Fire frequency, intensity, and burn severity in Kalimantan’s Peatland areas over two Decades

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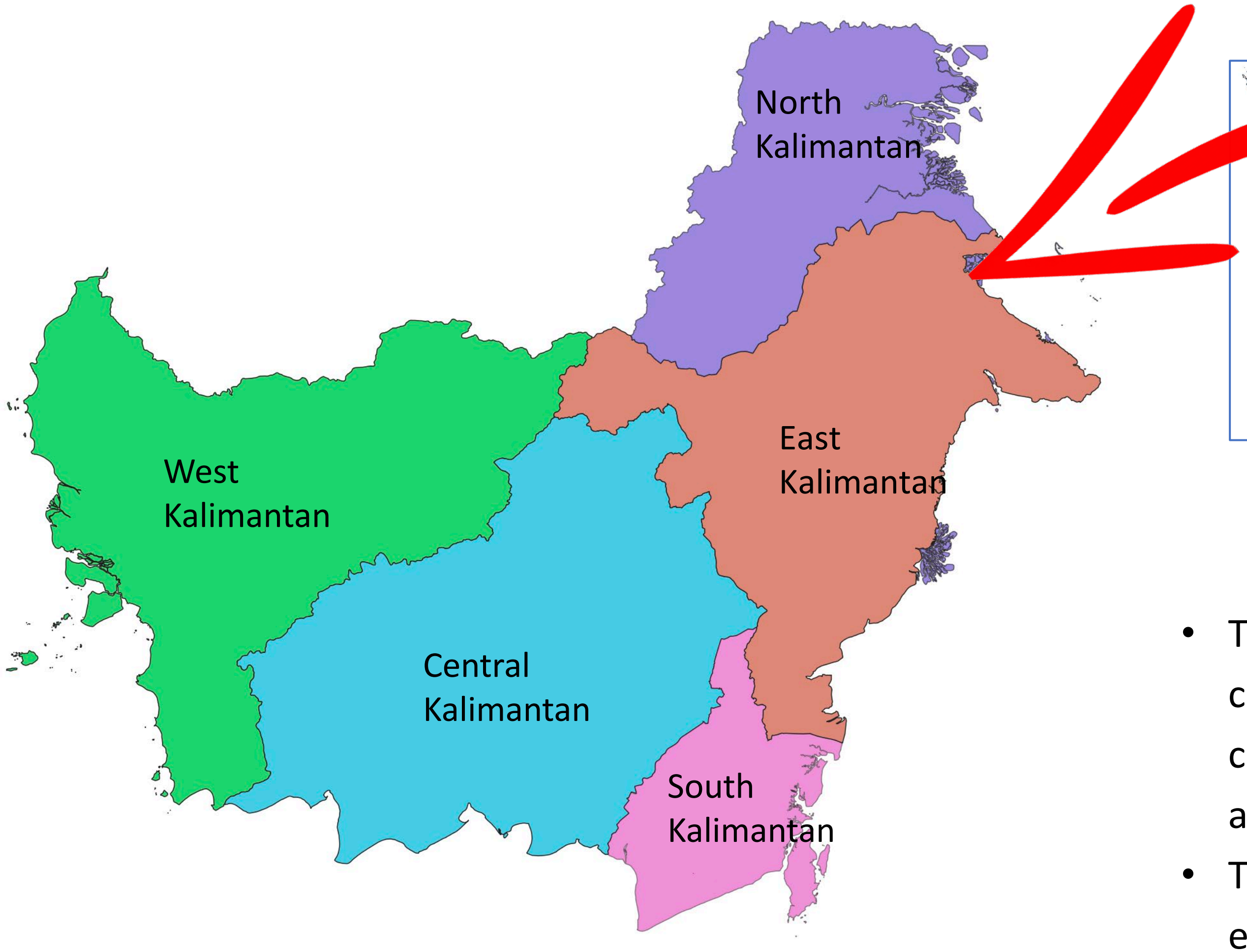
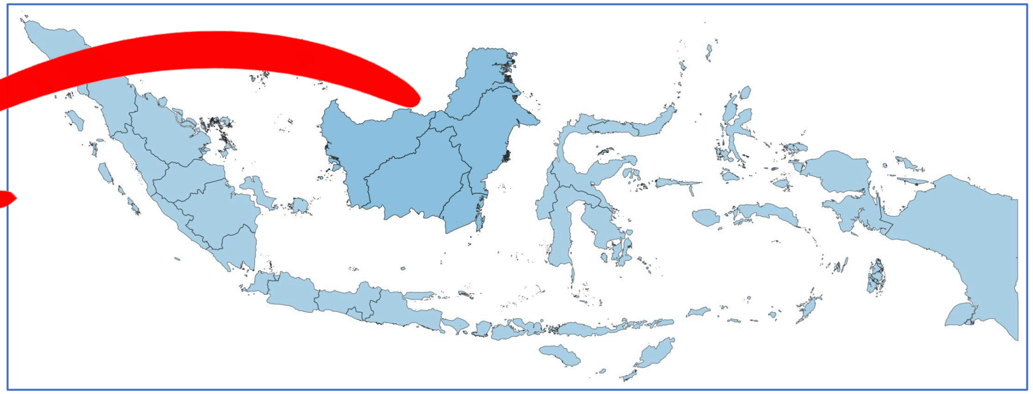
Background



