FOREST FIRES

VISUALIZATION & ANALYSIS

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AIM

Evaluate how effective is dNBR/NBR in comparison to other indices to delineate fire burned area across different geographies and different veg types.

PREPROCESSING

We were given two files:

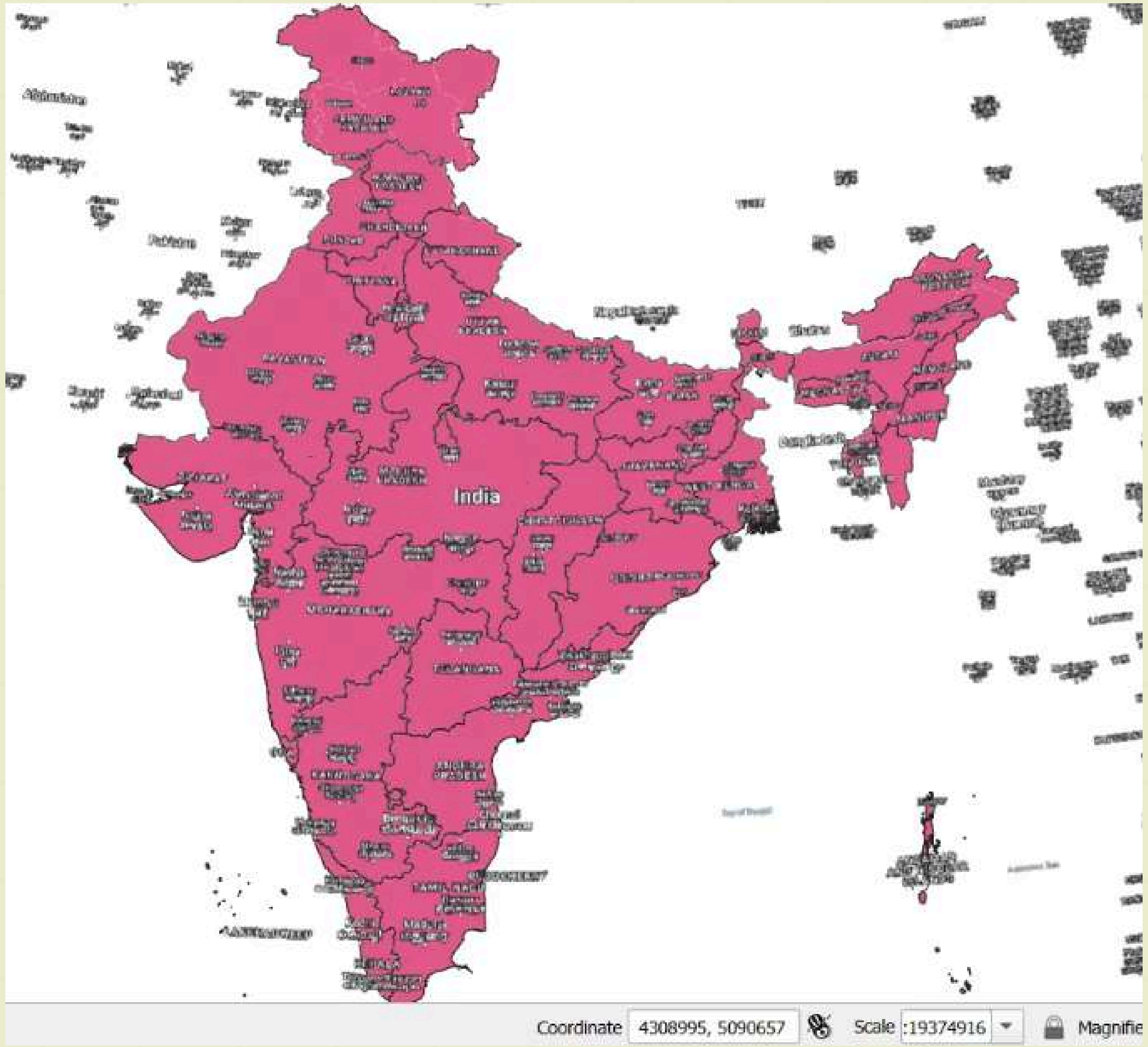
1. Protected areas shapefile (polygon)
2. Active fire locations shapefile (point)

For choosing areas with maximum accuracy on google earth engine wrt the shapefiles, we needed some sort of map overlay so that we can get nearby city/town name and plot accordingly on GE.

For this, we did the following steps:

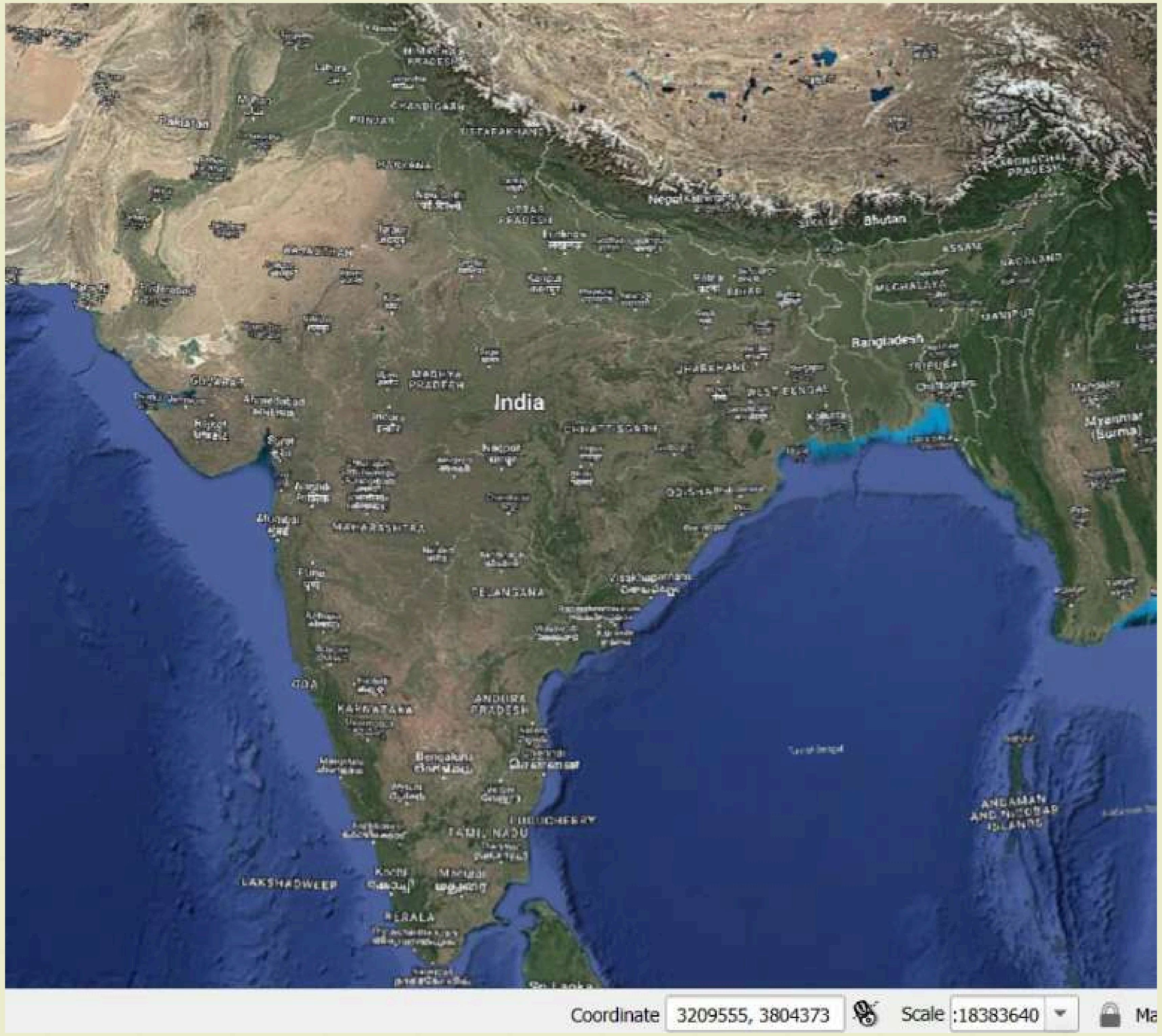
1. Overlay given polygon file with an indian political shapefile.
2. Classify the points file to get type of forests.
3. Installed QuickMapServices
4. QSM-> Google-> Choose google satellite & google labels for city names.
5. Overlayed final map with the points shapefile to get location of active fire

This gave us a map similar to Google earth engine.

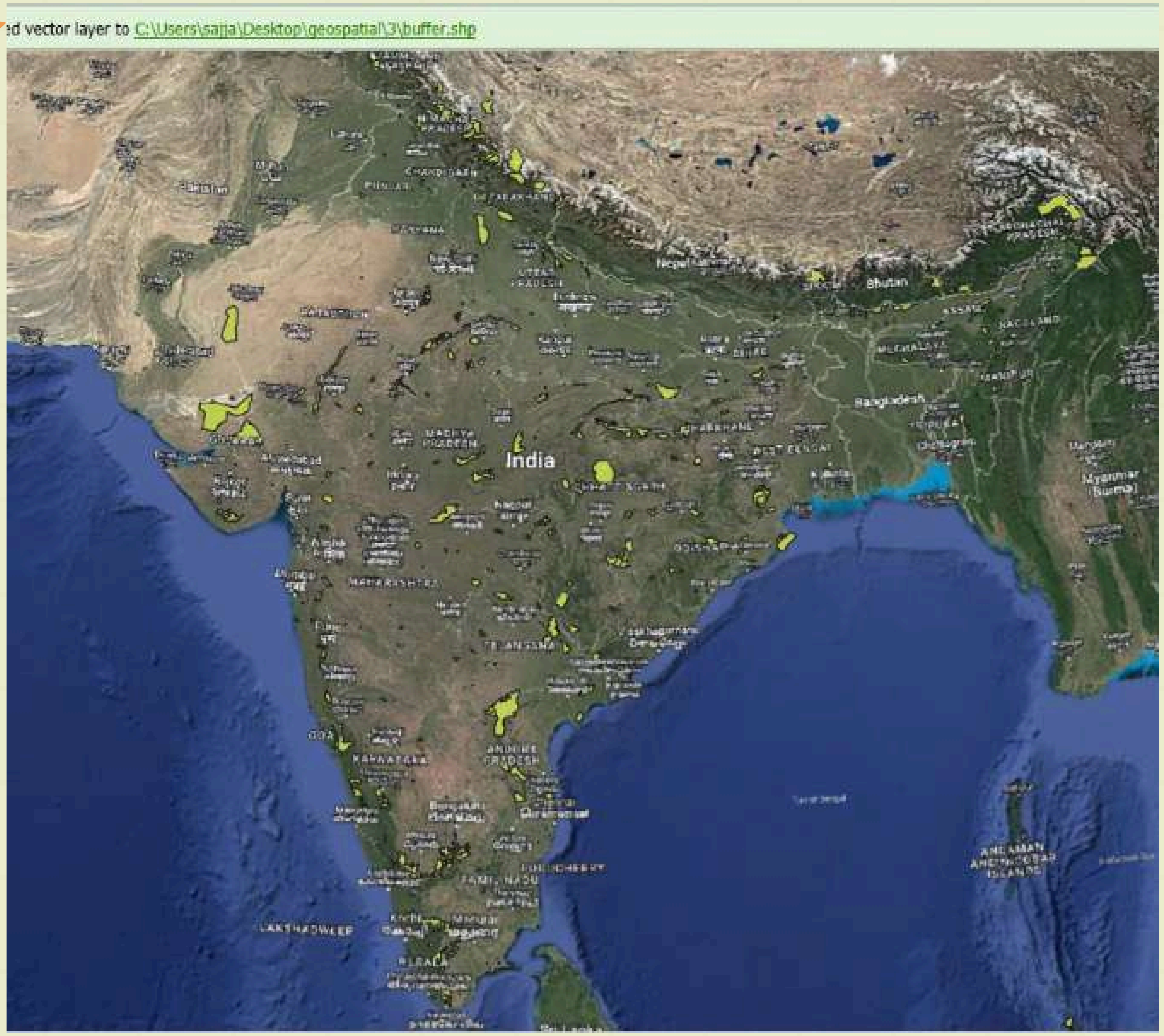


Step1

PREPROCESSING

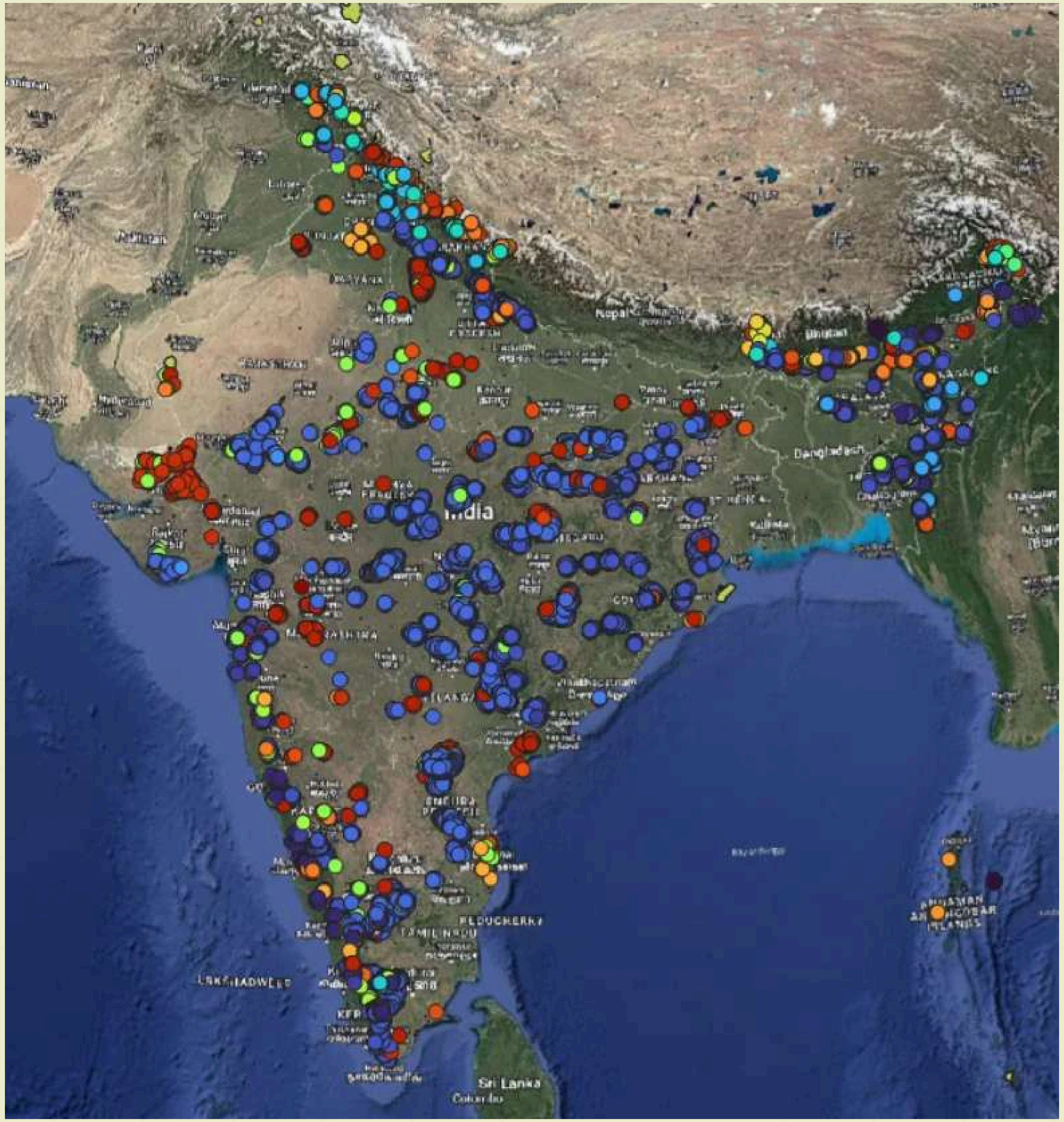


Step 2



Step 3

PREPROCESSING

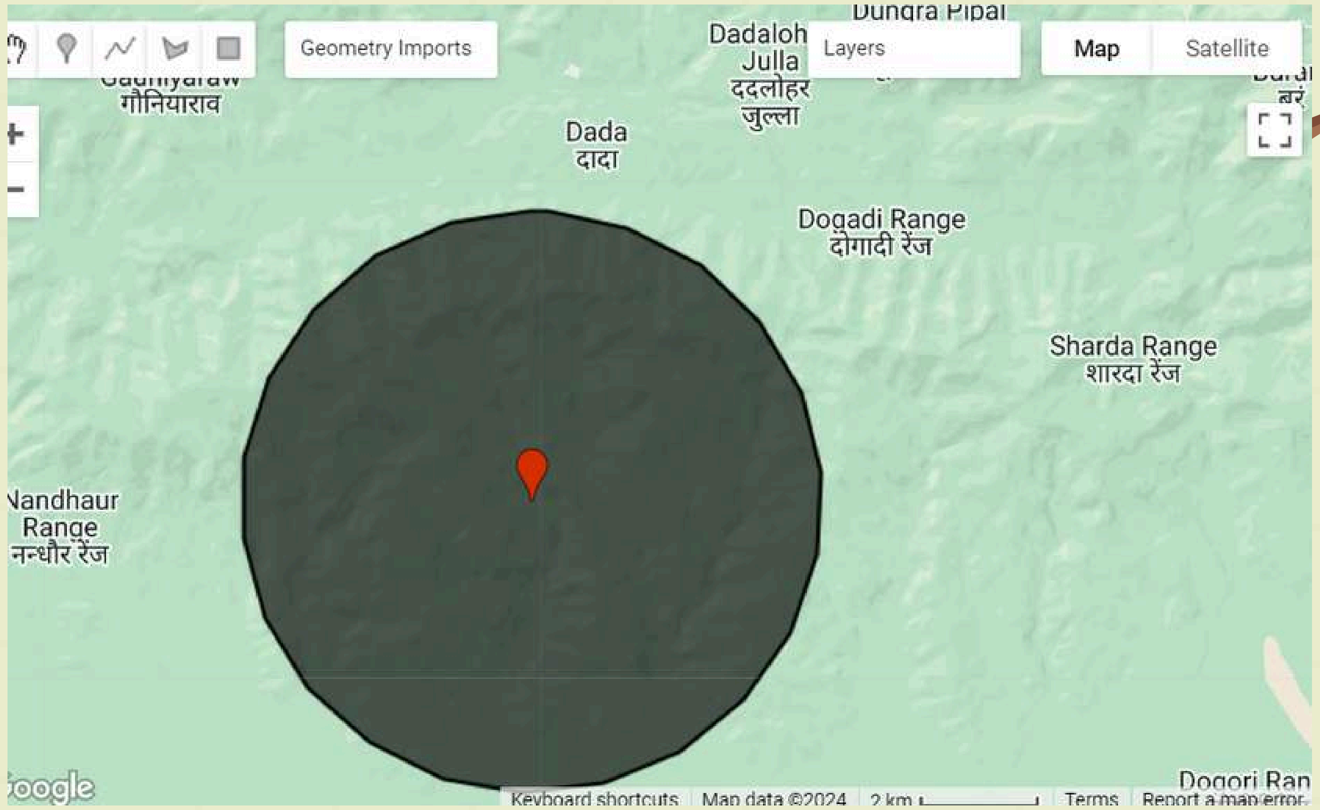


Final Output

REGIONS OF INTEREST

We have chosen three regions:

