# Land Surface Change Monitoring (LSCMS)

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## ABSTRACT

Wildfires are a recurring environmental problem in the northern Thailand, especially in Chiang Mai Province, where seasonal burning and complex terrain often lead to fire events and prolonged smoke pollution. Effective monitoring of affected areas is important for environmental management and decision-making.
This study develops a spatial monitoring approach using satellite data to detect land surface changes potentially associated with wildfire events in Chiang Mai. The method applies the differenced Normalized Burn Ratio (dNBR) derived from Sentinel-2 satellite imagery to identify vegetation and surface disturbances. The results are integrated with thermal hotspot data to highlight areas that may be related to wildfire activity. The analysis covers the period from 2023 to 2025 and evaluates changes on a monthly basis across districts in Chiang Mai Province. To improve accessibility for non-technical users, the analysis is implemented through a web-based platform that presents spatial maps, hotspot information, and summary statistics in an intuitive format.

## INTRODUCTION

Wildfire monitoring commonly relies on thermal hotspot data, which indicate locations of abnormal heat. However, hotspot information alone cannot clearly represent the spatial extent of areas affected by fire. Satellite imagery provides an opportunity to detect vegetation and land surface changes associated with wildfire disturbances. Analyzing these changes can improve the understanding of potentially affected areas and support more effective environmental monitoring.

## OBJECTIVE

This study aims to:

1. Develop a model for assessing spatial changes potentially related to forest fire events.
2. Create a web-based system that presents the results in an accessible format for non-technical users and provides monthly district-level information to support monitoring, planning, and decision-making by local administrative organizations.

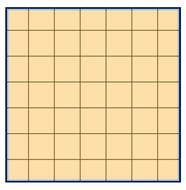


References

- **European Space Agency.** (2023). *Sentinel-2 User Handbook and Sentinel-2 Satellite Imagery*. Copernicus Programme.
- **NASA FIRMS.** (2024). *Fire Information for Resource Management System (FIRMS): Active Fire / Hotspot Data.*
- **OpenStreetMap Foundation.** (2024). *OpenStreetMap (OSM) Land Use Data.*
- ***United Nations Office for Outer Space Affairs.*** *Normalized Burn Ratio (NBR) – Burn Severity Mapping Recommended Practice. UN-SPIDER Knowledge Portal.*

## DATA

**Raster data**



### 1 Sentinel-2 Satellite Imagery (European Space Agency)

Raster data represent spatial information as a grid of pixels, where each pixel stores a value describing surface conditions used to analyze vegetation and land surface changes. In this study, raster data from Sentinel-2 bands (Band 3, Band 8A, Band 12) and the Scene Classification Layer (SCL) were used.

**Sentinel-2 Satellite Imagery (European Space Agency)**

| Category | Band 3 (Green) | Band 8A (NIR Narrow) | Band 12 (SWIR) | SCL (Scene Classification) |
|---|---|---|---|---|
| Spatial Resolution | 10 m | 20 m | 20 m | 20 m |
| Spectral Description | Green reflectance | Vegetation structure (NIR) | Moisture & burn sensitivity | Surface classification |
| Information Provided | NDWI water masking | NBR vegetation signal | NBR burn/moisture signal | Image quality filtering |

### 2 NASA FIRMS Hotspot Data

Used to identify locations of detected thermal anomalies (hotspots) that may indicate fire activity.

### 3 Land Use Data from OpenStreetMap (OSM)

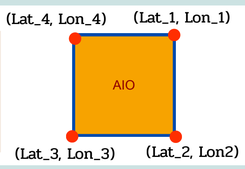
Used to understand the type of area affected (e.g., forest, agriculture) and support spatial interpretation.

## PROCESS

### 1 Data Retriveval

Daily Sentinel-2 Scene Classification Layer (SCL) imagery was retrieved through the Copernicus API within the defined Area of Interest (AOI) by specifying the coordinates of the four corners to create a square AOI covering the study area.

Area of Interest Definition Using Four-Corner Coordinates




### 2 Image Quality Filtering with SCL

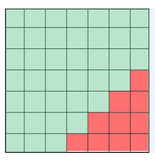
The Scene Classification Layer (SCL) was used to calculate the valid pixel fraction, as shown in the formula on the left. Pixels classified as 3 (cloud shadow), 4 (vegetation), and 5 (bare soil) were considered valid, while all other values were considered invalid. Images from a given date with a valid pixel fraction greater than 90% were selected as usable images for further analysis.