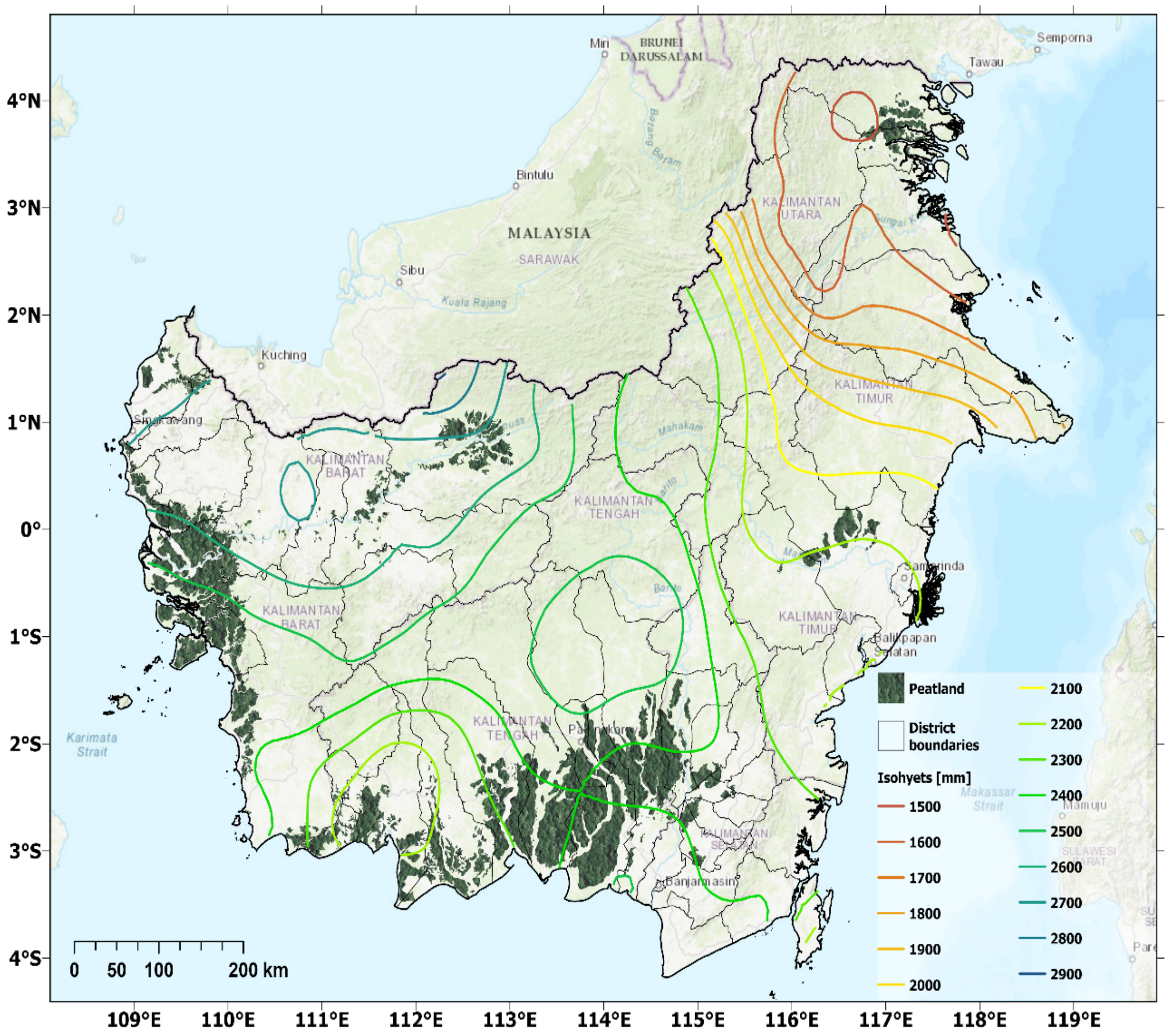


- The occurrence of peatland fires in Indonesia is driven by a complex combination of overarching meteorological conditions, the political framework, and socio-economic aspects within agricultural communities in peatland areas
- The province of Central Kalimantan in Indonesia, where an estimated 10,000 km^2 of tropical peat swamp forest was cleared during the Mega Rice project exhibits the highest density of peatland fires in Southeast Asia.

Objective

- Assess the effect of climate and meteorological conditions on the number and behavior of fires in tropical peatland
- Analyze spatiotemporal patterns in fire frequency and burn severity across all peatland areas of Kalimantan from January 2001 through December 2021
- Model potential surface fire intensity for four dominant land cover types in Kalimantan to better understand how changing LULC alters landscape flammability

Location



The study region showing the delineated peatland areas based on PEATMAP data and the average annual precipitation for the study period from Jan. 2001 to Dec. 2021.

Field Sites

Field sites (A) forest, (B) plantation, (C) oil palm, and (D) early successional grassland from which fuel models were developed and fire behaviour interpreted in Kalimantan, Indonesia.

Burn severity analyses and classification

The differenced Normalized Burn Ratio (dNBR) was used to assess aboveground damage to vegetated areas after fires. Unharmed vegetation exhibits high reflectance values in the near-infrared NIR , and low reflectance in the shortwave-infrared (SWIR) band spectrum whereas burnt vegetation shows low reflectance in the NIR and high reflectance in the SWIR band.