1. Near Dada, Uttarakhand (Western Himalayas)
2. Shiroli, Karnataka (Western Ghats)
3. Near Kunda, Assam (Northeast India)



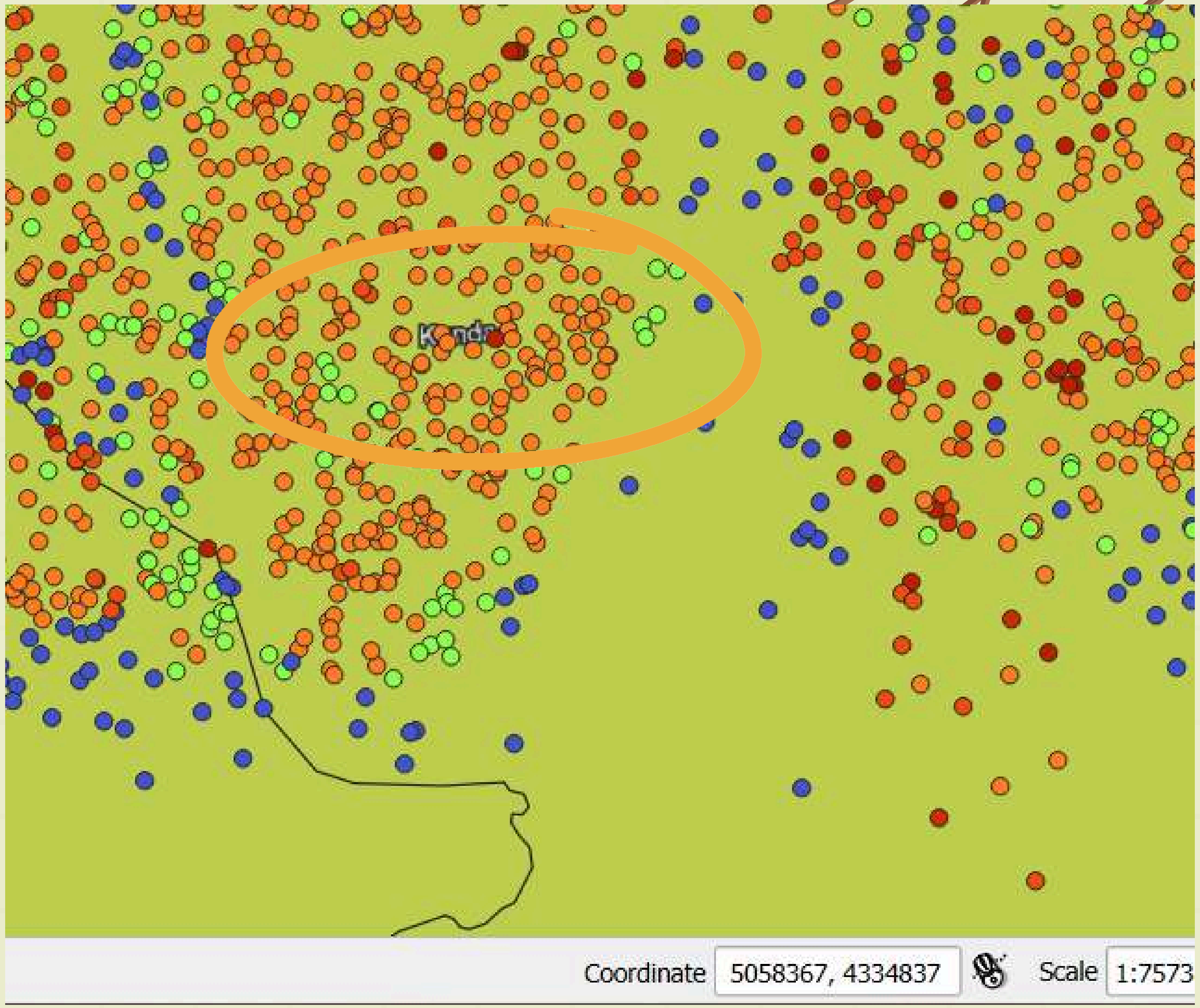
RATIONALE BEHIND CHOOSING ROI

Uttarakhand & Karnataka ROIs are mostly populated with **type3 & 4** of forests and according to the forest type legend- it stands for **moist and dry decidous** forest respectively while the one in assam is mostly **grasslands (type 29)**

- <u>Seasonal Dryness:</u> Both types have dry seasons when leaf litter accumulates, creating fuel for fires.
- <u>High Temperatures:</u> Hot pre-monsoon months raise the likelihood of ignition in both forest types.
- <u>Dense Understory Vegetation:</u> This adds to the fire load, especially when dry, facilitating fire spread.

Near Shiroli, Karnataka

Near dada, uttarakhand



Near Kunda, Assam

INDICES CHOSEN & WHY?

1) NBR/ dNBR :

- NBR and its derived index, dNBR, are the primary indices for identifying burn severity and extent. They are particularly effective because they highlight the contrast between vegetation and burned areas using near-infrared (NIR) and shortwave infrared (SWIR) bands, which are sensitive to vegetation health and fire damage.
- To refine our burn severity analysis, we applied an NDWI (Normalized Difference Water Index) mask to exclude water bodies from the calculation. This ensures that water bodies, which could potentially distort the dNBR analysis, are not included in the burn severity assessment.

$$\mathrm{NBR} = \frac{\rho_{\mathrm{NIR}} - \rho_{\mathrm{SWIR2}}}{\rho_{\mathrm{NIR}} + \rho_{\mathrm{SWIR2}}}$$

$$\mathrm{dNBR} = \mathrm{NBR}_{\mathrm{pre}} - \mathrm{NBR}_{\mathrm{post}}$$

INDICES CHOSEN & WHY?

2) MIRBI:

- MIRBI is specifically designed for detecting burned areas and monitoring fire susceptibility. It's particularly useful in highlighting dry and exposed areas, which often have higher burn risks.
- It focuses on shortwave infrared bands, which provides insights into dry or exposed areas prone to fire.
- While NBR is effective in identifying burn severity, MIRBI focuses more on the characteristics of the burned surfaces and highlights fire-susceptible regions post-burn.

$$\text{MIRBI} = 10 \times \rho_{\text{SWIR2}} - 9.8 \times \rho_{\text{SWIR1}} + 2$$

INDICES CHOSEN & WHY?

3) NDVI

- NDVI is a well-known index for assessing vegetation health, making it an ideal baseline to compare pre- and post-fire vegetation conditions.
- NDVI uses red and near-infrared bands to measure vegetation density and health, helping us understand how the fire affected vegetation cover.
- This index complements NBR by confirming vegetation reduction but is less specific to fire damage itself.

$$\mathrm{NDVI} = \frac{\rho_{\mathrm{NIR}} - \rho_{\mathrm{RED}}}{\rho_{\mathrm{NIR}} + \rho_{\mathrm{RED}}}$$

INDICES CHOSEN & WHY?

4) BAI :

- BAI highlights areas that have experienced fire damage by using the contrast between red and NIR bands, both sensitive to burned areas.
- It is particularly useful for identifying burned areas and tracking potential regrowth in regions like Kunda, where regrowth has been observed.
- BAI complements NBR by tracking the burn presence and helping to confirm post-fire regrowth patterns.

$$\mathrm{BAI} = \frac{1}{(\rho_{\mathrm{NIR}} - 0.06)^2 + (\rho_{\mathrm{RED}} - 0.1)^2}$$

DATA CHOSEN & WHY?

Why Landsat 9?

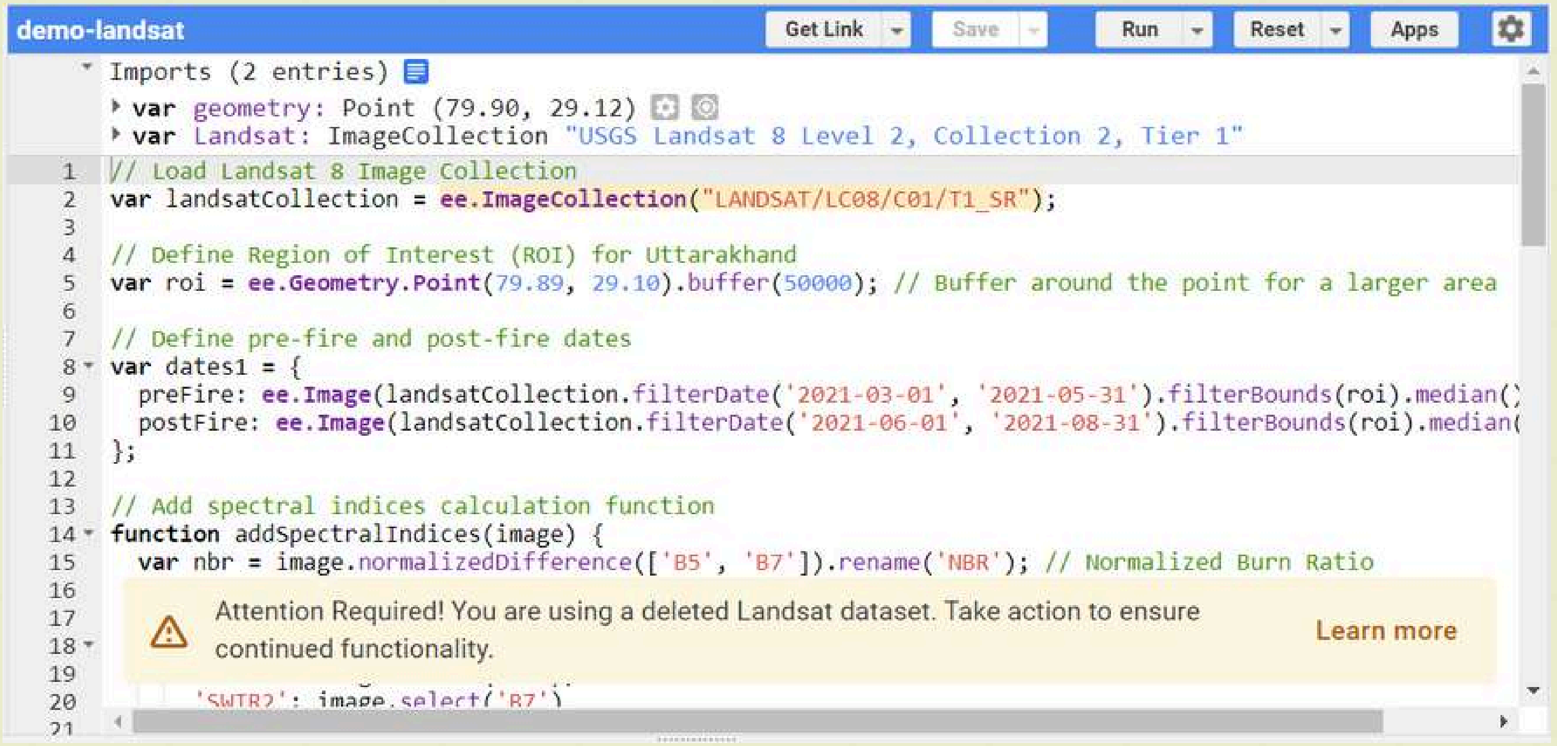
- Selected for its high spatial and spectral resolution, ideal for monitoring vegetation health and land changes.
- Provides necessary spectral bands for indices like NBR, MIRBI, NDVI, and BAI, crucial for fire impact and vegetation assessments.
- 16-day revisit time enables consistent monitoring of pre- and post-fire conditions.

Time Period Selection

- Pre-fire: April 1, 2022 – July 31, 2022 | Post-fire: April 1, 2023 – July 31, 2023.
- Ensures comparable seasonal cycles, minimizing seasonal bias in vegetation changes.
- Chosen during typical dry season to capture vegetation conditions when fire risk is heightened.

Initial Choice of Landsat 8

- Originally planned to use Landsat 8; encountered a “dataset deleted” error, leading to the switch to Landsat 9 for continued functionality.



INTRODUCTION TO THE ANALYSIS

- Platform & Tools: This analysis was conducted using Google Earth Engine (GEE), a powerful cloud-based geospatial analysis platform that allows processing and visualization of satellite imagery at scale. GEE's extensive data catalog and computational resources make it an ideal choice for rapid and large-scale environmental analysis.

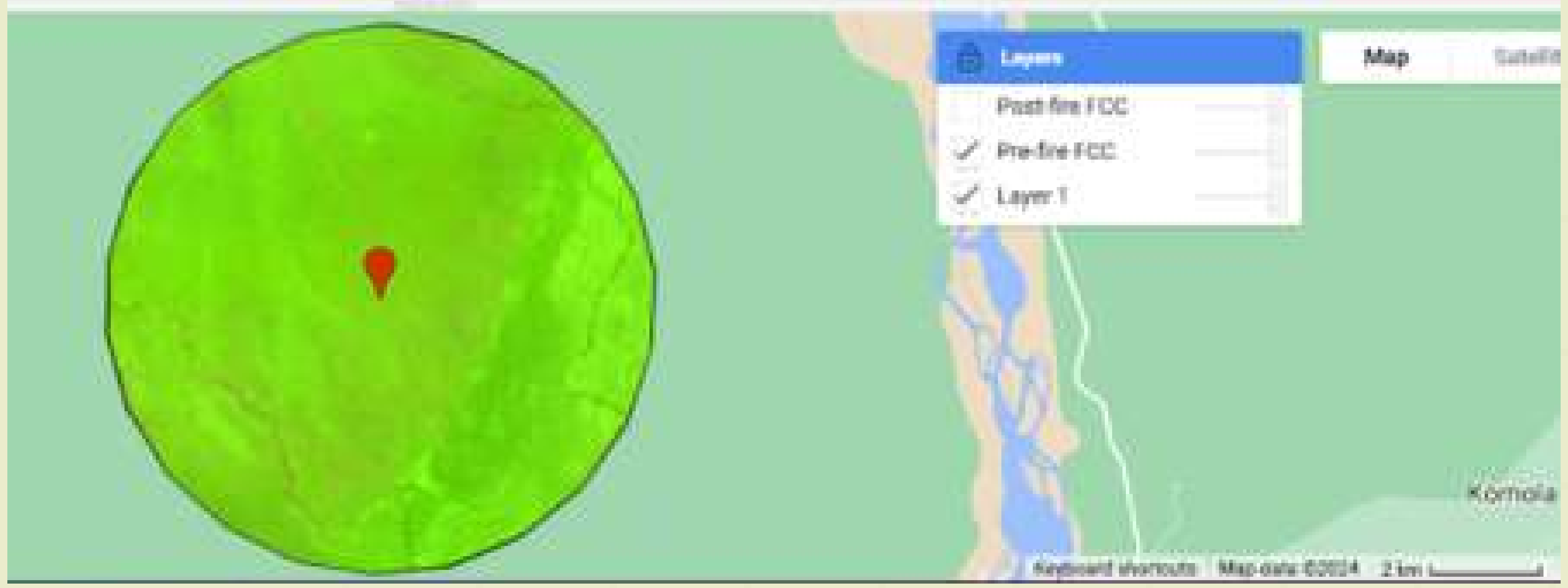
- Data Source: We selected the dataset LANDSAT/LC09/C02/T1_L2 from the Landsat 9 mission, known for its enhanced spatial and spectral resolution, ideal for observing land surface changes and assessing fire impacts on vegetation.

- Why Google Earth Engine (GEE)?
  - Scalability: GEE's cloud processing allows efficient handling of large datasets like Landsat imagery, avoiding local hardware limitations.
  - Data Accessibility: Direct access to updated satellite data and environmental datasets from sources like Landsat, which are crucial for timely environmental monitoring.
  - Advanced Analysis: GEE provides built-in functions for calculating indices and supports JavaScript-based scripting for customization, enabling efficient analysis of complex indices like NBR, MIRBI, NDVI, and BAI.

- Objective: By calculating pre- and post-fire indices for each AOI, we aimed to understand vegetation loss, burn severity, and potential regrowth, leveraging GEE's tools and Landsat 9 data to ensure accurate and efficient results across diverse landscapes.

KUNDA, ASSAM

Created a Buffer of 5km radius



FALSE COLOUR COMPOSITE (FCC)

- Pre-Fire FCC (Green)
    - Dominant green color around the area indicates healthy vegetation cover before the fire.