SCL Classes Used for Valid Pixel Selection

| SCL Value | Class Name |
|---|---|
| 4 | Vegetation |
| 5 | Bare Soil |
| 6 | Water |

Valid Fraction Formular

$$\text{valid fraction} = \frac{\text{valid pixels}}{\text{total AOI pixels}}$$



valid pixels  Invalid valid pixels

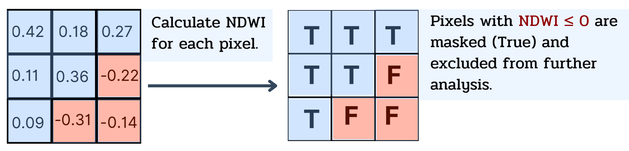
if the valise fraction is more than 90 percent image in that certeain date will be considered usable

### 3 NDWI-Based Water Masking

NDWI was calculated using Band 3 and Band 8 to create a water mask. Pixels with NDWI > 0 were classified as water (True), while NDWI ≤ 0 were non-water (False). Water pixels were removed using pixel-wise masking to avoid spectral misinterpretation in later analysis.

NDWI Formular

$$NDWI = \frac{B3 - B8A}{B3 + B8A}$$




### 4 NBR and dNBR Calculation

NBR was calculated using Band 8A (NIR) and Band 12 (SWIR). The dNBR was then computed as the difference between pre-event and post-event NBR values to quantify vegetation change potentially associated with wildfire events.

NBR Formular

$$NBR = \frac{B8A - B12}{B8A + B12}$$

dNBR Formular

$$\text{dNBR} = \text{NBR}_{\text{pre-fire}} - \text{NBR}_{\text{post-fire}}$$

### 5 Burn Severity Classification and Area Estimation

dNBR values were classified into seven burn severity levels based on standard thresholds, which were adjusted for the study area. Affected areas were calculated by counting classified pixels at 10 × 10 m resolution and converting pixel counts into area units.

Burn Severity Classification

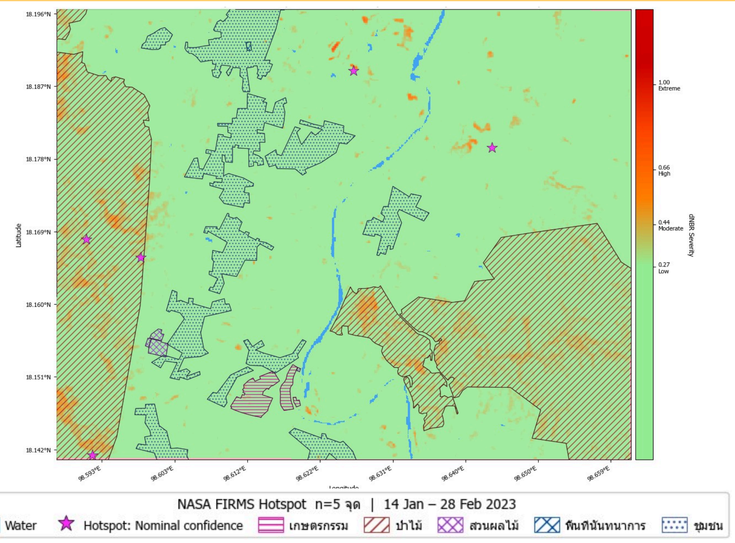
| Color | Serverity Level | dNBR Range |
|---|---|---|
| | Low | -0.5 to 0.269 |
| | Moderate | 0.27 to 0.439 |
| | High | 0.44 to 0.659 |
| | Extreme | 0.66 to 1.300 |

### 6 Hotspot and Land Use Data Integration

Hotspot data from NASA FIRMS and land use data were spatially overlaid with the dNBR severity map to assess spatial consistency and support interpretation. The integrated results were then prepared for web-based visualization.

## RESULT

**dNBR Analysis in Hod District, Chiang Mai (Jan–Feb 2023)**




Model results indicate that several areas in Hod District, Chiang Mai, exhibited moderate to high dNBR values (≥ 0.66) during 14 January–28 February 2023, a period when forest fires were reported. Many of these areas are located in forest regions and partially correspond with recorded hotspot locations, suggesting a potential association with wildfire events.

## DISCUSSION

Although dNBR indicates vegetation change, it cannot identify the cause directly, so land use and hotspot data are used to support interpretation. While burn mask data would enable more accurate model training, such data were unavailable in this study. Therefore, dNBR combined with supporting data remains a practical approach for identifying areas potentially affected by wildfire events.

## CONCLUSION

When burn mask data are limited, dNBR can preliminarily identify vegetation disturbances potentially related to wildfire events, but it cannot determine the cause of the change and requires supporting data such as hotspots and land use for interpretation.