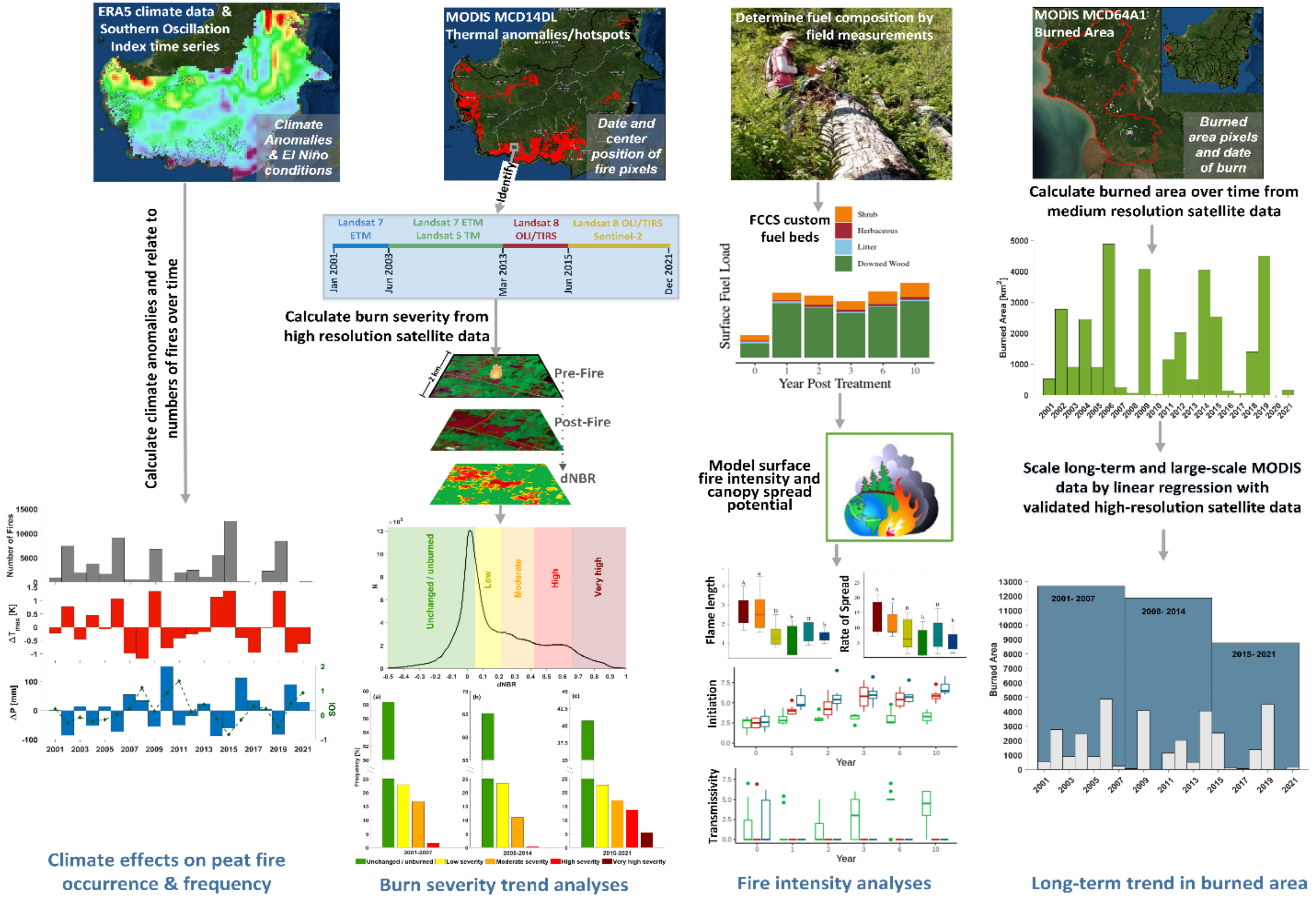
High NBR (Eq. 1) values indicate healthy unburned vegetation while low NBR values indicate bare ground, charred vegetation, and recently burnt areas.

By comparing pre-fire reflectance with post-fire reflectance through the dNBR (Eq. 2), damage to the surface vegetation (i.e., burn severity) can be assessed and classified following equations 1 and 2:

$$NBR = \frac{(NIR - SWIR)}{(NIR + SWIR)}$$

$$dNBR = NBR_{pre-fire} - NBR_{post-fire}$$

(Eq. 1) (Eq. 2)



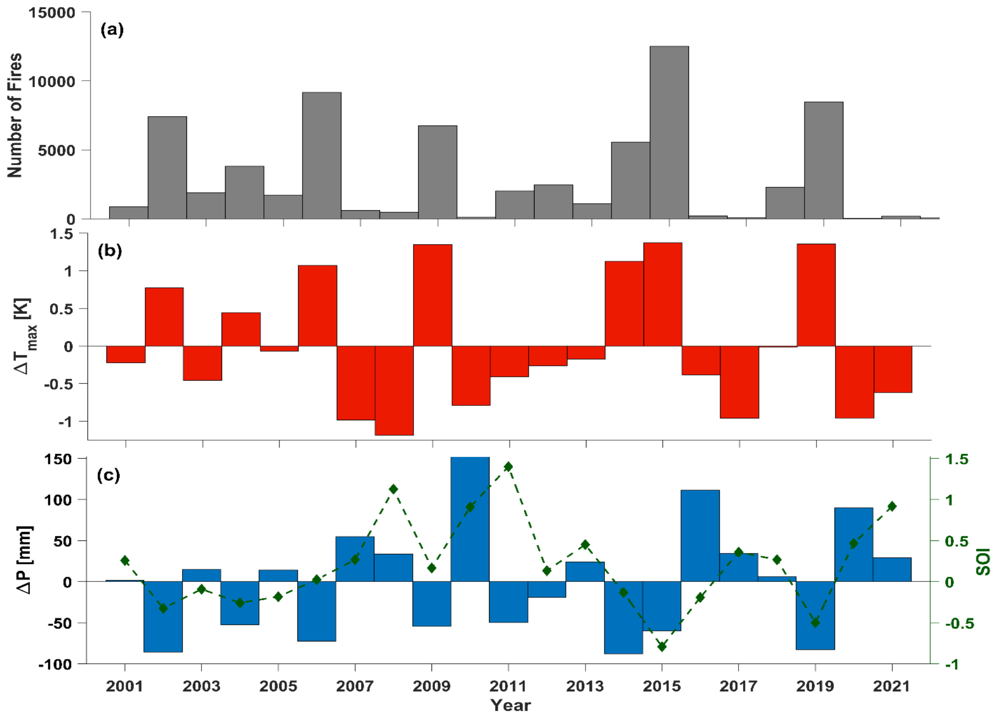
Schematic overview of processing steps and data used for the analyses.