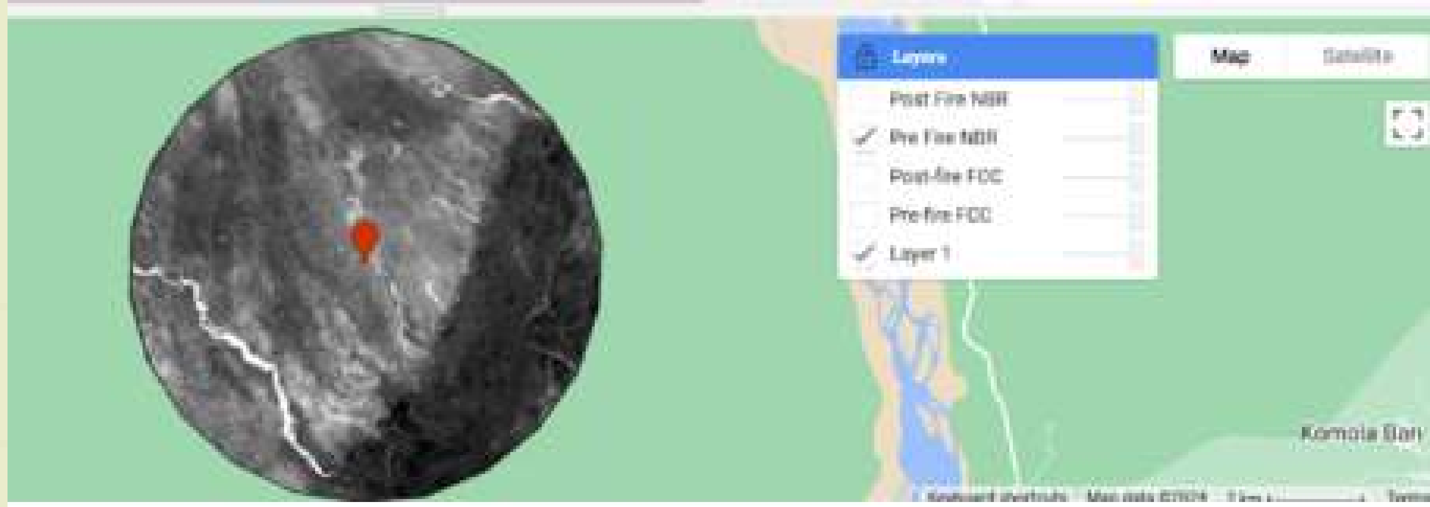
- Post-Fire FCC (Grey)
    - Shift to grey tone suggests reduced vegetation cover, likely due to fire impact, exposing bare soil.

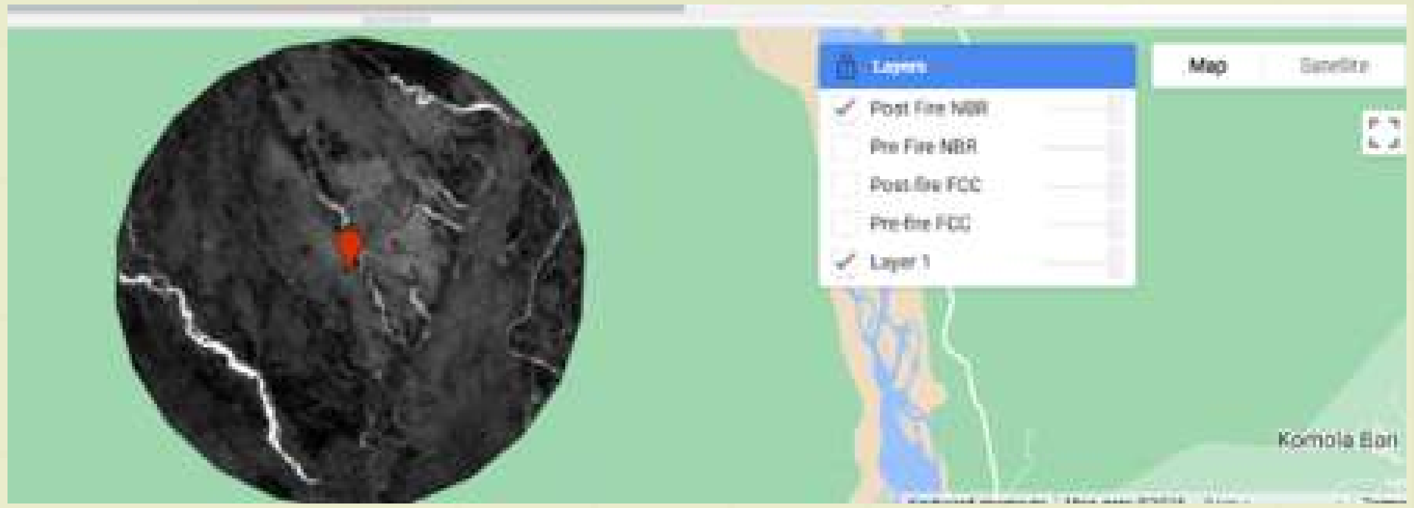
- FCC Change Analysis
    - Transition from green to grey visually highlights potential fire-affected zones, showing vegetation compromise post-fire.

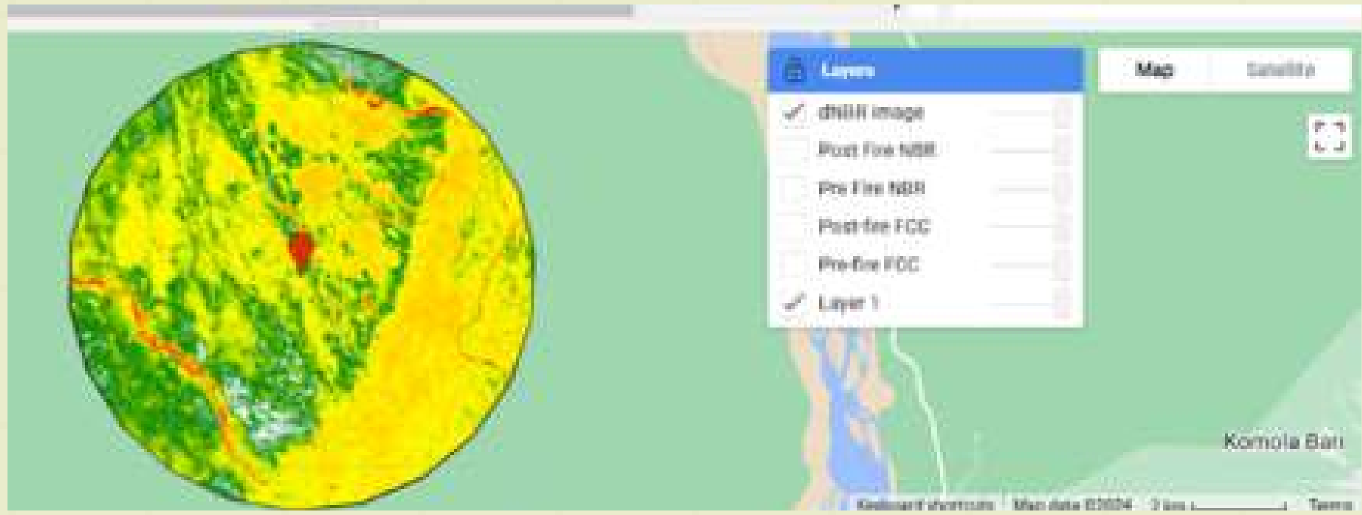
KUNDA, ASSAM

NORMALIZED BURN RATIO (NBR)

- Pre-Fire NBR (White)
  - Low NBR values indicate reduced vegetation, suggesting possible ongoing fire effects that diminished vegetation cover.
- Post-Fire NBR (Black)
  - High NBR values (black color) show healthy vegetation cover, indicating substantial regrowth post-fire, likely due to high rainfall and favorable climate.
- dNBR (Yellow)
  - Yellow tone in dNBR suggests mild burn severity, showing partial vegetation loss but not extreme devastation.
- Masked dNBR (Yellow)
  - Water-masked dNBR maintains yellow, indicating moderate burn severity with potential regrowth accelerated by the region's high rainfall.







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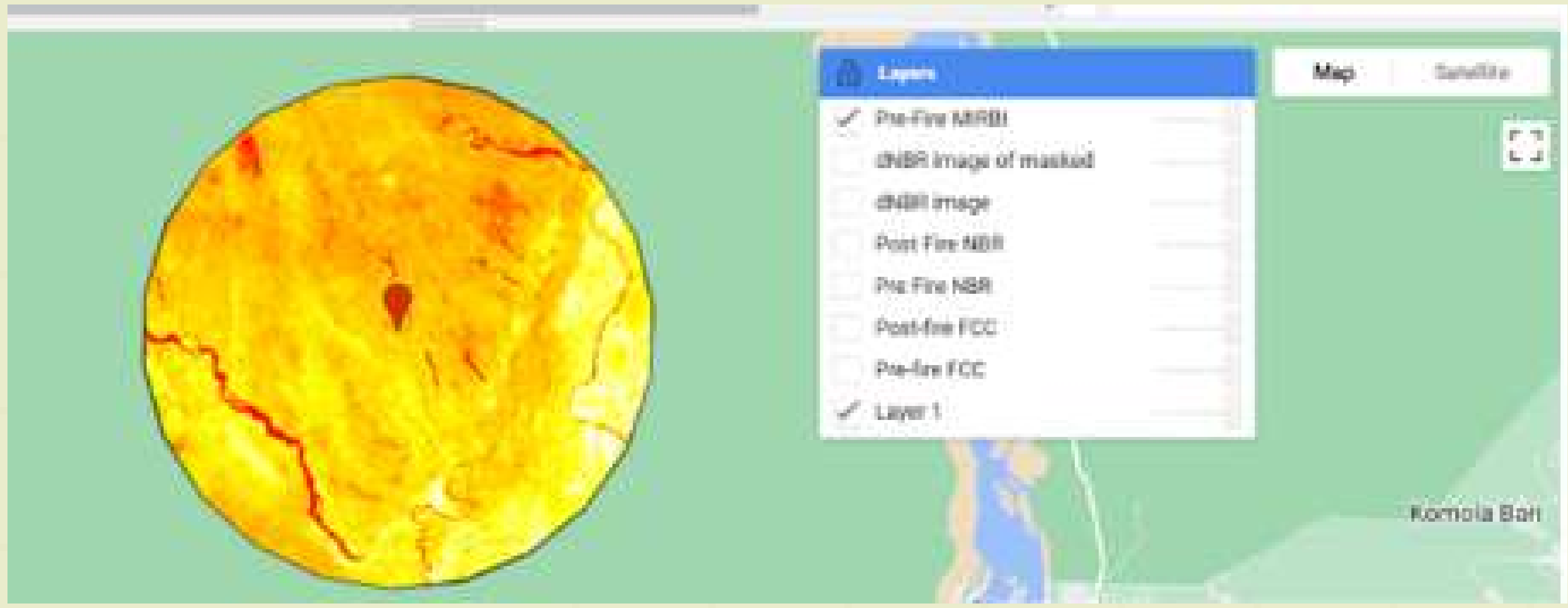
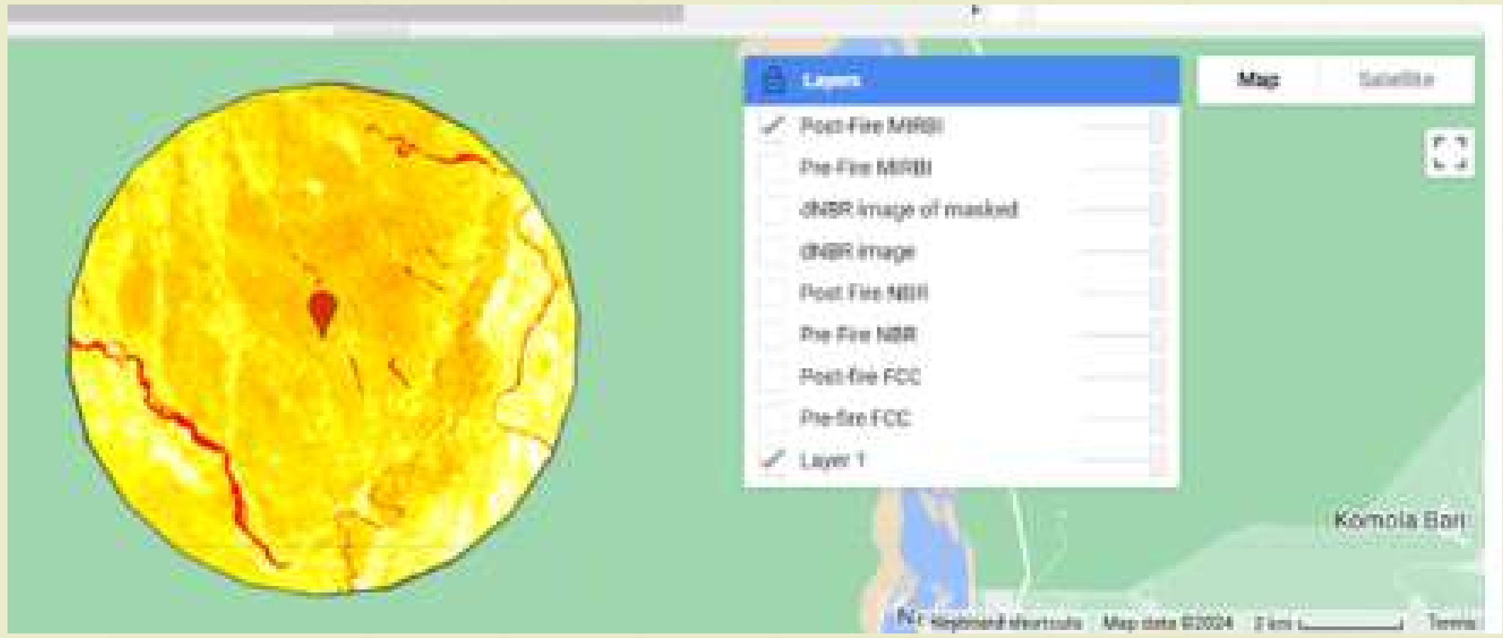
MID-INFRARED BURN INDEX (MIRBI)

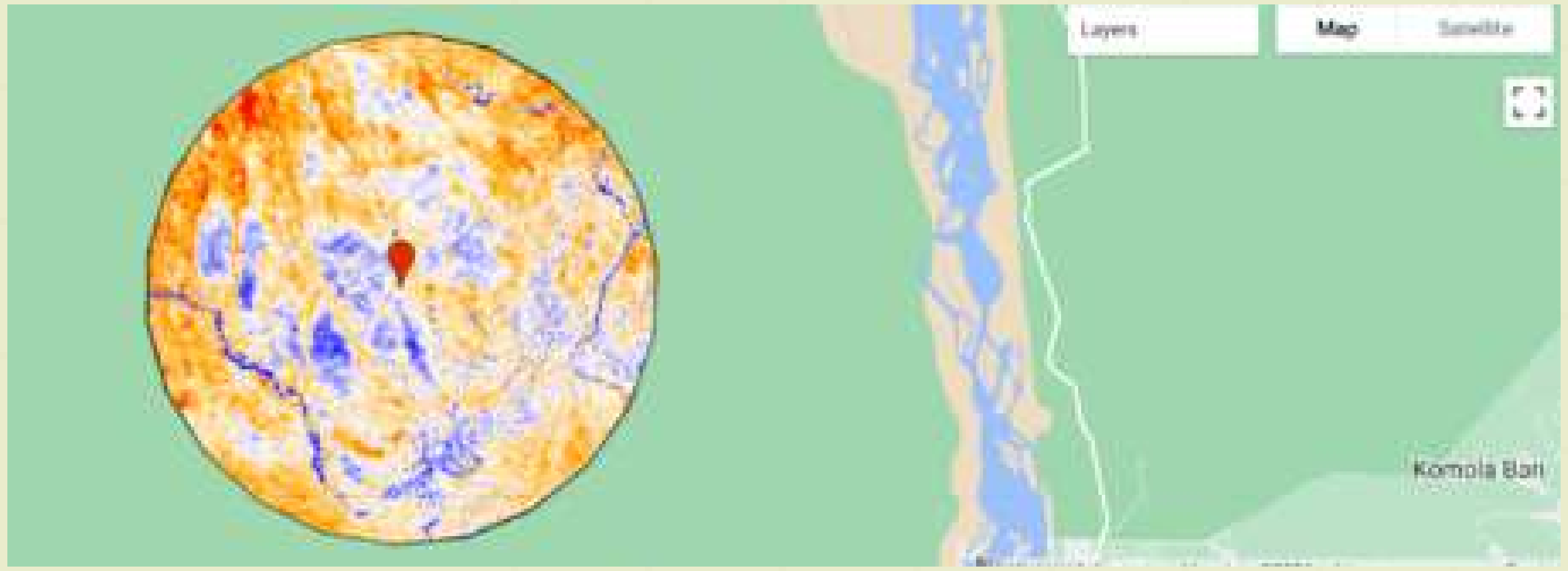


- Pre-Fire MIRBI (Yellow)
  - Indicates moderate susceptibility to burning, with dry surface conditions.



- Post-Fire MIRBI (Orange)
  - Increase to orange shows intensified burn effects, with exposed ash and reduced moisture.

- dMIRBI (Orange)
  - Orange dMIRBI suggests a significant increase in burn severity, highlighting areas with exposed, dry surfaces due to fire.



- Effectiveness
  - MIRBI effectively captures burn severity changes, reflecting Kunda's post-fire increased burn susceptibility.

