%20Volume%201/Westports%20Phase%20II%20EIA-ExecutiveSummary-F0.pdf</a>
Sunway Iskandar	Map posted by Sunway Property	<a href="https://www.sunwayproperty.com/malaysia-properties/malaysia-property-detail/sunway-city-iskandar-puteri/id/1a74e0f0-572b-688c-a7be-ff000068ef51/type/1">https://www.sunwayproperty.com/malaysia-properties/malaysia-property-detail/sunway-city-iskandar-puteri/id/1a74e0f0-572b-688c-a7be-ff000068ef51/type/1</a>
Papar Dam	Map published on SabahKini2.com	<a href="https://sabahkini2.com/en/news/1104/mengapa-shafie-lantik-amarjit-singh-pengarah-jabatan-air-semuanya-kerana-projek-empangan-papar-rm2b/view">https://sabahkini2.com/en/news/1104/mengapa-shafie-lantik-amarjit-singh-pengarah-jabatan-air-semuanya-kerana-projek-empangan-papar-rm2b/view</a>
SOGIP	Investment slides published by SOGIP	<a href="https://slideplayer.com/slide/4891835/">https://slideplayer.com/slide/4891835/</a>
Lawas Airport	Map published by contractor	<a href="https://minsar.com.my/minsars-airport-division-2/">https://minsar.com.my/minsars-airport-division-2/</a>

Samalaju Industrial Park	Map published by Samalaju Properties	<a href="http://www.samalajuproperties.com.my/about-us/samalaju-industrial-park-score/">http://www.samalajuproperties.com.my/about-us/samalaju-industrial-park-score/</a>
Tanjung Manis Halal Hub	Map published by Ministry of International Trade & Industry, Industrial Terminal & Entrepreneur Development Sarawak	<a href="https://mid.sarawak.gov.my/modules/web/pages.php?lang=en&amp;mod=webpage&amp;sub=page&amp;id=100&amp;menu_id=21&amp;sub_id=129">https://mid.sarawak.gov.my/modules/web/pages.php?lang=en&amp;mod=webpage&amp;sub=page&amp;id=100&amp;menu_id=21&amp;sub_id=129</a>
LBS Bina	Map published by The Edge	<a href="https://theedgemalaysia.com/article/lbs-bina-buys-bentong-land-plots-rm9785m-plans-rm9b-mixed-development">https://theedgemalaysia.com/article/lbs-bina-buys-bentong-land-plots-rm9785m-plans-rm9b-mixed-development</a>
Tropicana Windcity	Maps published by Tropicana	<a href="https://tropicanawindcity.com/#concept">https://tropicanawindcity.com/#concept</a>
LBS Bina Cameron Highlands	Maps published by MalaysiaKini	<a href="https://www.malaysiakini.com/news/607878">https://www.malaysiakini.com/news/607878</a>
Pavillion Genting	Maps published by KL Property	<a href="https://klproperty.cc/pavilion-genting-highlands-to-launch-in-2023/">https://klproperty.cc/pavilion-genting-highlands-to-launch-in-2023/</a>
Proposed roads, Hulu Besut	Rancangan Tempatan Daerah Besut, 2035	<a href="https://www.planmalaysia.gov.my/planmalaysia/resources/epublisiti/turun/rtd_Besut2035/Jilid%203%20Draf%20RT%20Daerah%20Besut%202035%20%28Penggantian%29.pdf">https://www.planmalaysia.gov.my/planmalaysia/resources/epublisiti/turun/rtd_Besut2035/Jilid%203%20Draf%20RT%20Daerah%20Besut%202035%20%28Penggantian%29.pdf</a>
Sarawak Sabah Link Road	Map published by Dayak Daily	<a href="https://dayakdaily.com/sarawak-sabah-link-road-akan-hubungan-14-bandar-pedalaman-utama/">https://dayakdaily.com/sarawak-sabah-link-road-akan-hubungan-14-bandar-pedalaman-utama/</a>
Proposed roads, Negeri Sembilan	Negeri Sembilan State Structure Plan, 2045	<a href="https://www.planmalaysia.gov.my/index.php/pages/view/59">https://www.planmalaysia.gov.my/index.php/pages/view/59</a>