Fire intensity modeling

Fuel Characteristic Classification System (FCCS) is applied to build custom fuel models based on field observations and characterized surface fire intensity and canopy fire transmission in the Fuel and Fire Tool.

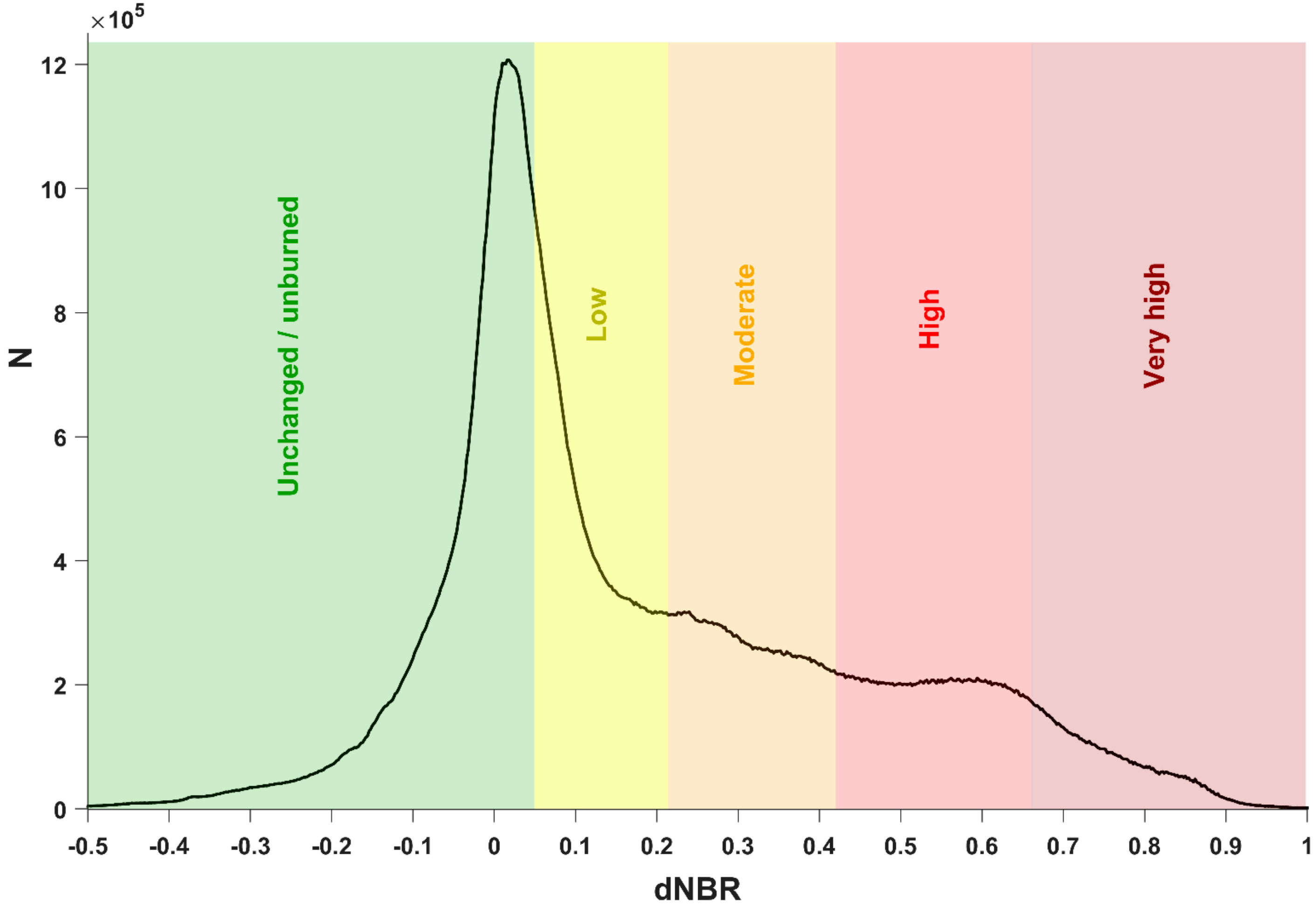
The model results indicate a substantial tradeoff in reduced surface fire risk in plantations, but much greater risks of tree canopy fire initiation and crown fire spread relative to natural forest vegetation.