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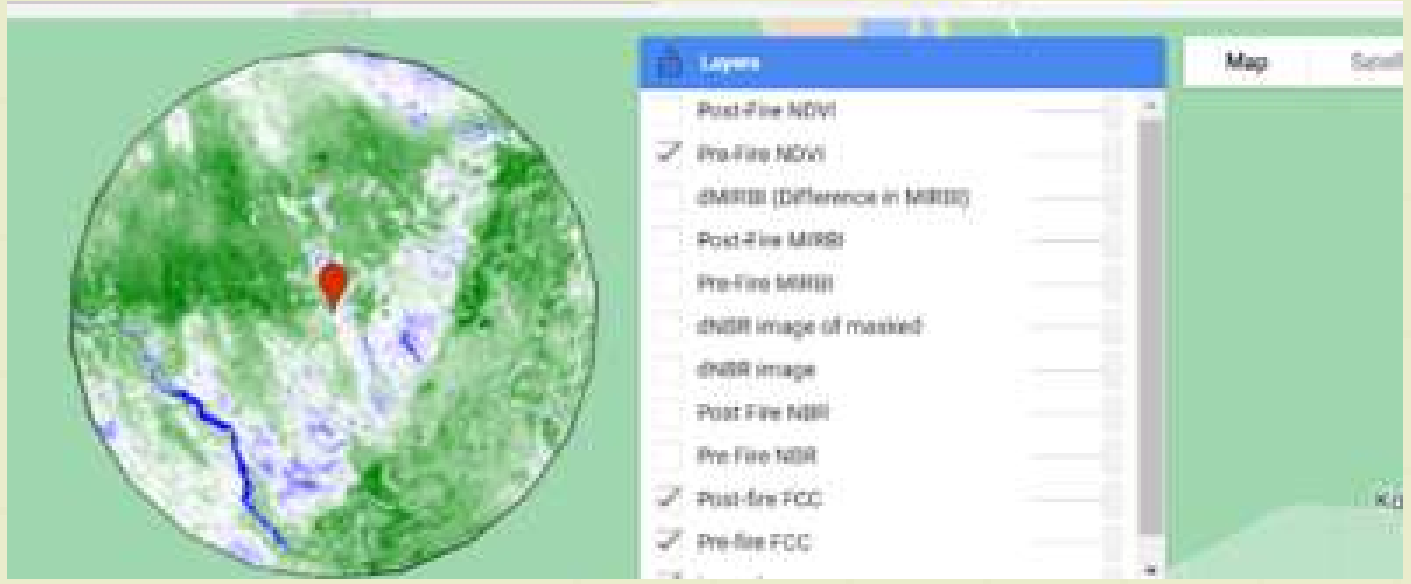
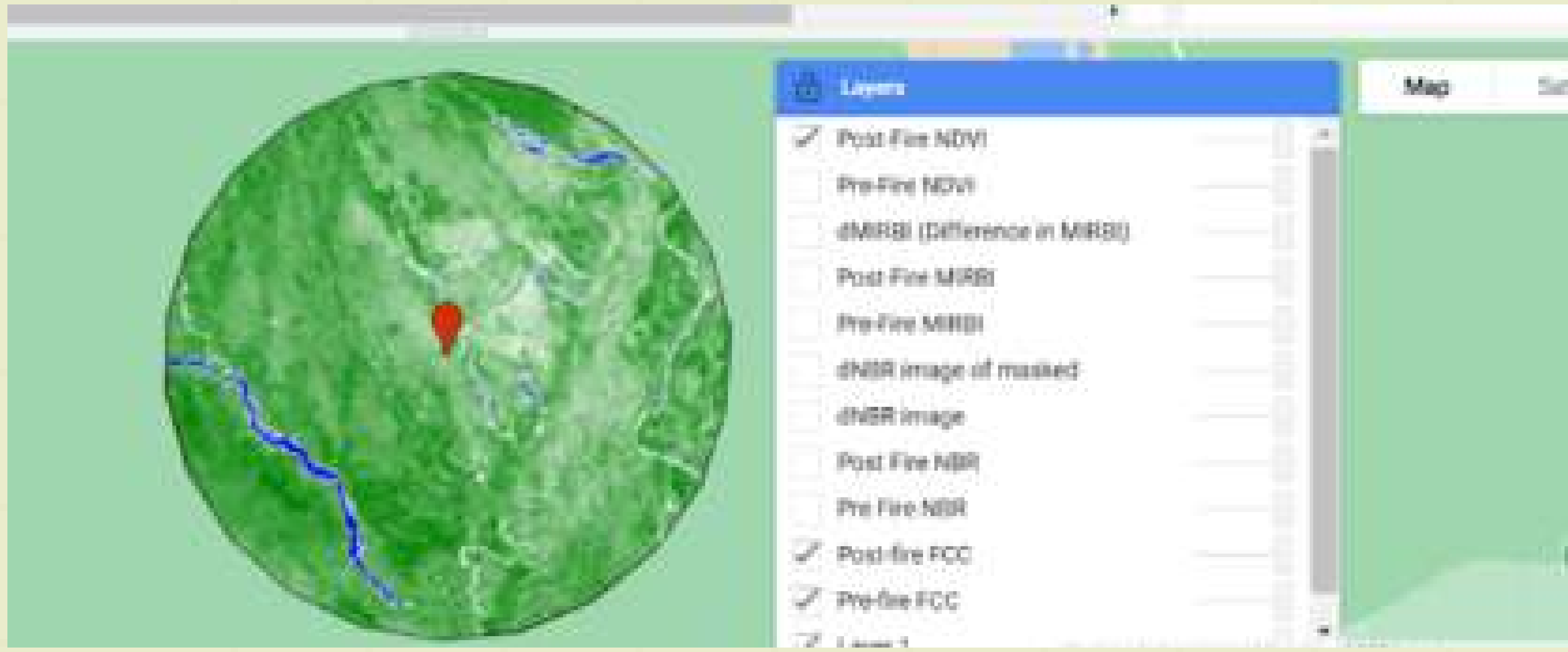
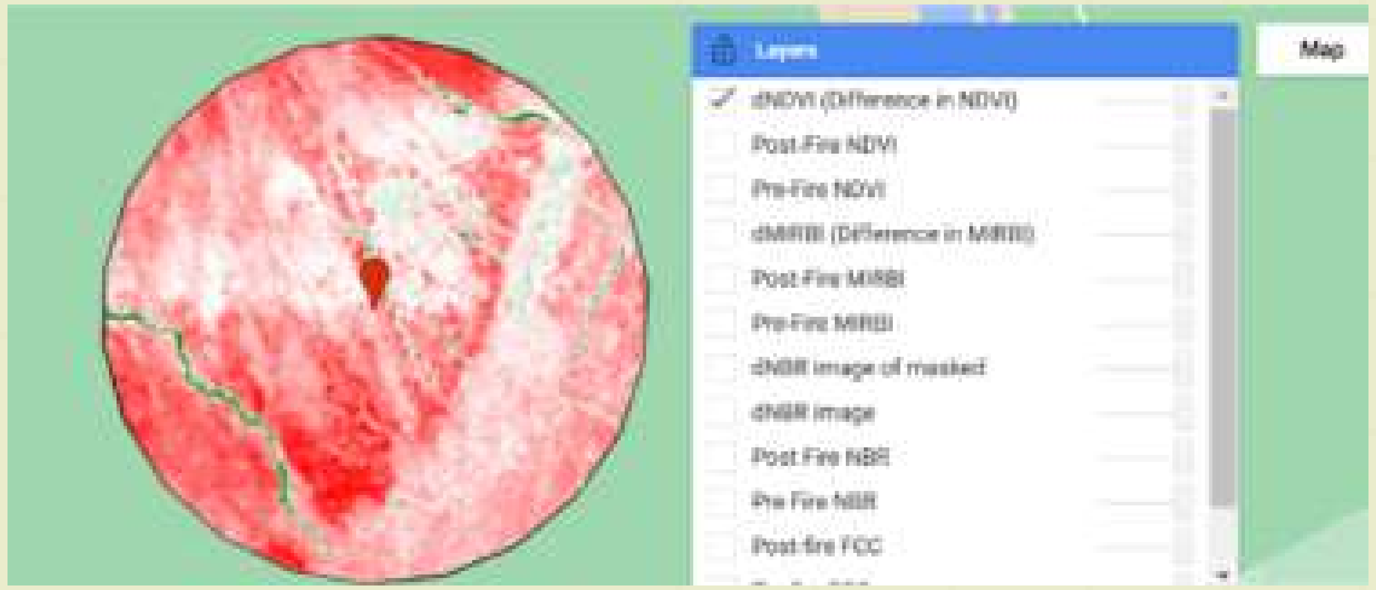
NORMALIZED DIFFERENCE VEGETATION INDEX (NDVI)

- Pre-Fire NDVI (White)
  - White tone indicates low vegetation density or health, suggesting compromised vegetation before the fire.
- Post-Fire NDVI (Green)
  - Transition to green signifies increased vegetation health and density, indicating significant regrowth post-fire, possibly due to favorable rainfall and climate.
- dNDVI (Red)
  - Red tone in dNDVI shows a substantial decrease in vegetation density post-fire, highlighting the fire's lasting impact on vegetation.
- Effectiveness
  - NDVI effectively captures vegetation health changes, with clear indications of both pre-fire conditions and post-fire recovery.







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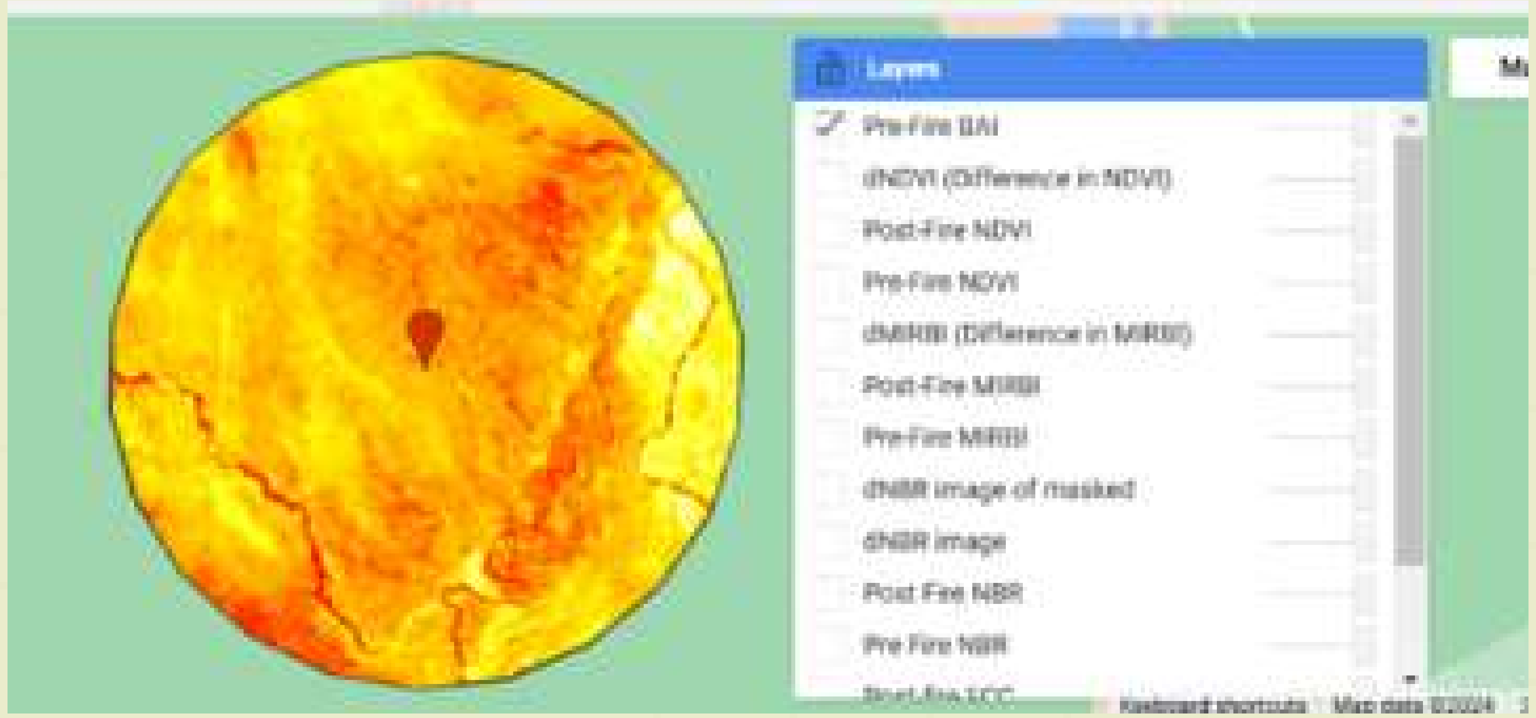
BURN AREA INDEX (BAI)

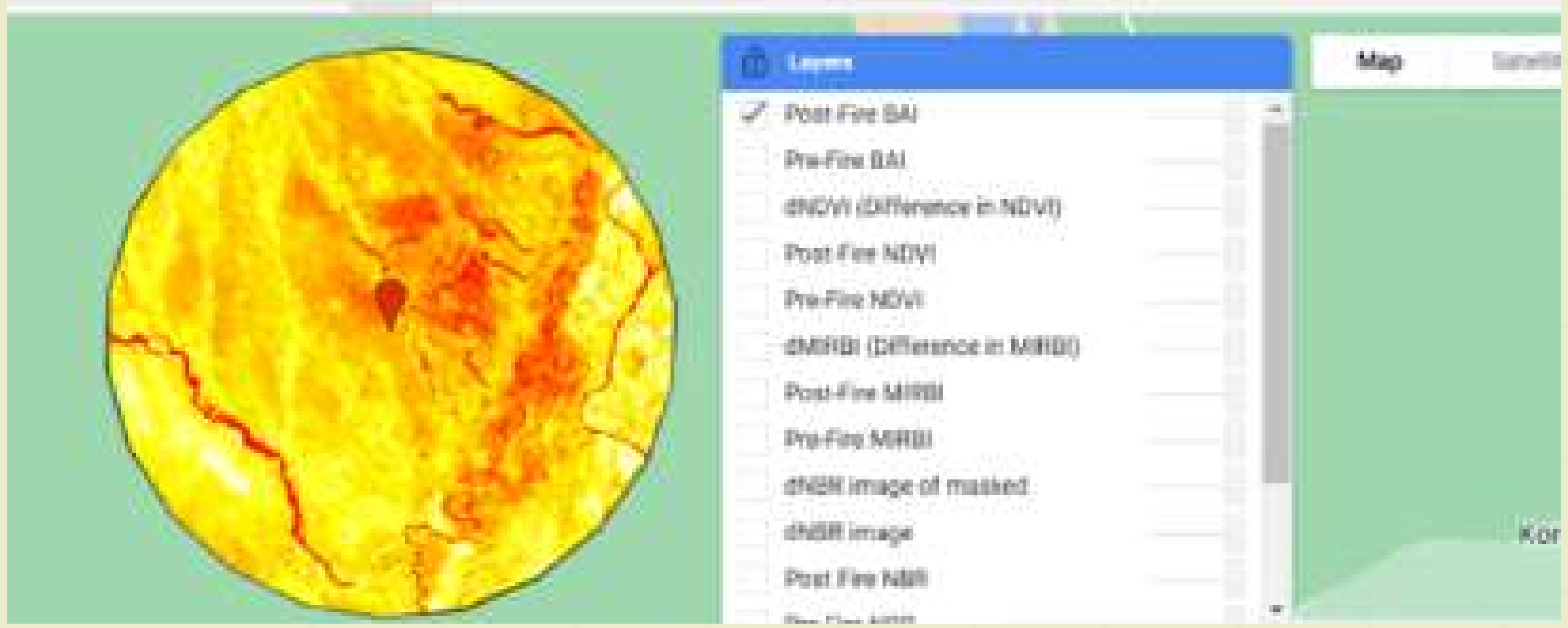
- Pre-Fire BAI (Orange):
  - High initial burn presence or dry vegetation, possibly from prior burns or dry season stress.

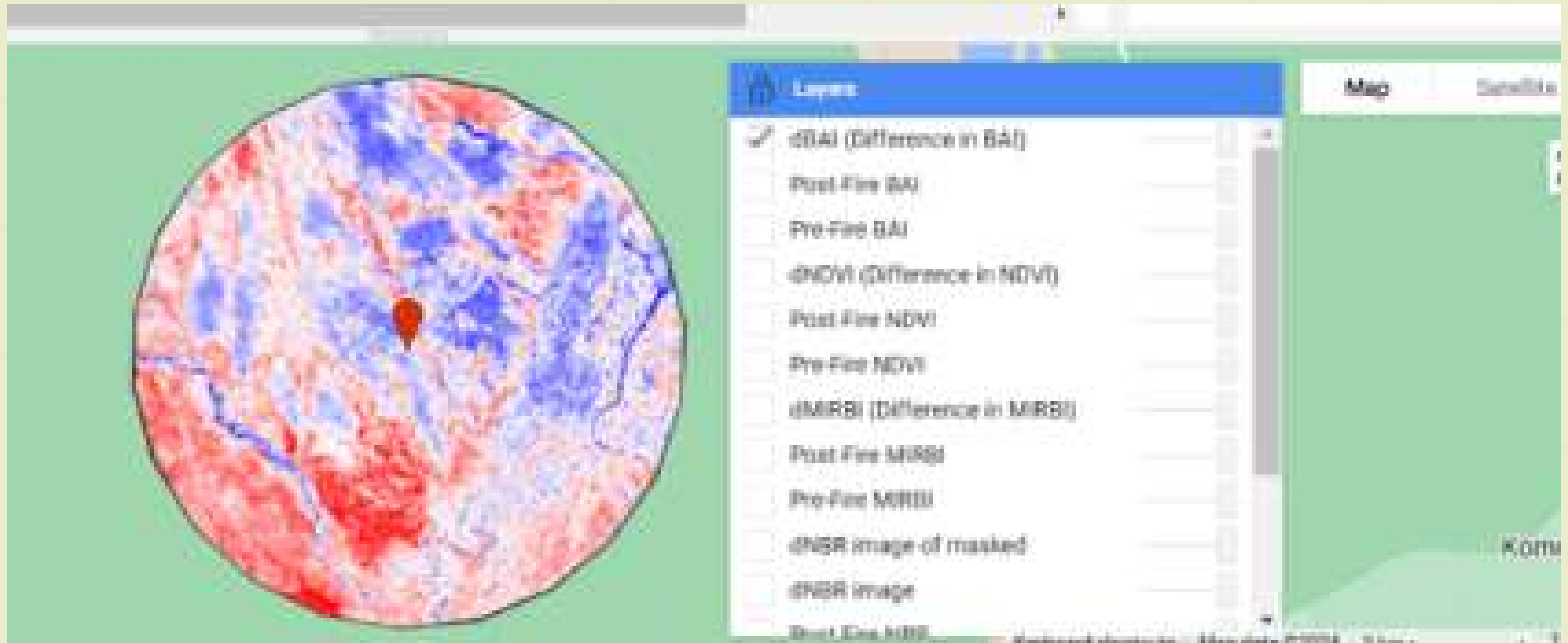
- Post-Fire BAI (Yellow):
  - Indicates reduced burn signature, likely from rapid regrowth aided by high rainfall and improved moisture retention.

- dBAI (White):
  - Minimal change in burn presence, suggesting stable post-fire conditions with effective regrowth or low burn severity.

- Effectiveness: BAI effectively tracks burn status and regrowth, with Kunda's climate enhancing vegetation recovery.