		8?cats=12
Proposed road, Negeri Sembilan	Map from EIA titled: MEMBINA JALAN BAHARU DARI KAMPUNG GAGU – ULU BERANANG, NEGERI SEMBILAN	Link removed from Department of Environment website
Pasir Raja-Ulu Tembeling Road	Map published by contractor	<a href="https://khairiconsult.com.my/project/construction-of-road-from-pasir-raja-hulu-dungun-terengganu-to-kampung-mat-daling-jerantut-pahang-phase-3a-3b/">https://khairiconsult.com.my/project/construction-of-road-from-pasir-raja-hulu-dungun-terengganu-to-kampung-mat-daling-jerantut-pahang-phase-3a-3b/</a>
Proposed road, Piah Forest Reserve	Map from EIA titled: PROJEK JALAN KG BATU RENG KE INTAN SURAYA (CADANGAN PROJEK MEMBINA DAN MENYIAPKAN JALAN DARI KG BENG KE KG RAJA INTAN SURAYA, HULU PERAK (FASA 2-DARI KG BATU RENG KE KG RAJA INTAN SURAYA) PERAK UNTUK TETUAN JABATAN KERJA RAYA PERAK	Link removed from Department of Environment website
Proposed pylon, Janda Baik	Official survey map published by Save Janda Baik Facebook Group	<a href="https://www.facebook.com/savejandabaik/photos/a.523232304790809/1604102230037139">https://www.facebook.com/savejandabaik/photos/a.523232304790809/1604102230037139</a>
Nenggiri Dam	Map from EIA titled: THE PROPOSED NENGGIRI HYDROELECTRIC PROJECT	Link removed from Department of Environment website
Sungai Pelus Dam	Map from EIA titled: PROPOSED HYDROPOWER PLANT (25.8 MW) WITH A SMALL SCHEME COVERING AN AREA OF 53.78 HECTARES (132.893 ACRES) AT SUNGAI PELUS & SUNGAI YUM IN KORBU FOREST RESERVE & RPS LEGAP ORANG ASLI RESERVE,	Link removed from Department of Environment website

	MUKIM SUNGAI SIPUT, FOREST DISTRICT OF KUALA KANGSAR, PERAK	
Upper Padas Dam	Map from EIA titled: Special Environmental Impact Assessment for Upper Padas Hydroelectric Project, Sabah	Link removed from Environmental Protection Department Sabah

Other		
Name	Source	Link
Proposed developments in Lojing	Lojing Special Area Plan	<a href="https://mdgm.kelantan.gov.my/images/2021/Bahagian_Perancangan/DRAF_RANCANGAN_KAWASAN_KHAS_TANAH_TINGGI_LOJING_PENGUBAHAN_KALI_KE_2_BIL_1_2021.pdf">https://mdgm.kelantan.gov.my/images/2021/Bahagian_Perancangan/DRAF_RANCANGAN_KAWASAN_KHAS_TANAH_TINGGI_LOJING_PENGUBAHAN_KALI_KE_2_BIL_1_2021.pdf</a>
Proposed clearances in HS Rasau Kerteh	Plans sighted by Zoologi Malaysia	<a href="https://twitter.com/ZoologiMY/status/1489960446958653442/photo/1">https://twitter.com/ZoologiMY/status/1489960446958653442/photo/1</a>
Selangor Smart Agro Park	Sahabat Alam Malaysia article	<a href="https://foe-malaysia.org/articles/stop-peat-swamp-forest-conversion-and-clearance-at-mukim-sungai-panjang-sabak-bernam-for-the-selangor-smart-agro-park-ssap-project/">https://foe-malaysia.org/articles/stop-peat-swamp-forest-conversion-and-clearance-at-mukim-sungai-panjang-sabak-bernam-for-the-selangor-smart-agro-park-ssap-project/</a>
Mentiga Plantation Concession	Image from Deru Semangat/Tabung Haji EIA	Link removed from Department of Environment website
NCR Land Development Area/Salra Tunoh Development Area	Map published by Regional Corridor Development Authority	<a href="http://bigconnectivity.org/beta/sites/default/files/2018-10/Module2_Session5_Topic5.3_Asian%20Development%20Bank%20Economic%20Corridor%20Development%201472018.pdf">http://bigconnectivity.org/beta/sites/default/files/2018-10/Module2_Session5_Topic5.3_Asian%20Development%20Bank%20Economic%20Corridor%20Development%201472018.pdf</a>
Area reserved for agricultural purposes	Maps prepared by partners	Sarawak Government Gazette, Vol. LXXV No.63 (9 September 2020)
Seruan Gemilang	Map from EIA titled: The	Link removed from