Dependence of fire frequencies on meteorological conditions



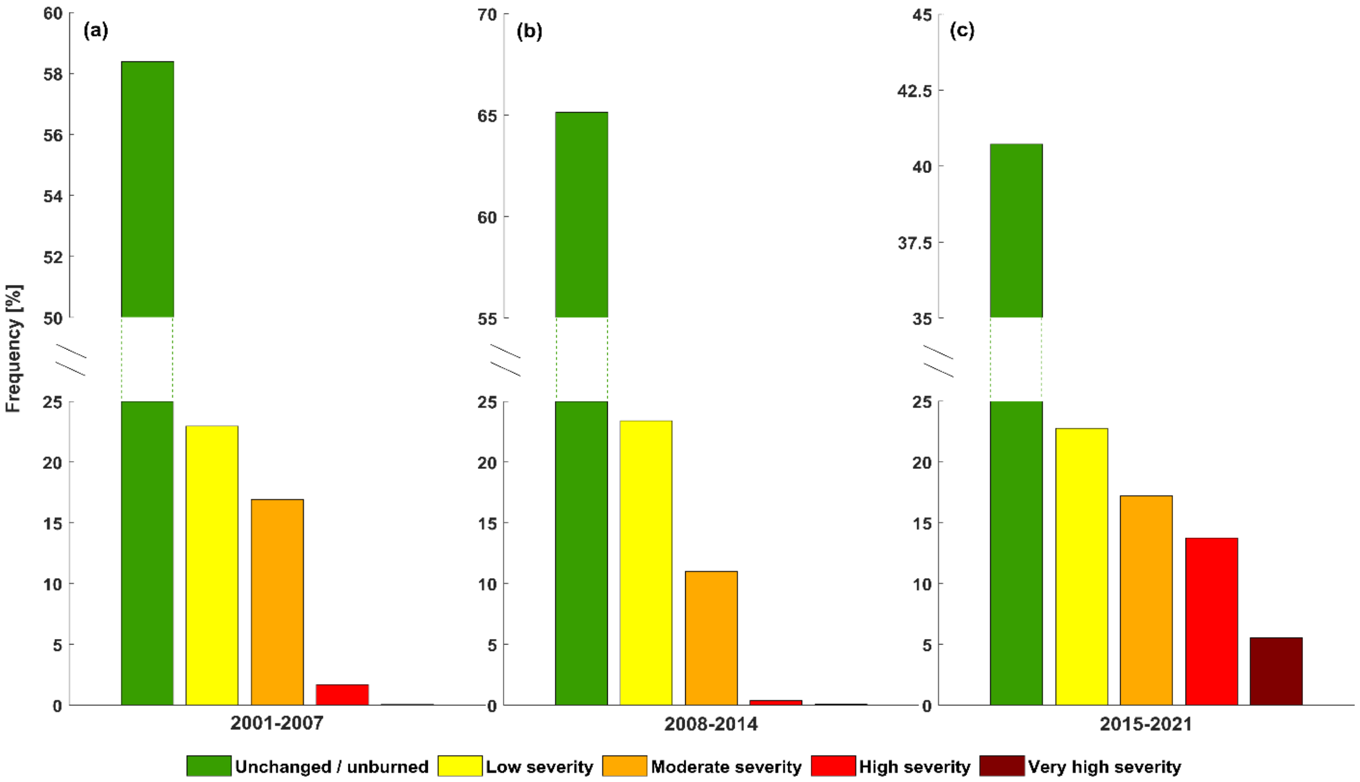
Annual number of peatland fires in Kalimantan based on MODIS hotspot data (A) and the corresponding anomalies of maximum monthly temperature (B) and total precipitation (C) integrated over the peatland areas of Kalimantan based on ERA5 Reanalysis data. The green line in panel (C) shows the annual mean SOI (derived from) https://www.cpc.ncep.noaa.gov/data/indices/soi with negative values indicating El Niño conditions.

Regional trends in peat fire burn severity



Frequency distribution of calculated dNBR pixel values and applied dNBR class boundaries for the burn severity classification of all fires included in the analysis across Kalimantan.

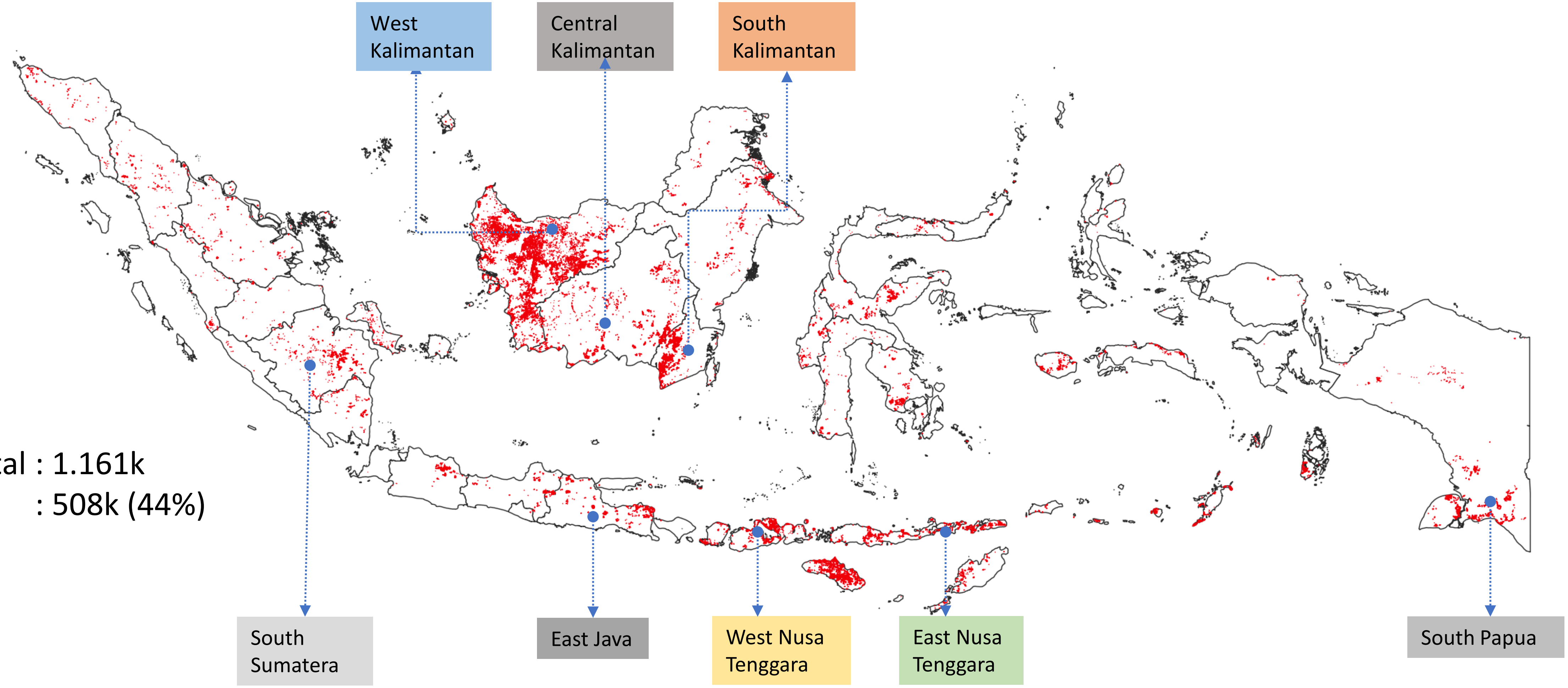
dNBR range	Severity class
< 0.053	Unchanged/unburned
0.053 – 0.212	Low
0.213 – 0.419	Moderate
0.420 – 0.660	High
>0.660	Very high



Histograms of average burn severities over the consecutive periods 2001–2007 (a), 2008–2014 (b), and 2015–2021 (c).