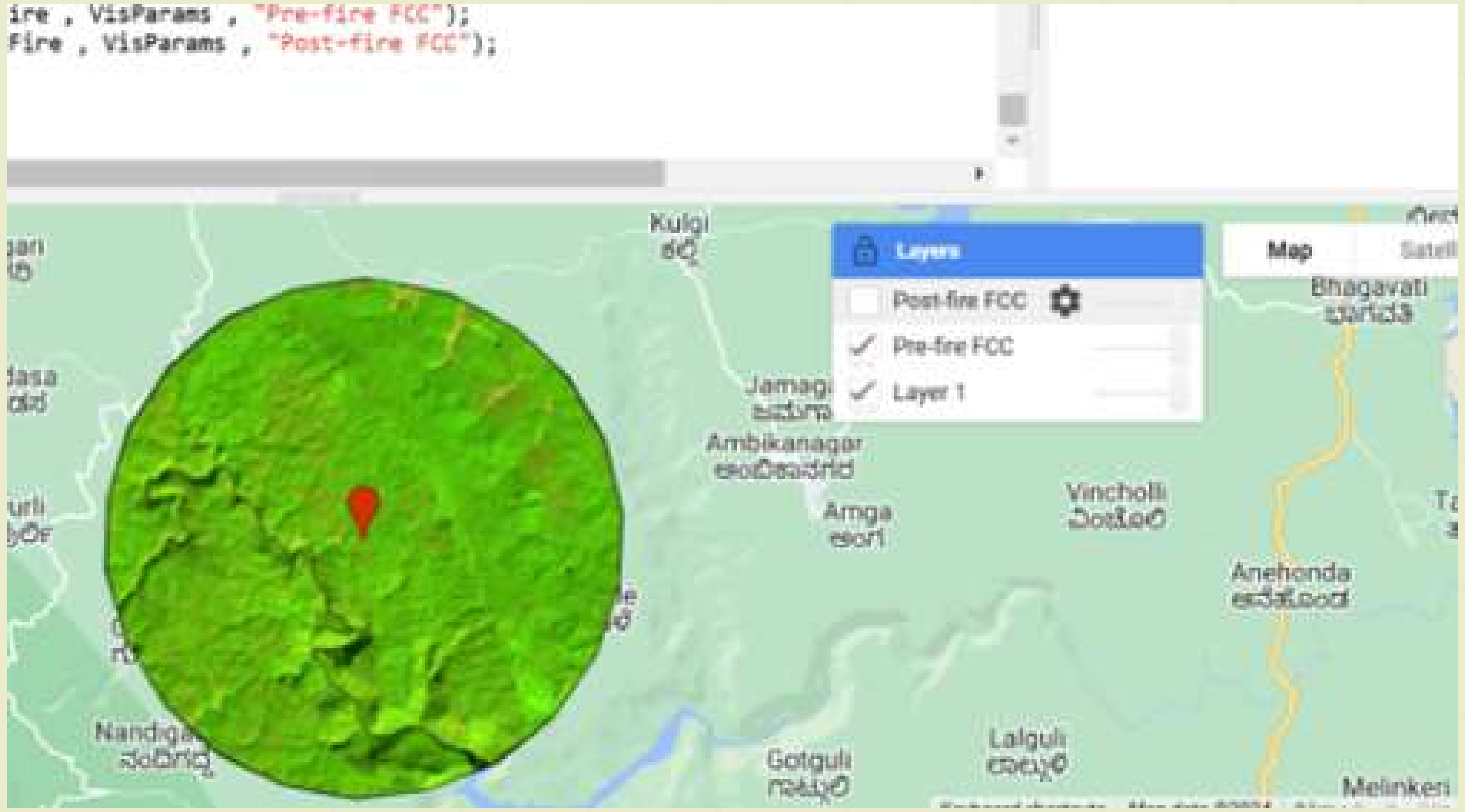


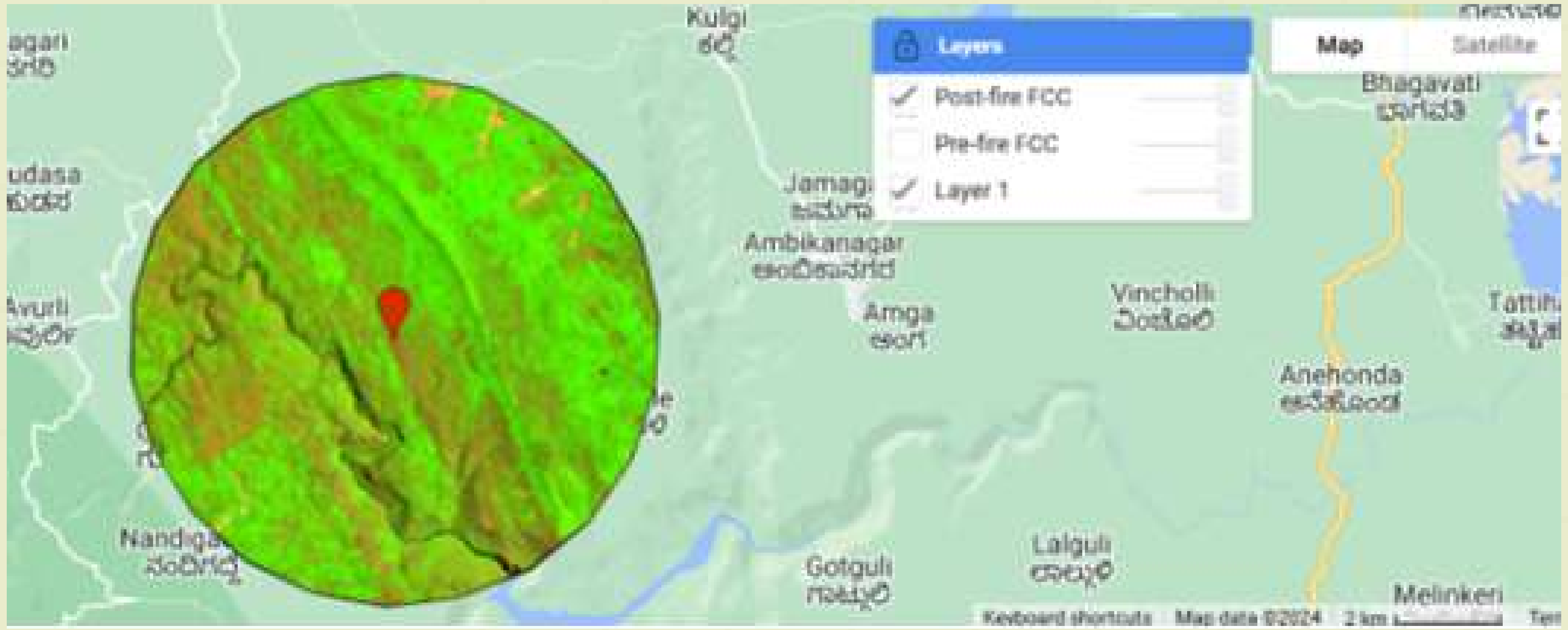
SHIROLI, KARNATAKA

Created a Buffer of 5km radius

FALSE COLOUR COMPOSITE (FCC)

- Pre-Fire FCC (Green):
  - Dominant green indicates healthy, dense vegetation and moisture-rich conditions pre-fire.
- Post-Fire FCC (Grey):
  - Shift to grey color shows significant vegetation loss due to fire impact, exposing bare or lightly vegetated soil.
- Summary
  - FCC analysis highlights substantial vegetation damage, with healthy vegetation replaced by sparse land cover post-fire.

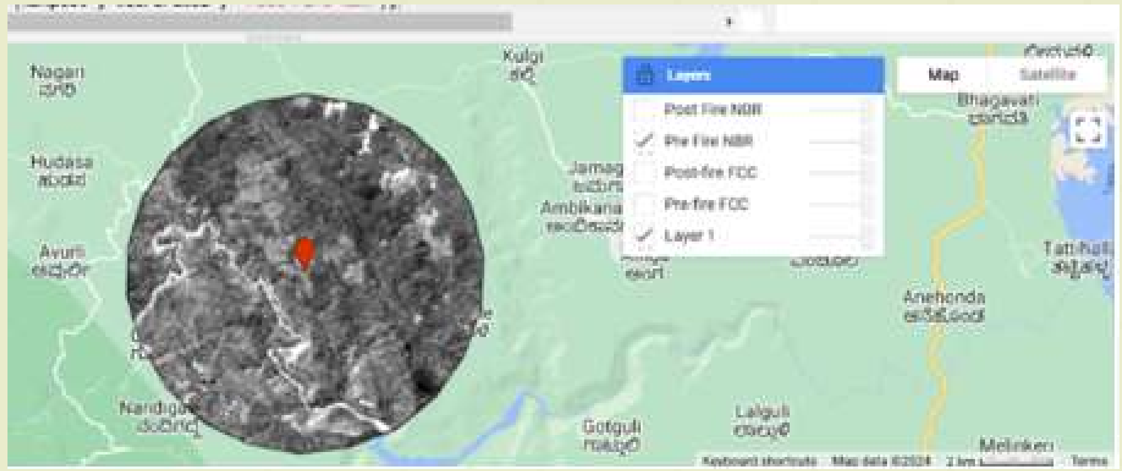


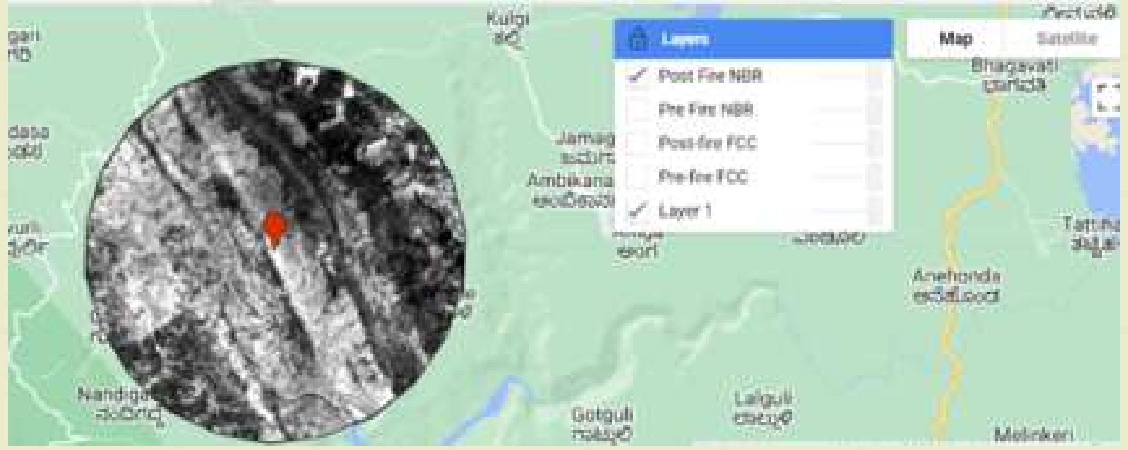


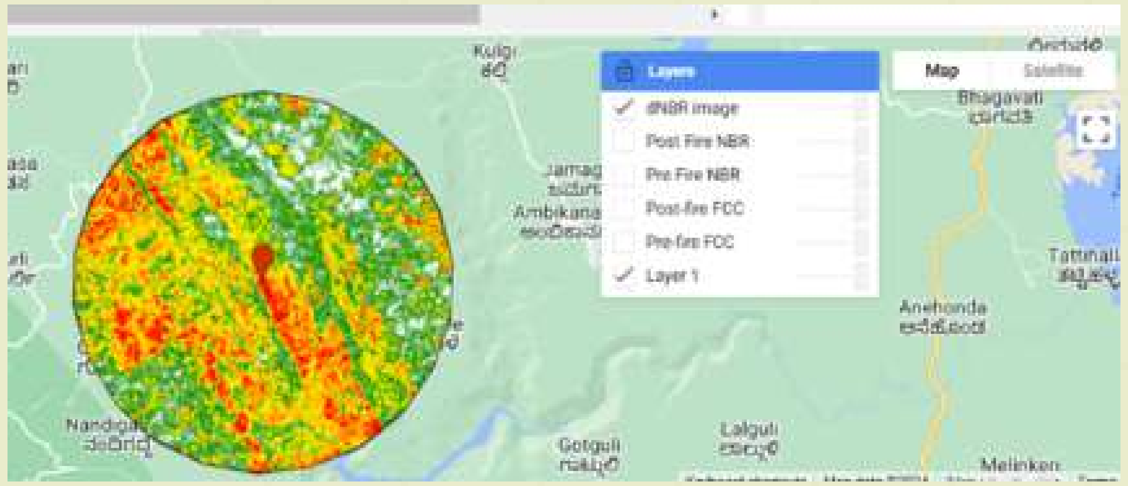
SHIROLI, KARNATAKA

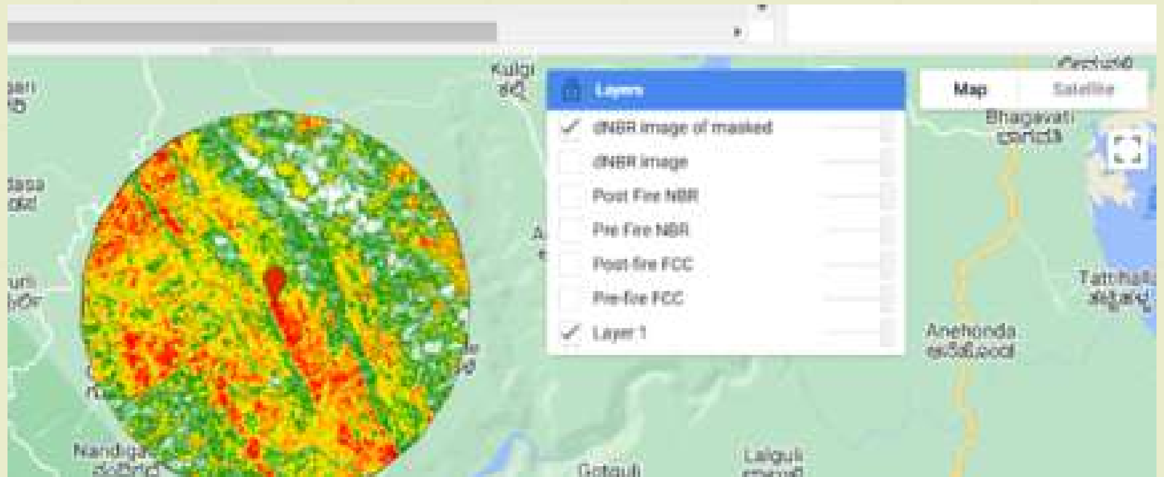
NORMALIZED BURN RATIO (NBR)

- Pre-Fire NBR (Black)
  - High NBR (black) indicates healthy vegetation and moisture-rich areas pre-fire.
- Post-Fire NBR (White)
  - Low NBR (white) reflects significant vegetation loss due to fire.
- dNBR (Orange)
  - Moderate burn severity indicated by orange, showing vegetation loss.
- Masked dNBR (Red)
  - High burn severity (red) after masking water, highlighting intense vegetation loss.