Concession	Proposed 3844.60 Hectares (9500 Acres) Of Logging Activity In Bukit Ibam Forest Reserve In Mukim Keratong, District Of Rompin, Pahang Darul Makmur	Department of Environment website
Super Radiance Concession	Map from EIA titled: The Proposed 360.82 Hectares (891.61 Acres) Of Logging Activity In State land, In Mukim Endau And Rompin, District Of Rompin, Pahang Darul Makmur	Link removed from Department of Environment website
Koperasi Usahawan Bersatu Selangor Berhad	Map from EIA titled: Cadangan Pembangunan Pertanian Bercampur di Tanah Hutan Simpan Sg. Karang Sabak Bernam, Selangor	Link not available
Kinta Highlands	Map published by KUASA Perak	<a href="https://www.kuasaperak.org/?p=562">https://www.kuasaperak.org/?p=562</a>

Mining and Quarrying		
Name	Source	Link
Bukit Lagong Quarries	Map sighted and published by RimbaWatch	<a href="https://www.malaysiakini.com/news/637165">https://www.malaysiakini.com/news/637165</a>
BornOil Mine	Maps published by MalaysiaKini	<a href="https://www.malaysiakini.com/announcement/573797">https://www.malaysiakini.com/announcement/573797</a>
Sultan Ibrahim Gold Mine	Map from EIA titled: PROPOSED GOLD MINING OPERATION ON PART OF PLOT PTD 216, HS(D) 6881, MUKIM TENGGAROH, DAERAH MERSING, NEGERI JOHOR DARUL TAKZIM OLEH DYMM SULTAN IBRAHIM <u>IBNI</u> <u>ALMARHUM SULTAN ISKANDAR</u>	Link removed from Department of Environment website
Balingian Coal Mine	Map published by Sarawak	<a href="http://www2.sesco.com.my/n">http://www2.sesco.com.my/n</a>
	Energy	<a href="oticeDoc/BEM-2019-003%20-%20Tender%20Notice.pdf">oticeDoc/BEM-2019-003%20-%20Tender%20Notice.pdf</a>
Nanga Merit Coal Mine	Map published by Regional Corridor Development Authority	<a href="http://bigconnectivity.org/beta/sites/default/files/2018-10/Module2_Session5_Topic5.3_Asian%20Development%20Bank%20Economic%20Corridor%20Development%201472018.pdf">http://bigconnectivity.org/beta/sites/default/files/2018-10/Module2_Session5_Topic5.3_Asian%20Development%20Bank%20Economic%20Corridor%20Development%201472018.pdf</a>

Forest Reserve Degazettements		
Name	Source	Link
Belara Forest Reserve	Gaps in map of Belara Forest Reserve, CFS Masterplan	<a href="https://myplan.planmalaysia.gov.my/www/admin/uploads_publication/pelan-induk-rangkaian-ekologi-central-forest-spin-e-pirecfs-2022-jilid-2-perecfs-2022-jilid-2-negeri-terengganu-my-17032023.pdf">https://myplan.planmalaysia.gov.my/www/admin/uploads_publication/pelan-induk-rangkaian-ekologi-central-forest-spin-e-pirecfs-2022-jilid-2-perecfs-2022-jilid-2-negeri-terengganu-my-17032023.pdf</a>
Lesong Forest Reserve	Maps published by HutanWatch	<a href="https://www.hutanwatch.com/news/tags/endau-rompin-national-park">https://www.hutanwatch.com/news/tags/endau-rompin-national-park</a>

Areas proposed for sale			
Name	Source	Link	Image
Refer to Dataset <a href="#">here</a> .			

Oil Palm		
Name	Source	Link
Refer to Oil Palm Dataset <a href="#">here</a> .		

### **About RimbaWatch**

RimbaWatch is a regional, independent watchdog conducting research and analysis on climate-related issues.

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