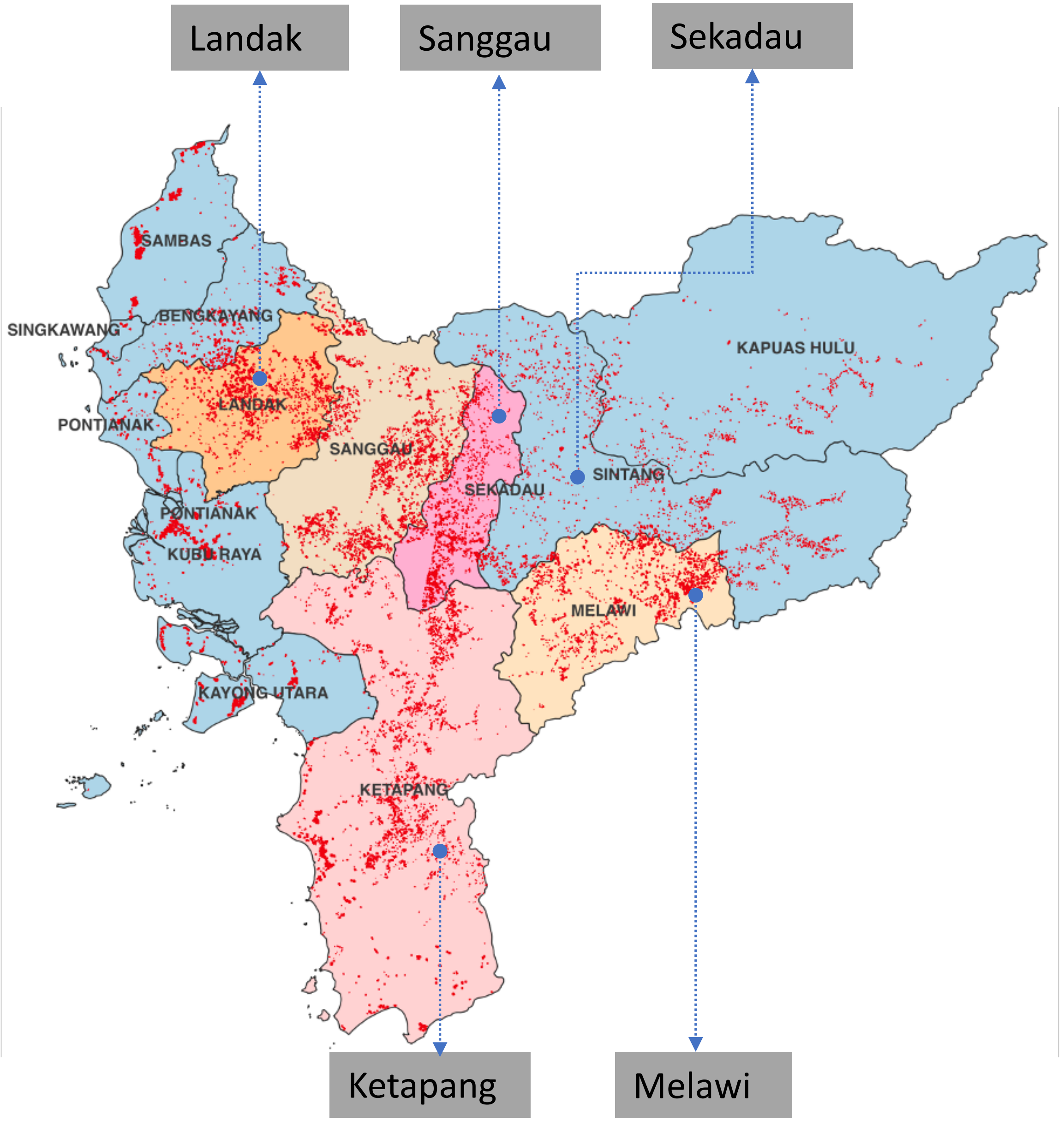
To account for increased numbers of unchanged/unburned pixels inevitably captured in satellite imagery cutouts, the histograms are plotted with breaks in the y-axes for better visibility of the relative distribution values that refer to burned areas.