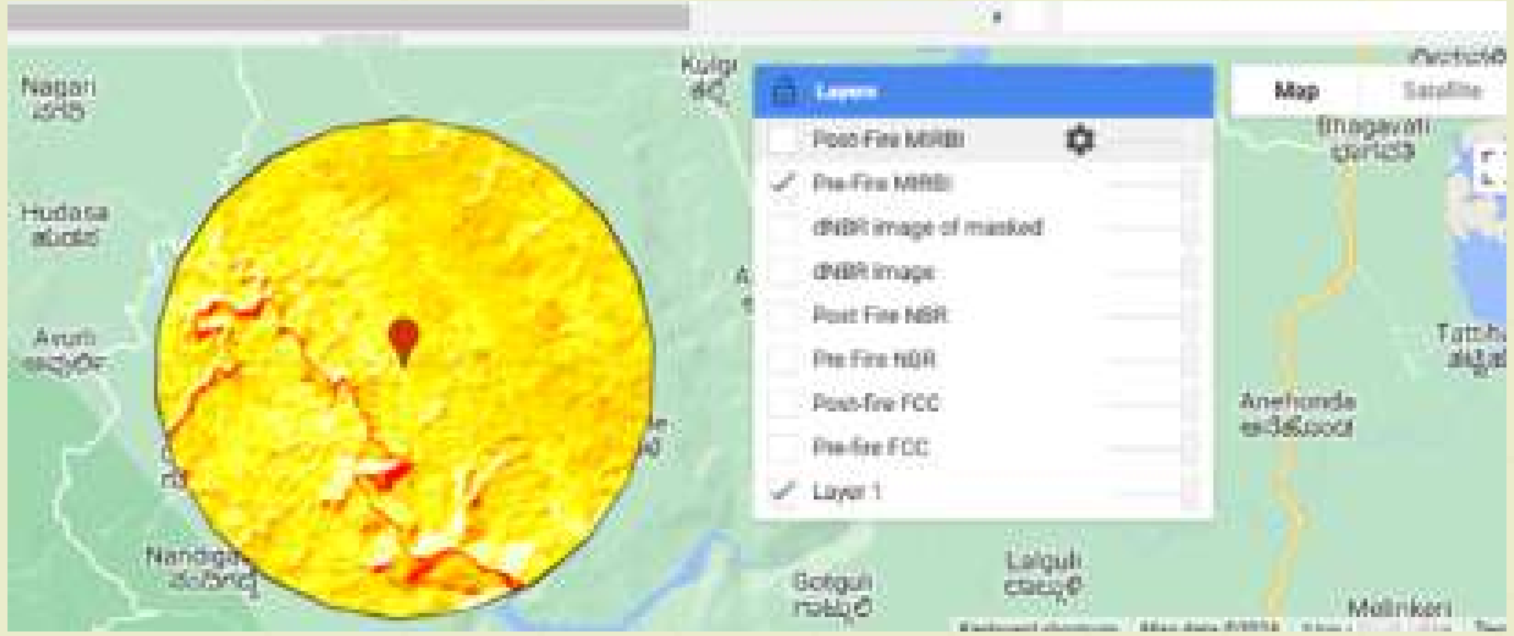


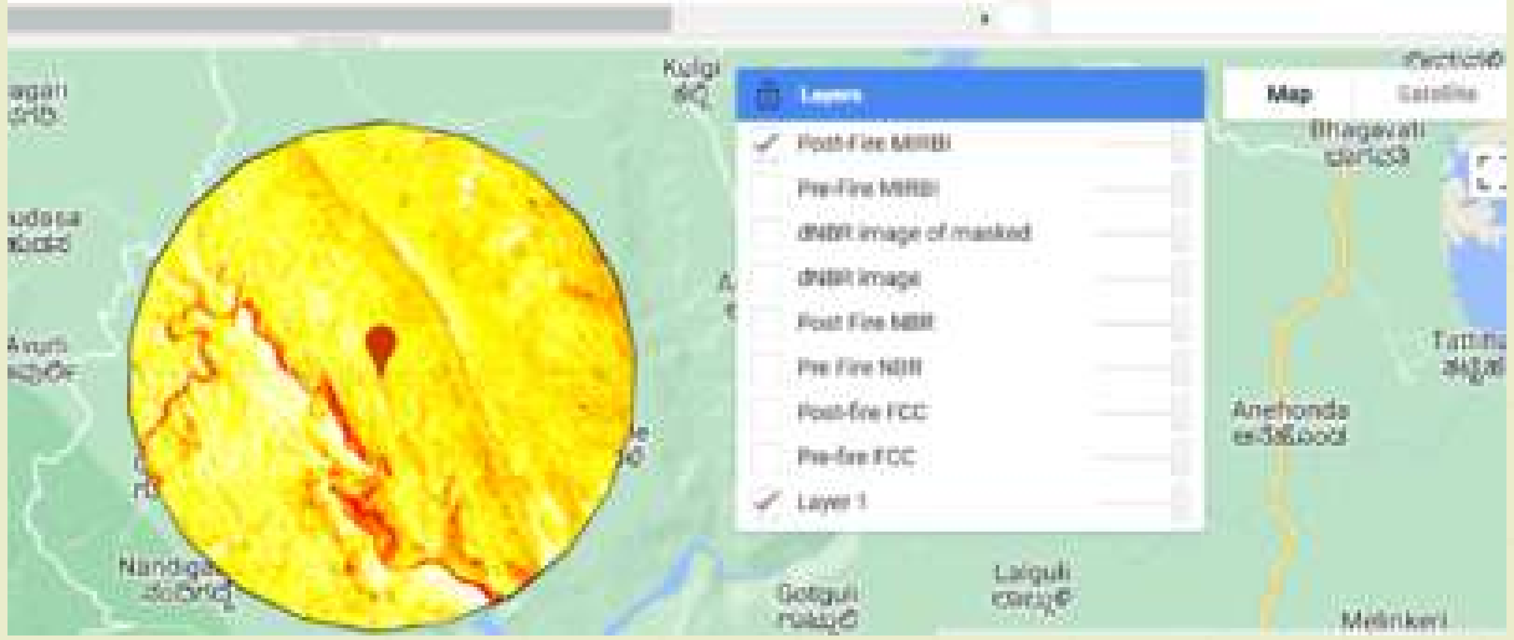


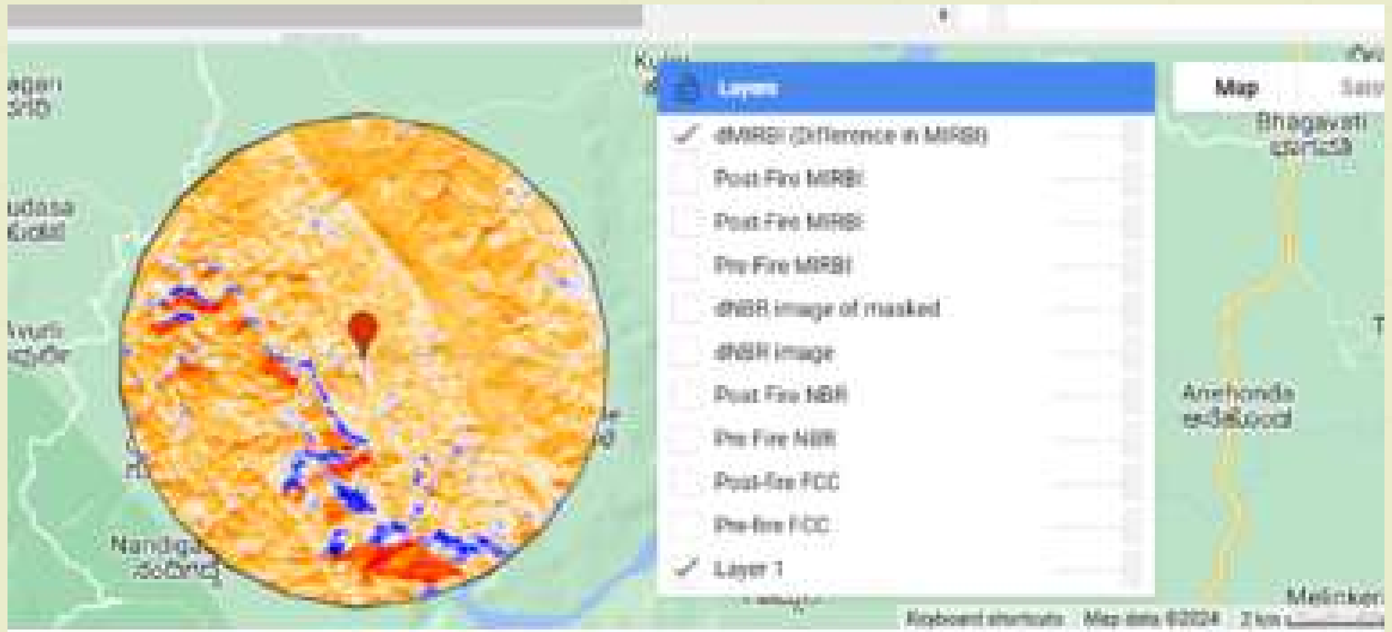
SHIROLI, KARNATAKA

MID-INFRARED BURN INDEX (MIRBI)

- Pre-Fire MIRBI (Yellow)
    - Indicates moderate burn susceptibility or drier conditions pre-fire.
- Post-Fire MIRBI (Yellow)
    - MIRBI remains yellow, showing no significant increase in ash or surface dryness.
- dMIRBI (Orange)
    - Moderate change in burn severity, with some ash/char exposure post-fire.







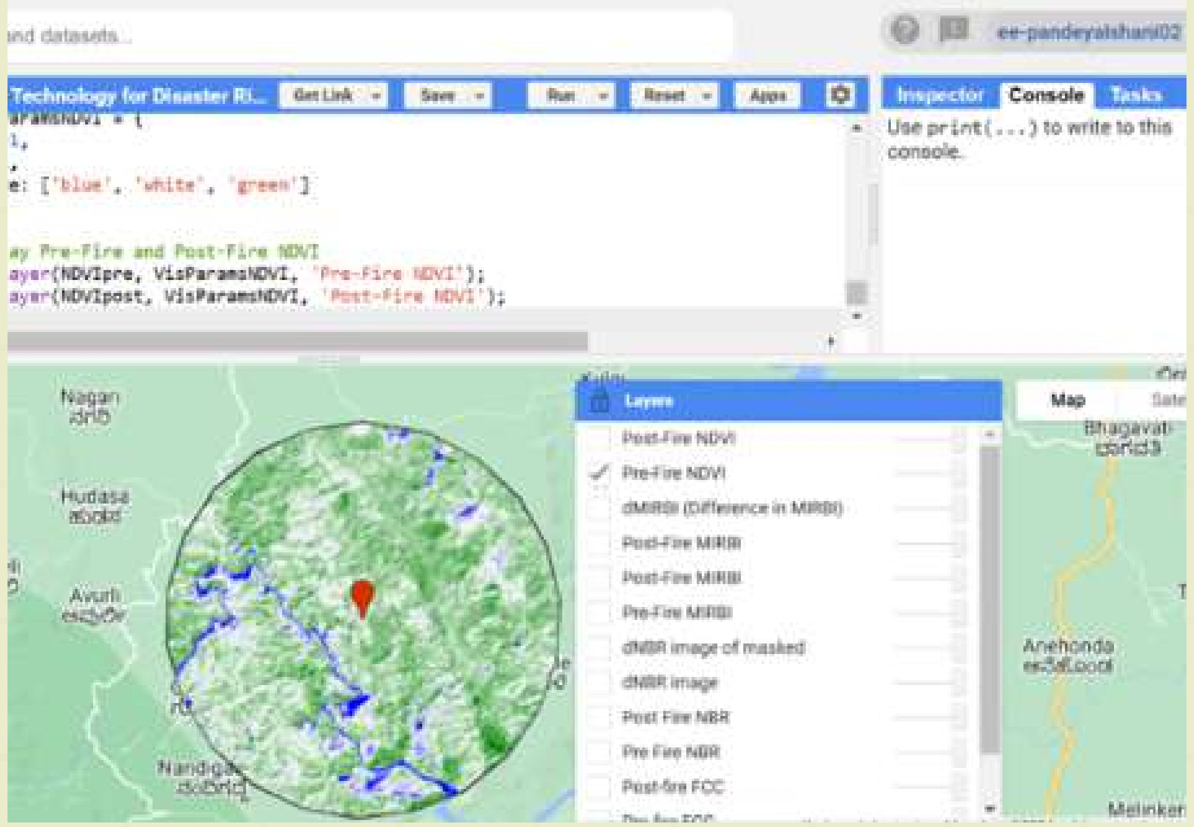
SHIROLI, KARNATAKA

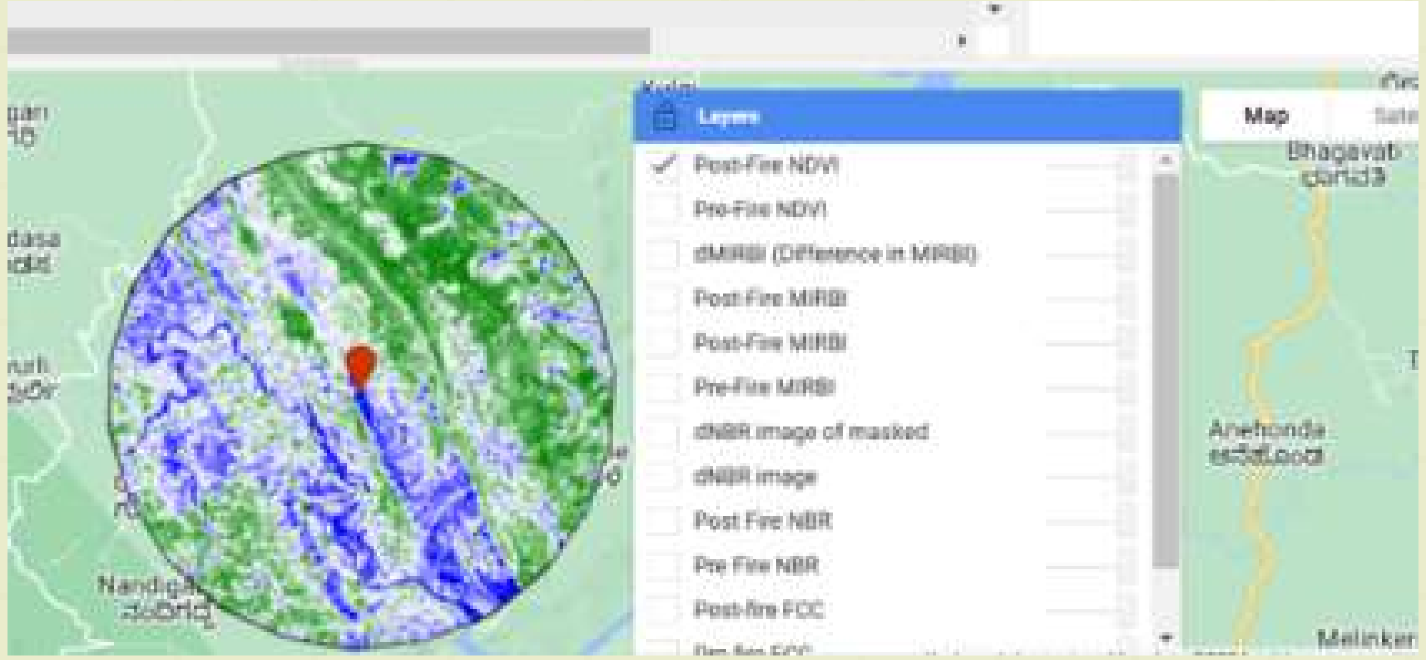
NORMALIZED DIFFERENCE VEGETATION INDEX (NDVI)

- Pre-Fire NDVI (Light Green)
  - Indicates moderate vegetation health; not fully dense or healthy.

- Post-Fire NDVI (Blue)
  - Low vegetation health, likely damaged by fire.

- dNDVI (Green)
  - Positive change post-fire, suggesting some natural recovery in specific areas.

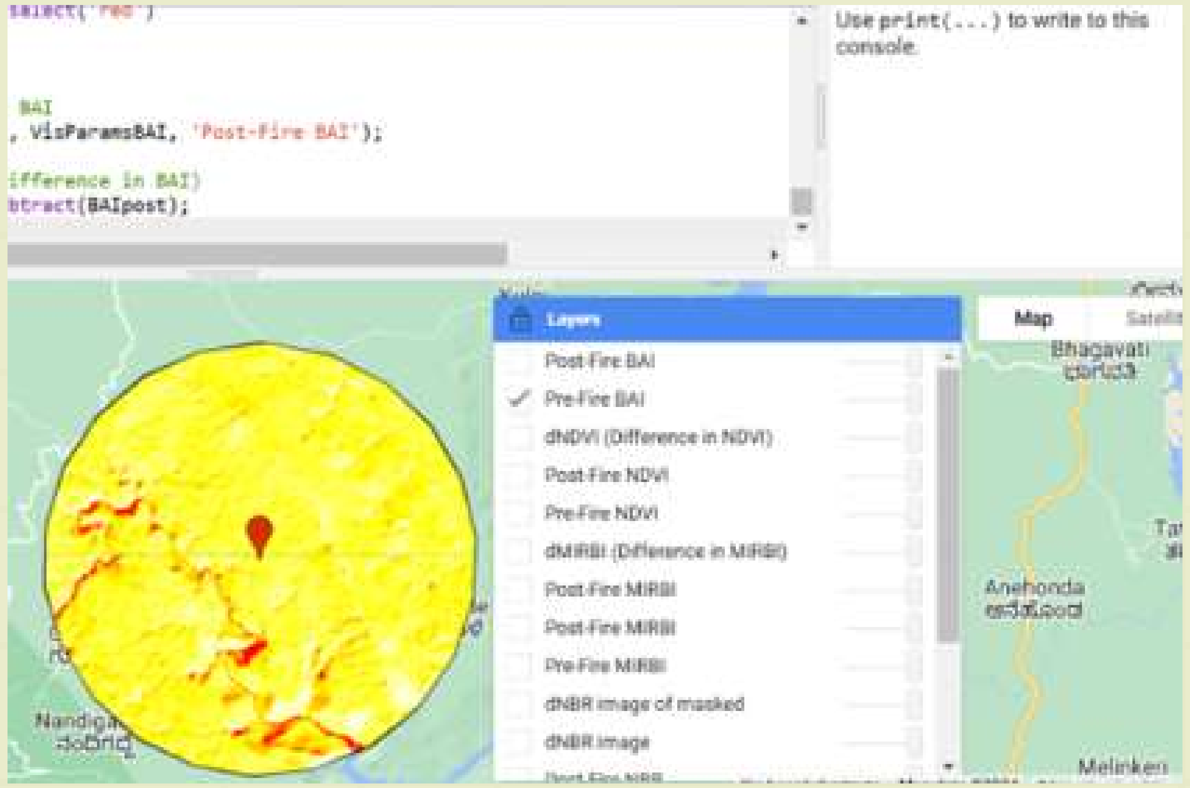


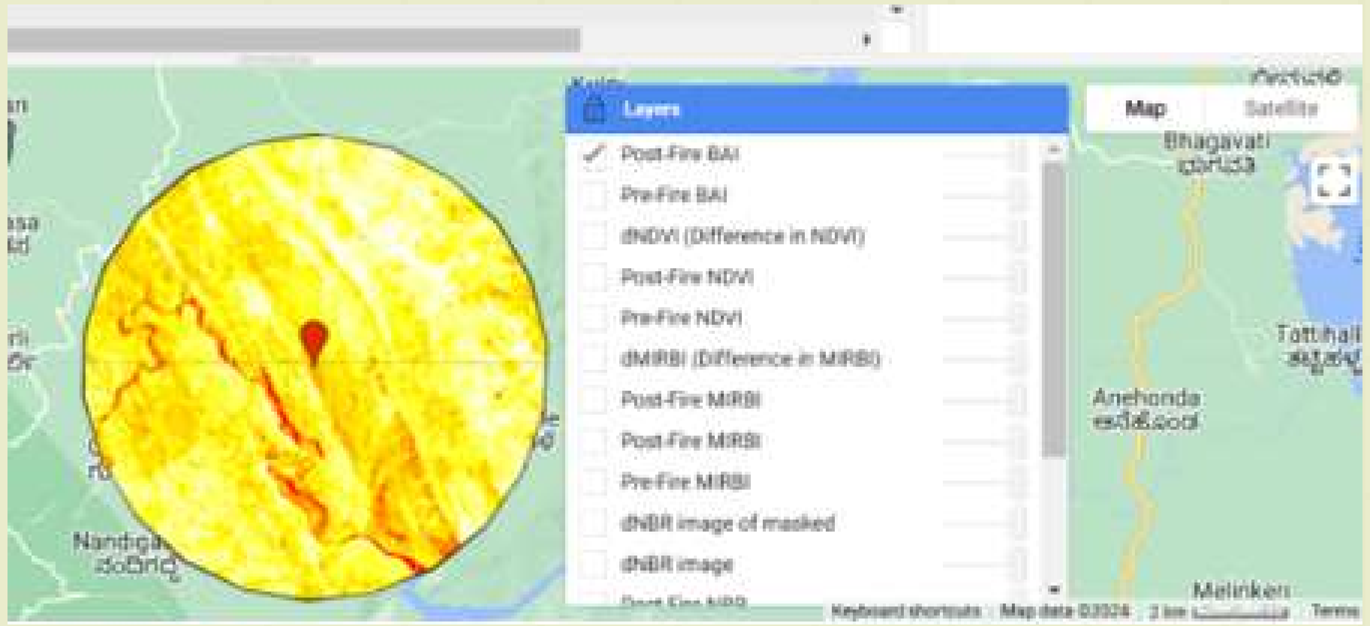


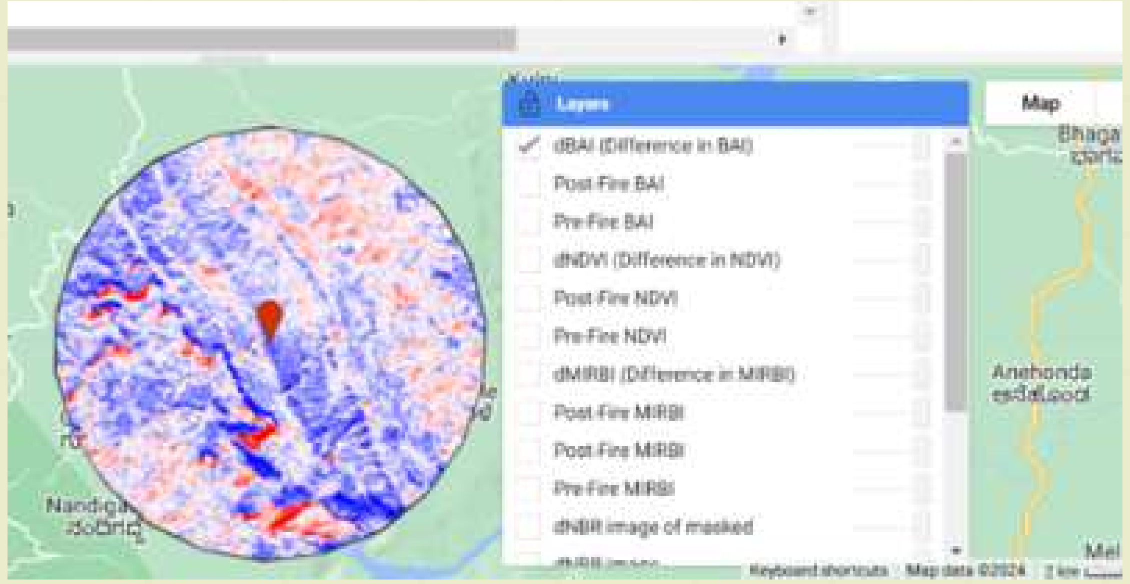
SHIROLI, KARNATAKA

BURN AREA INDEX (BAI)

- Pre-Fire BAI (Yellow)
  - Indicates moderate vegetation and soil dryness, suggesting susceptibility to fire.
- Post-Fire BAI (Yellow)
  - Remains yellow, implying limited burn severity; surface reflectance largely unchanged.
- dBAI (Blue)
  - Minimal change in burn status; no major vegetation recovery or degradation observed.