Burned Area in Indonesia 2023

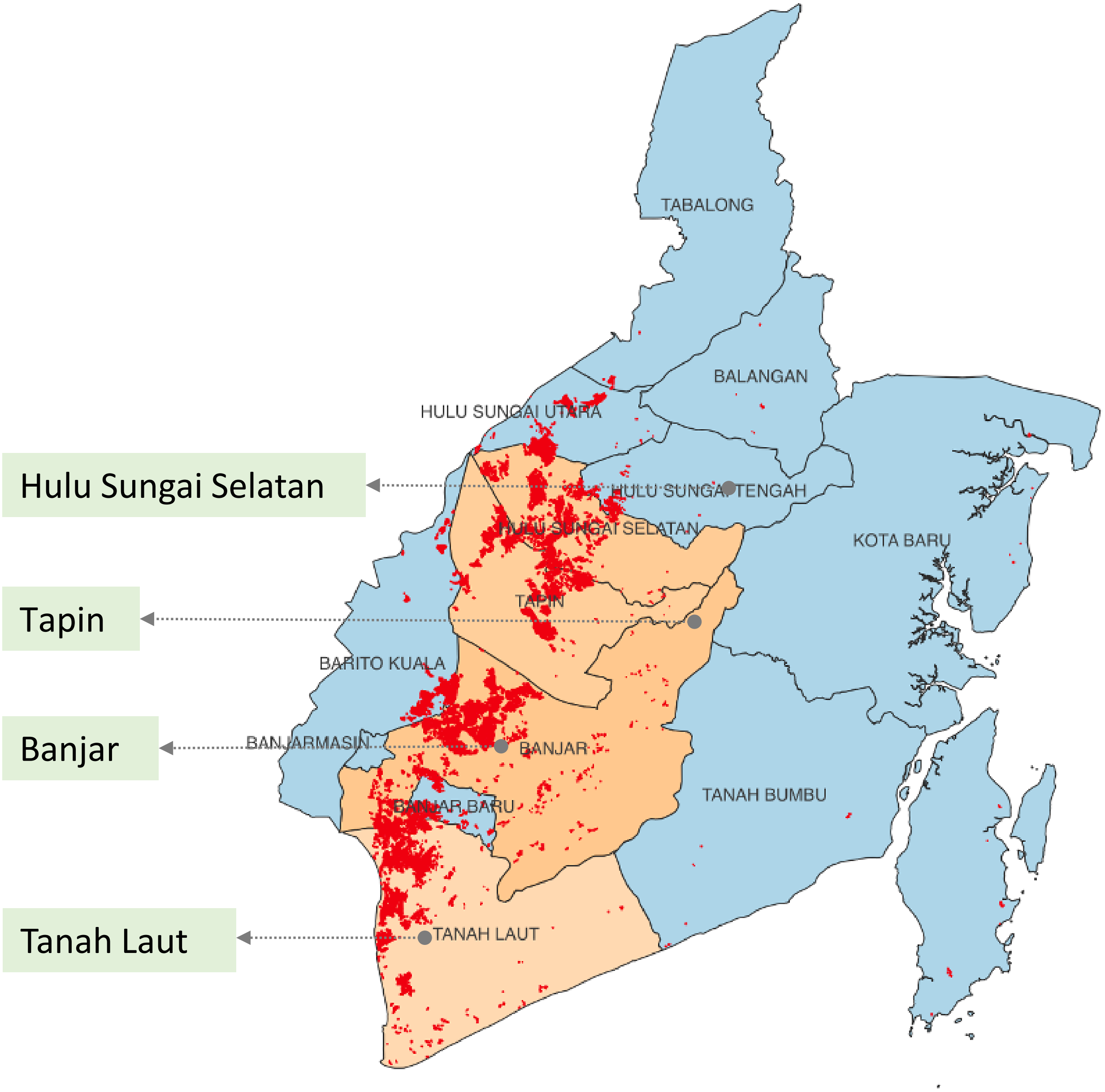


Total : 1.161k
Kal : 508k (44%)

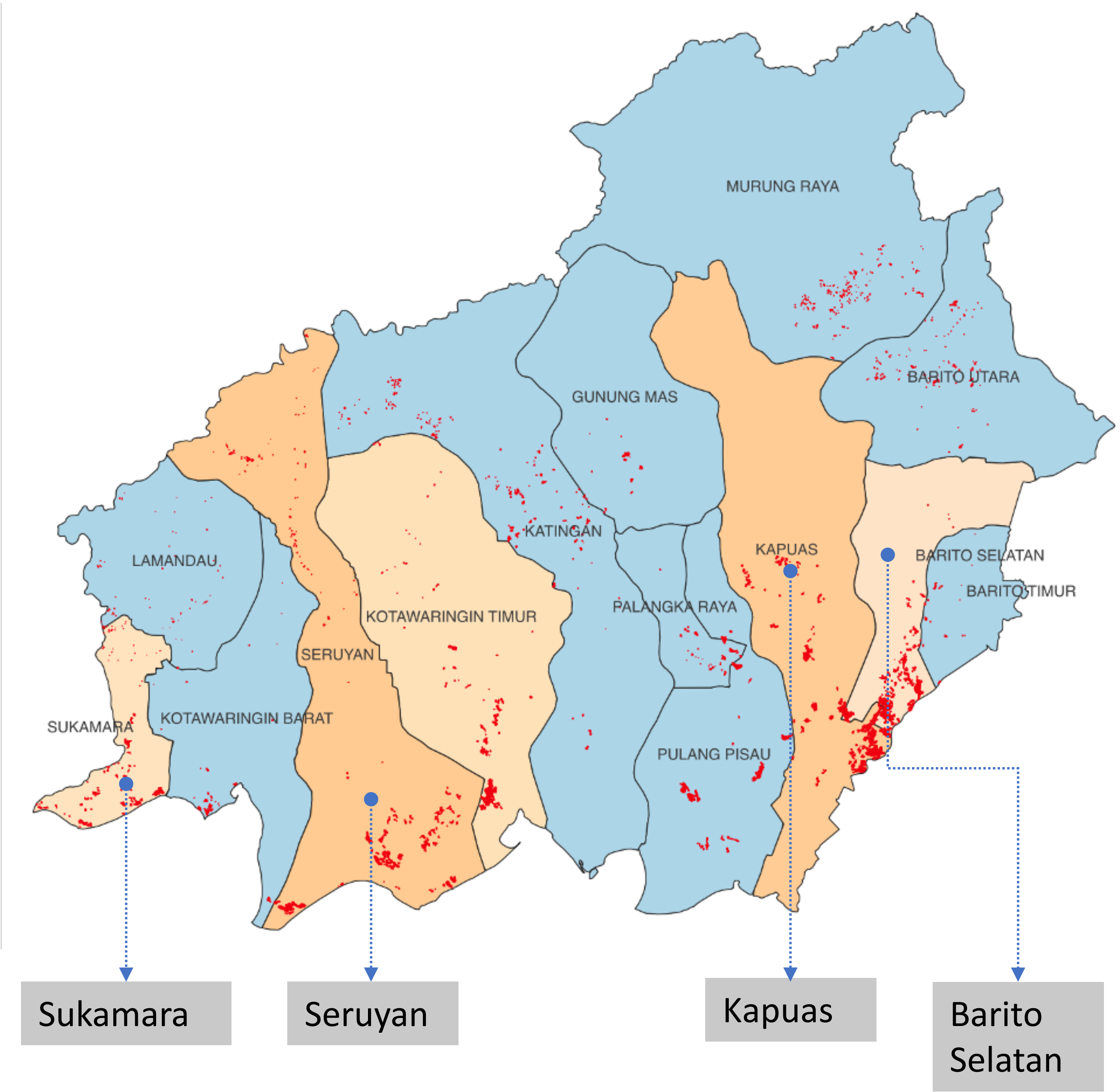
Burned Area in West Kalimantan



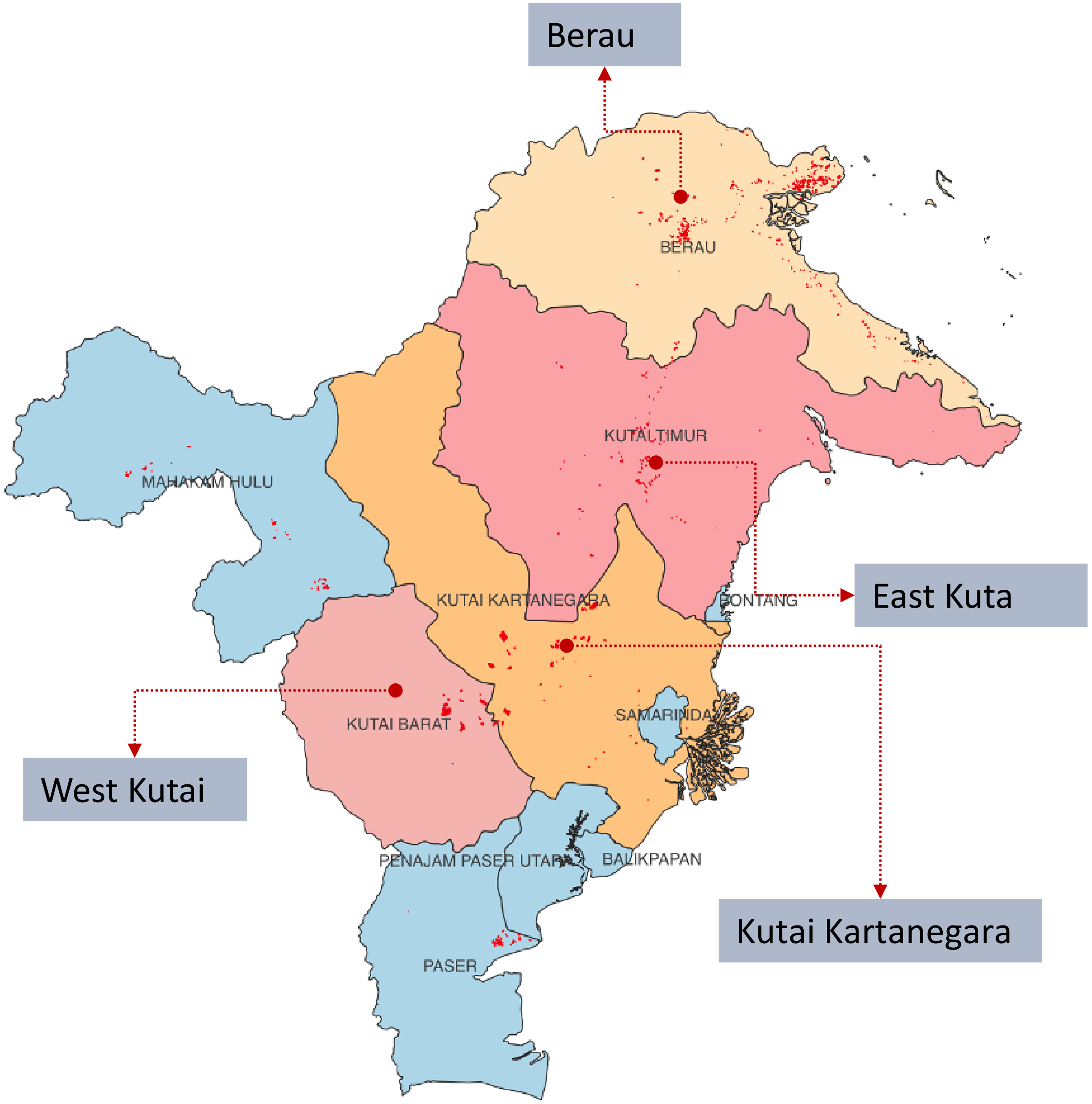
Burned Area in South Kalimantan



Burned Area in Central Kalimantan



Burned Area in East Kalimantan



Conclusions

1. A strong spatiotemporal correlation between climatological drivers and corresponding peatland fire frequency and burned area
2. The fire model results show an increased fire intensity (elevated flame lengths and rates of spread) for grassland and oil-palm plantations compared to forest stands prior to the LULC conversion.
3. Climate change effect and El-Nino exacerbate the decreased fire resilience of degraded peatland and increased proneness to fire of converted areas

Recommendations

For better peatland fire management are:

01 More focus on fire prevention activities,

02 Alignment and harmonization of government regulations at the national and regional levels,

03 Improve availability and accessibility of sufficient funding for pre-fire mitigation, suppression, and post-fire recovery efforts on regional and local scales

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BRIN BADAN RISET DAN INOVASI NASIONAL

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