NEAR DADA, UTTARAKHAND

- Created a buffer in 5km radius around the location.

False Colour Composite (FCC):

1. <u>Pre fire FCC</u>- green tones typically indicate healthy vegetation due to the strong reflectance in the Near-Infrared (NIR) and absorption in the red bands.
2. <u>Post fire FCC</u>- shift from green to mustard or yellow indicates vegetation loss or alteration in surface composition- as vegetation is burned, and the landscape reflects more in the red and SWIR bands, which represent soil or charred ground

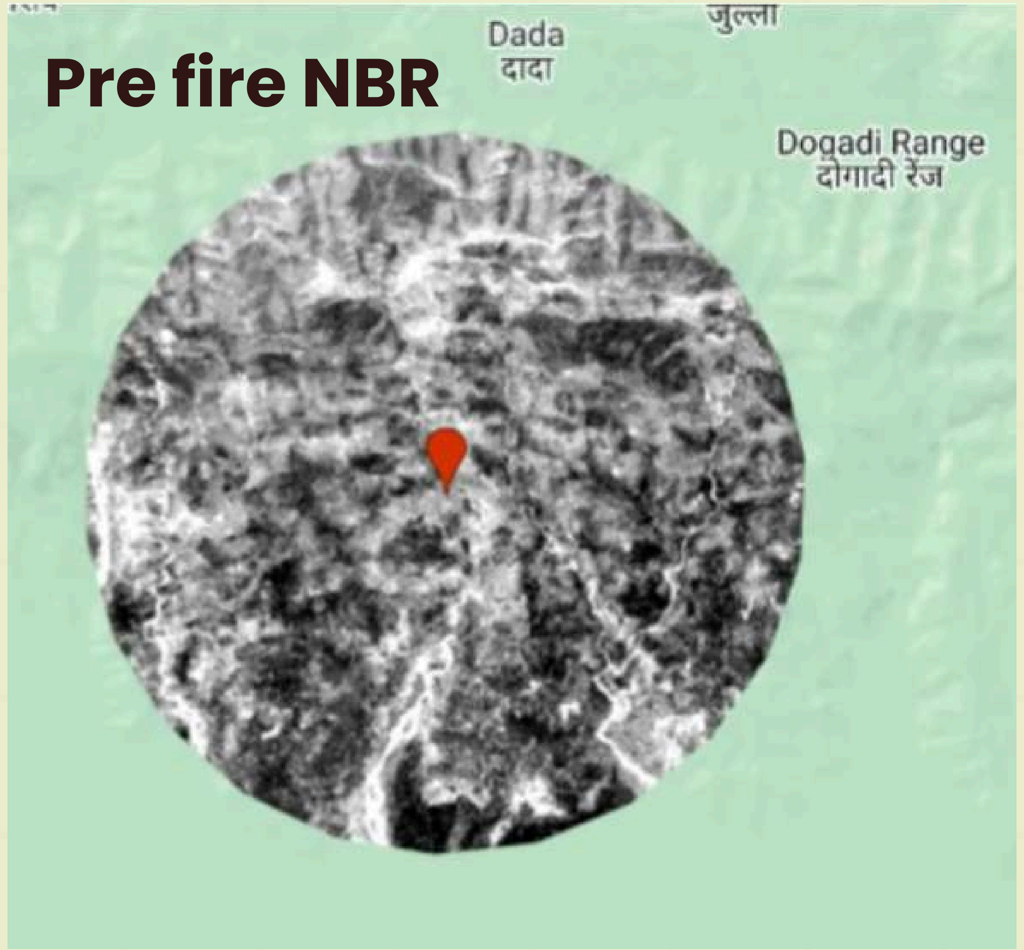
Pre fire FCC

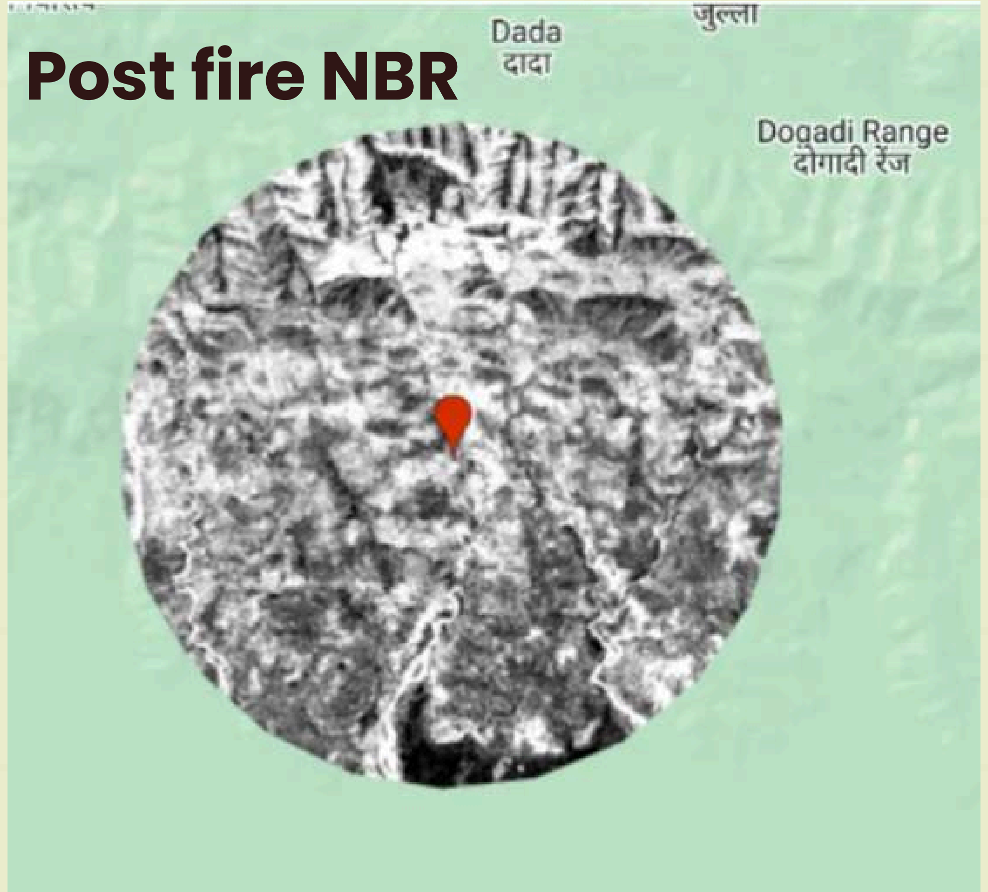
Post fire FCC

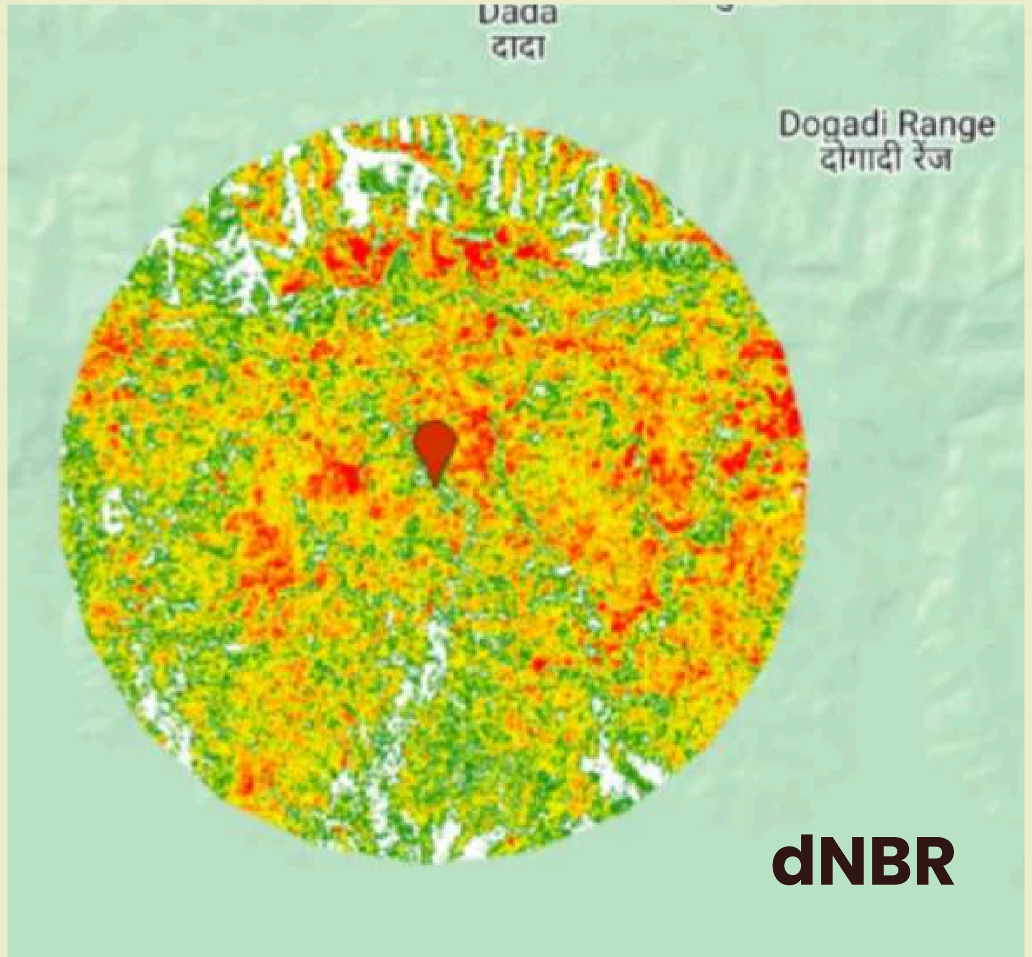
NEAR DADA, UTTARAKHAND

Normalised Burn Ratio:

1. Pre fire NBR- NBR measures vegetation health- dark Grey tones in the pre-fire NBR image suggest moderately healthy vegetation, which corresponds to undisturbed areas, though not with extremely dense canopy cover.
2. Post fire NBR- shift to lighter grey after the fire reflects a decrease in vegetation health or density. Fires reduce the vegetation's NIR reflectance due to the loss of biomass and increased reflectance in the SWIR bands, which is associated with exposed or charred ground.
3. dNBR - The yellow here suggests the fire may have had low-to-moderate severity in these regions.



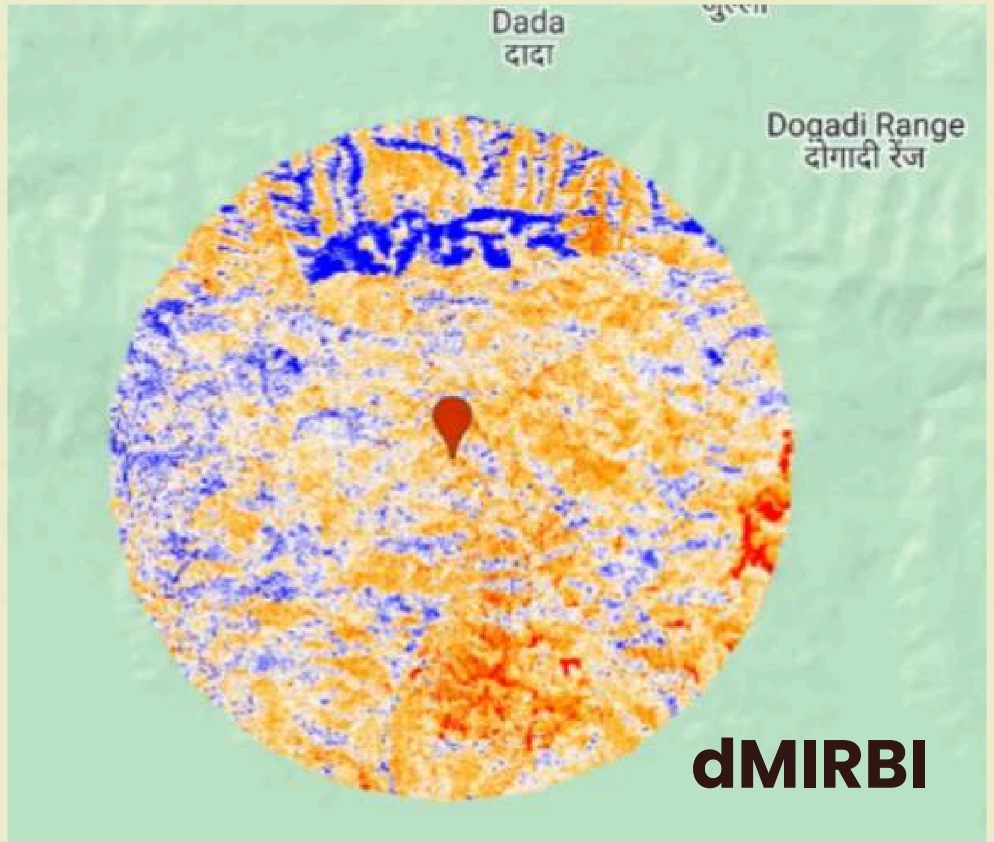




NEAR DADA, UTTARAKHAND

MIRBI:

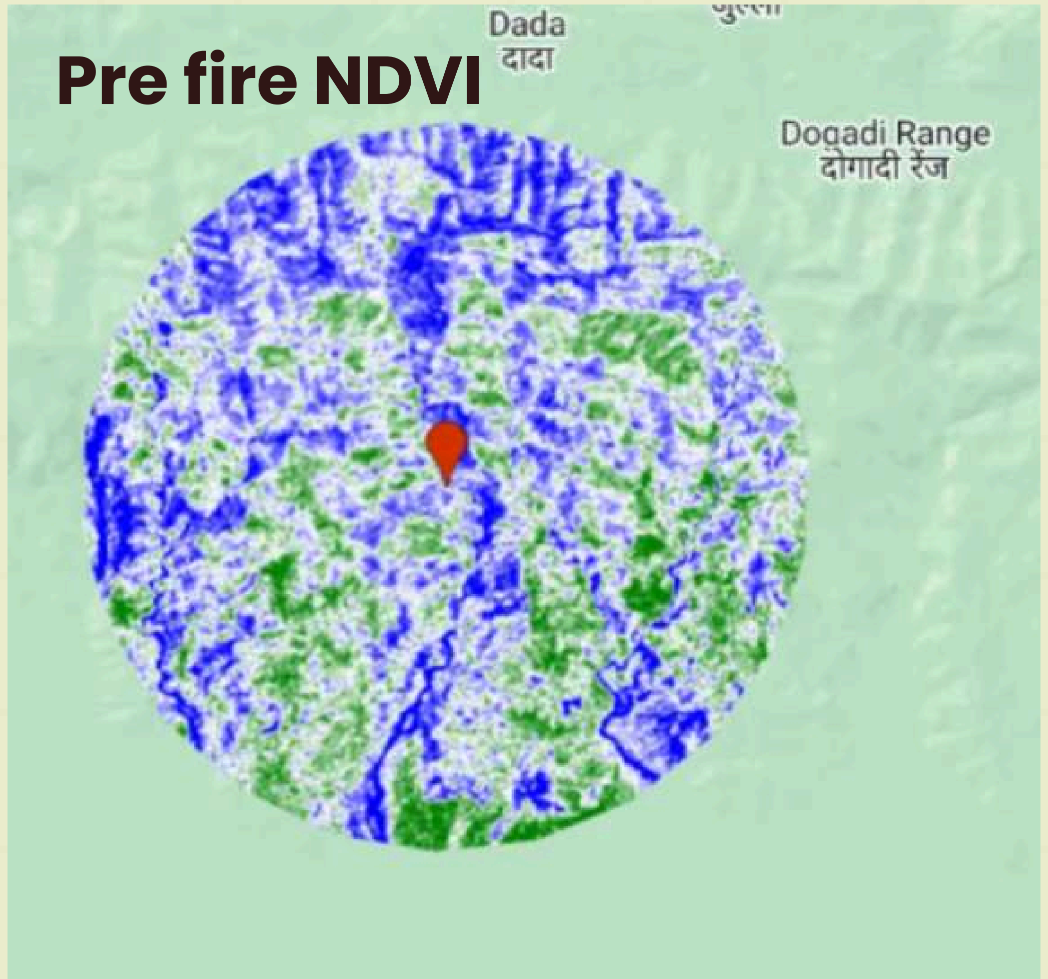
1. <u>pre fire MIRBI</u>- designed to detect burned areas using SWIR bands- yellow indicates a lower baseline of burn intensity, likely representing unburned or healthy vegetation.
2. <u>Post fire MIRBI</u>- Post-fire, the land reflects more SWIR due to the absence of vegetation & the presence of charred material or bare soil- arker yellow and orange tones suggest an increase in MIRBI values->implies burns
3. <u>dMIRBI</u>- Higher values of dMIRBI in orange highlight areas of significant change- orange dMIRBI in the output indicates a moderate-to-high burn severity.

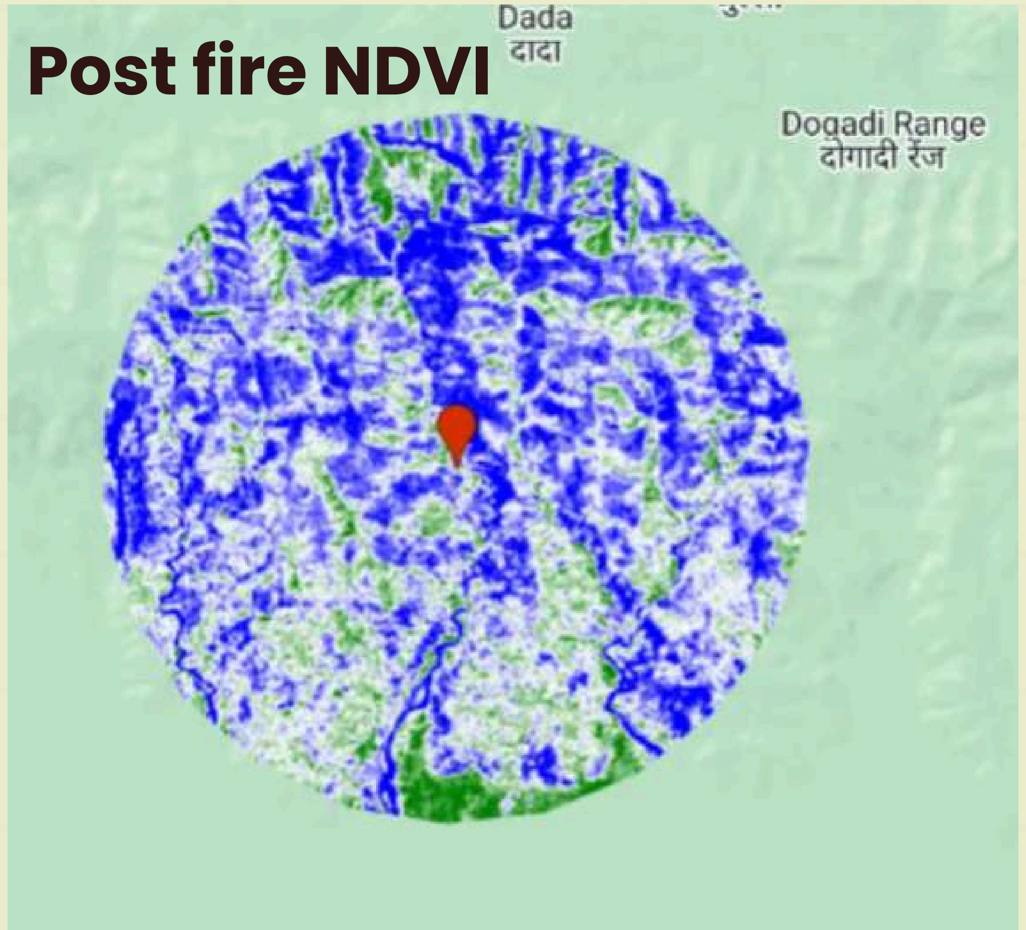


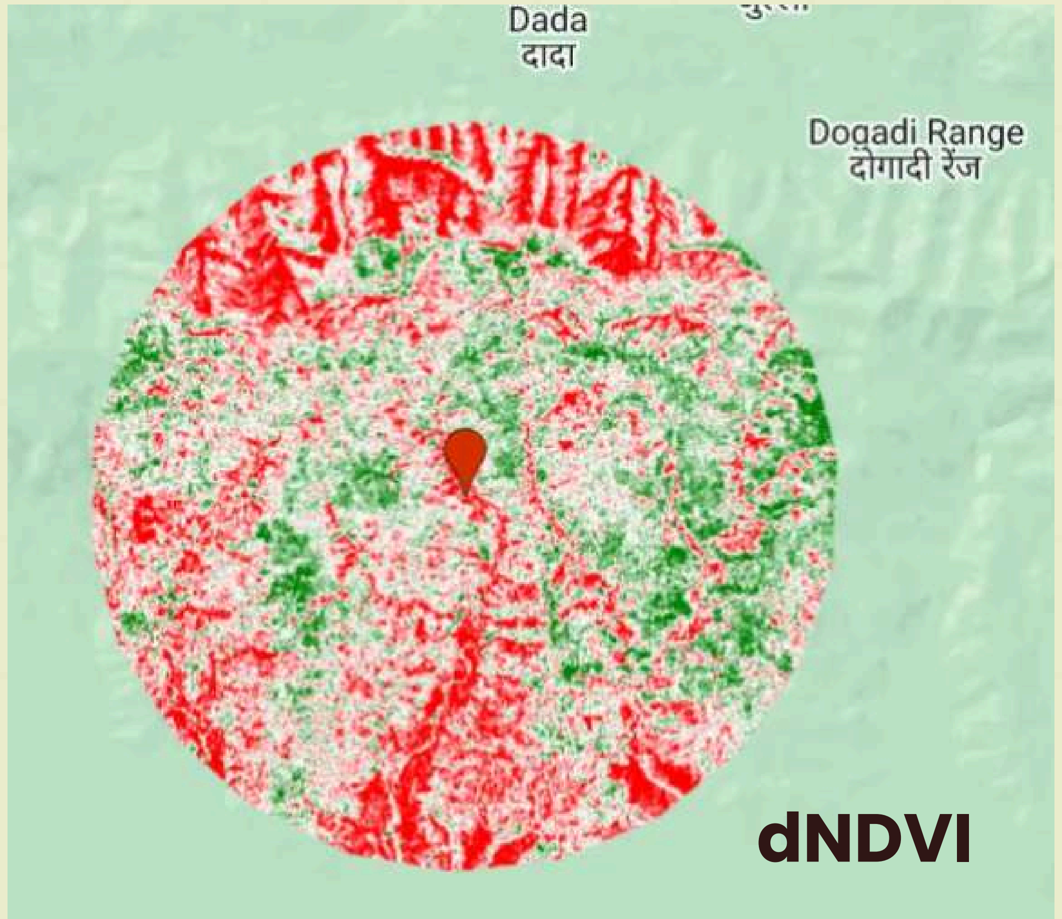
NEAR DADA, UTTARAKHAND

Normalised diff vegetation index(NDVI):

1. <u>pre fire NDVI</u>- higher values indicating lush vegetation- Sage green represents moderate NDVI value which implies moderate density canopy.
2. <u>Post fire NDVI</u>- DVI values generally decrease as vegetation is lost or damaged. The lighter green color in the post-fire NDVI indicates a decline in vegetation density or health, likely due to reduced photosynthetic activity in remaining vegetation.
3. <u>dNDVI</u>- A high dNDVI drop (red) suggests severe fire impact, as healthy vegetation (high NDVI) has transitioned to low or no vegetation cover (low NDVI)- Red in dNDVI acts as a good indicator of burn severity.



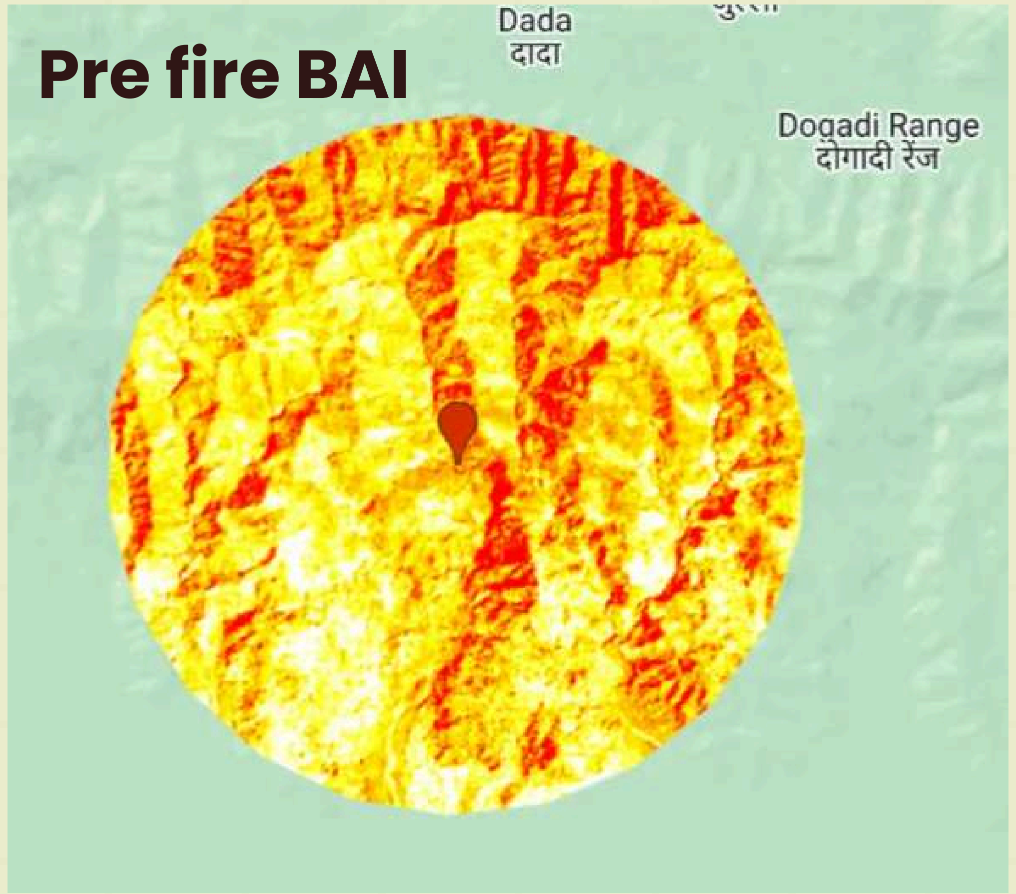


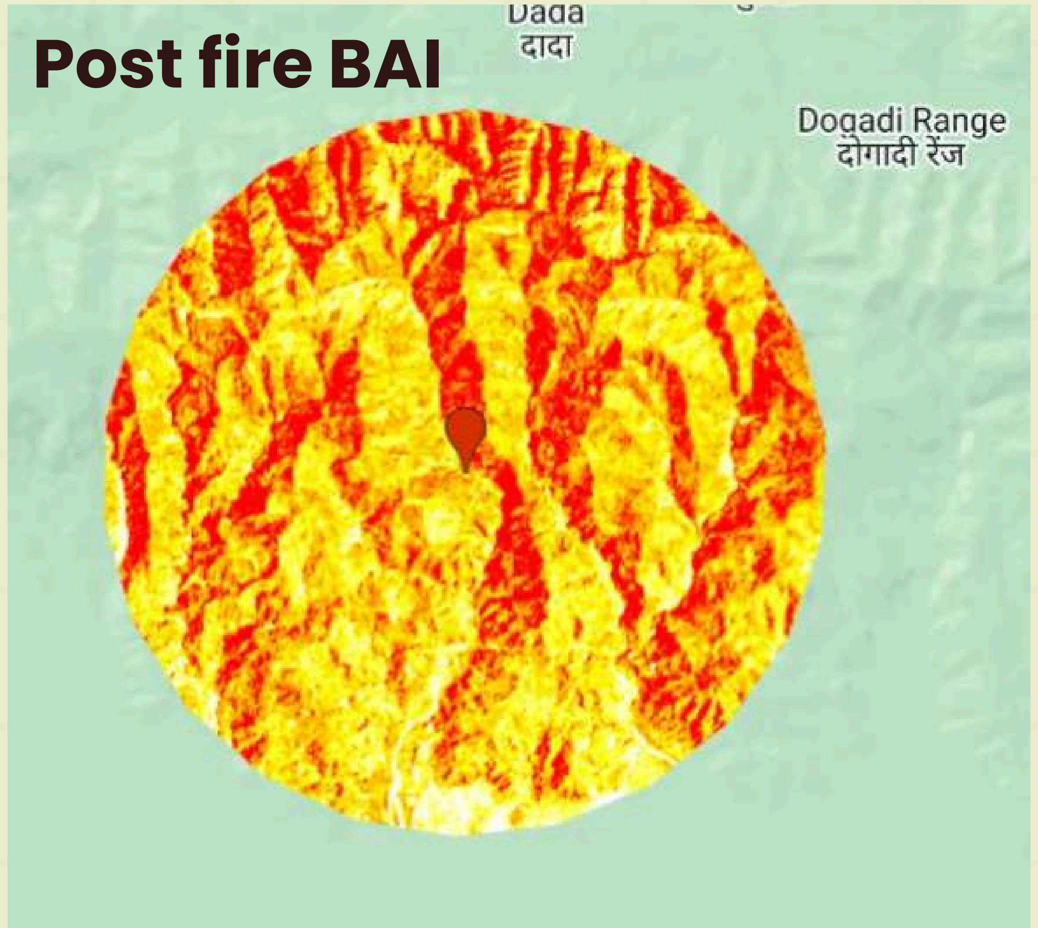


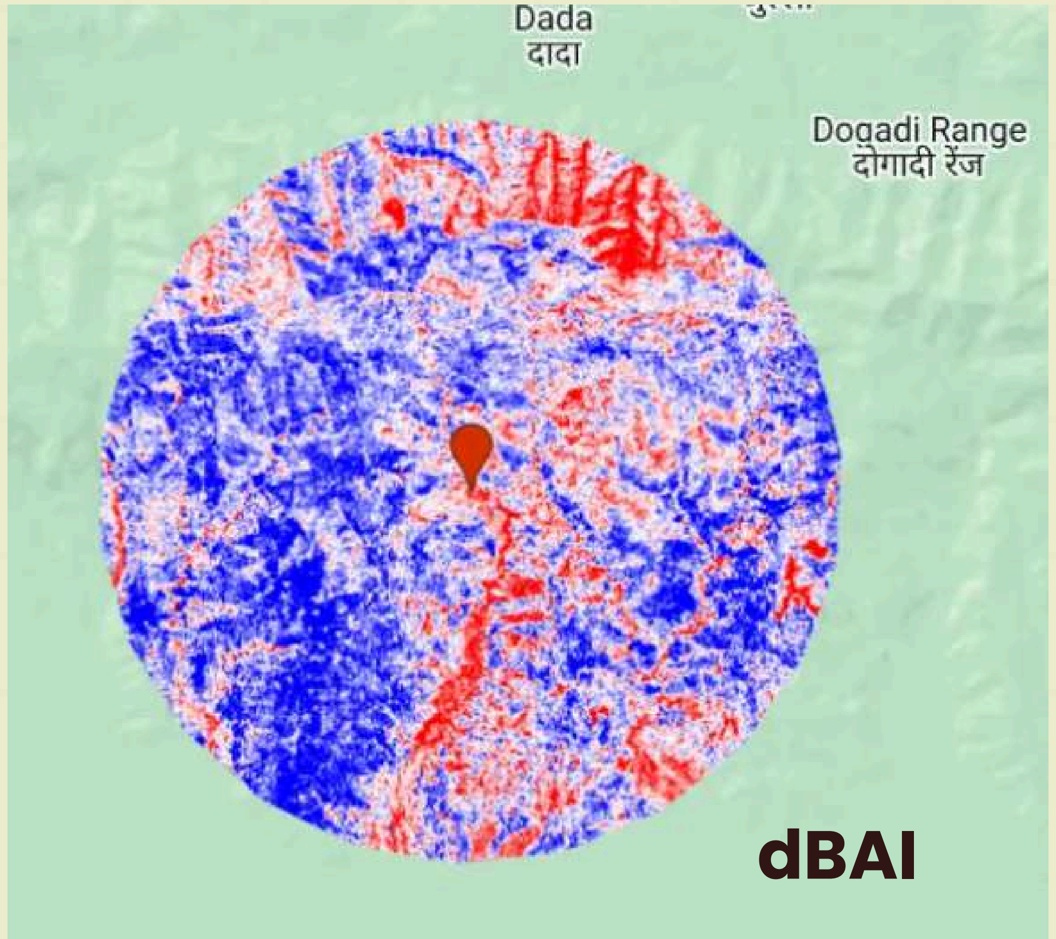
NEAR DADA, UTTARAKHAND

Burned Area index(BAI):

1. <u>pre fire BAI</u>- Detects recently burned areas- Dark orange tones here represent a low baseline BAI, meaning the area was undisturbed before the fire event.
2. <u>Post fire BAI</u>- darker shades of orange/yellow- BAI typically increases in burned areas because the charred remains and ash absorb more near-infrared and red light, resulting in these darker, more intense shades.
3. <u>dBAI</u>- The color shift to light red in the dBAI difference image signals a reduction in burned area index post-fire, likely due to early signs of regeneration- fire may not have left long-lasting burn scars.







EVALUATION OF NBR/DNBR EFFECTIVENESS

- Effectiveness of NBR/dNBR
  - NBR: Distinguishes healthy vs. burned vegetation.
  - dNBR: Highlights burn severity effectively, with orange and red tones showing moderate-to-high impact areas.

- Comparison with Other Indices
  - MIRBI: Detects ash and char well but less sensitive to subtle vegetation changes.
  - NDVI: Good for general vegetation health but less precise for burn severity.
  - BAI: Detects burned areas but less effective for post-fire recovery analysis.

- In General Effectiveness Ranking (Increasing Order)
  - BAI - Limited in post-fire sensitivity.
  - NDVI - Lacks specificity for burn severity.
  - MIRBI - Good for burn detection but misses fine vegetation changes.
  - NBR/dNBR - Best for burn severity differentiation and vegetation recovery.

Evaluation of NBR/dNBR Effectivenes in Kunda

- Effectiveness Ranking:
    - Highest - MIRBI: Ideal for severe burn assessment, sensitive to ash and exposed soil.
    - Second - BAI: BAI captures burn presence effectively by identifying increased reflectance in the red and NIR bands. It can detect burned regions well and track early regrowth, making it valuable in a high-rainfall region like Kunda, where regrowth is prominent.
    - Third - NBR/dNBR: Effective for vegetation burn delineation, especially with varied vegetation health.
    - Lowest - NDVI: Reflects general vegetation health but lacks specificity for burn severity.
- Conclusion: While NBR/dNBR serves as a primary burn tool for vegetation, MIRBI provides additional precision in assessing soil and ash exposure, offering a comprehensive approach to fire impact analysis in mixed vegetation areas.

THANK YOU!!!