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Leveraging big data to understand impact and recovery from 2022 Pakistan floods

Rob Marty

IE CONNECT FOR IMPACT

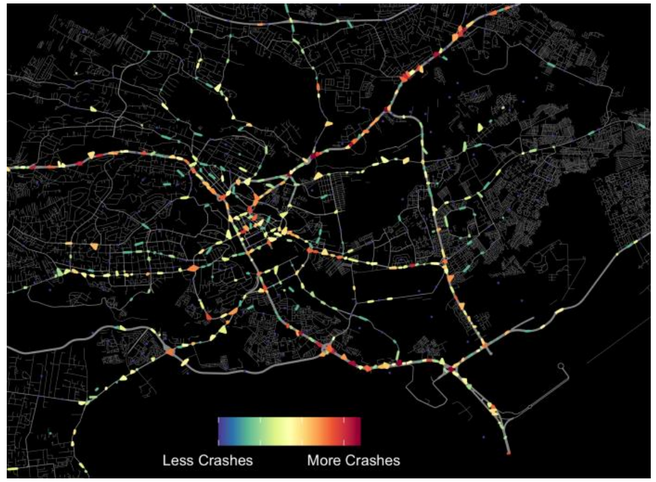
UK International Development
Partnership | Progress | Prosperity

THE WORLD BANK
IBRD • IDA | WORLD BANK GROUP
Development Economics • Impact

i2i DIME
TRANSFORM DEVELOPMENT

Using data & new technologies to inform policy decisions and investments in transport

Urban Mobility | Development Corridors | Road Safety | Rural Roads
Gender | Fragile Situations | Climate Change | COVID-19



2022 Pakistan Floods

The New York Times

Deadly Floods Devastate an Already Fragile Pakistan

More than 1,100 have died as record monsoon rains inundate the country, washing away bridges, roads and crop fields. Much of Pakistan is underwater.

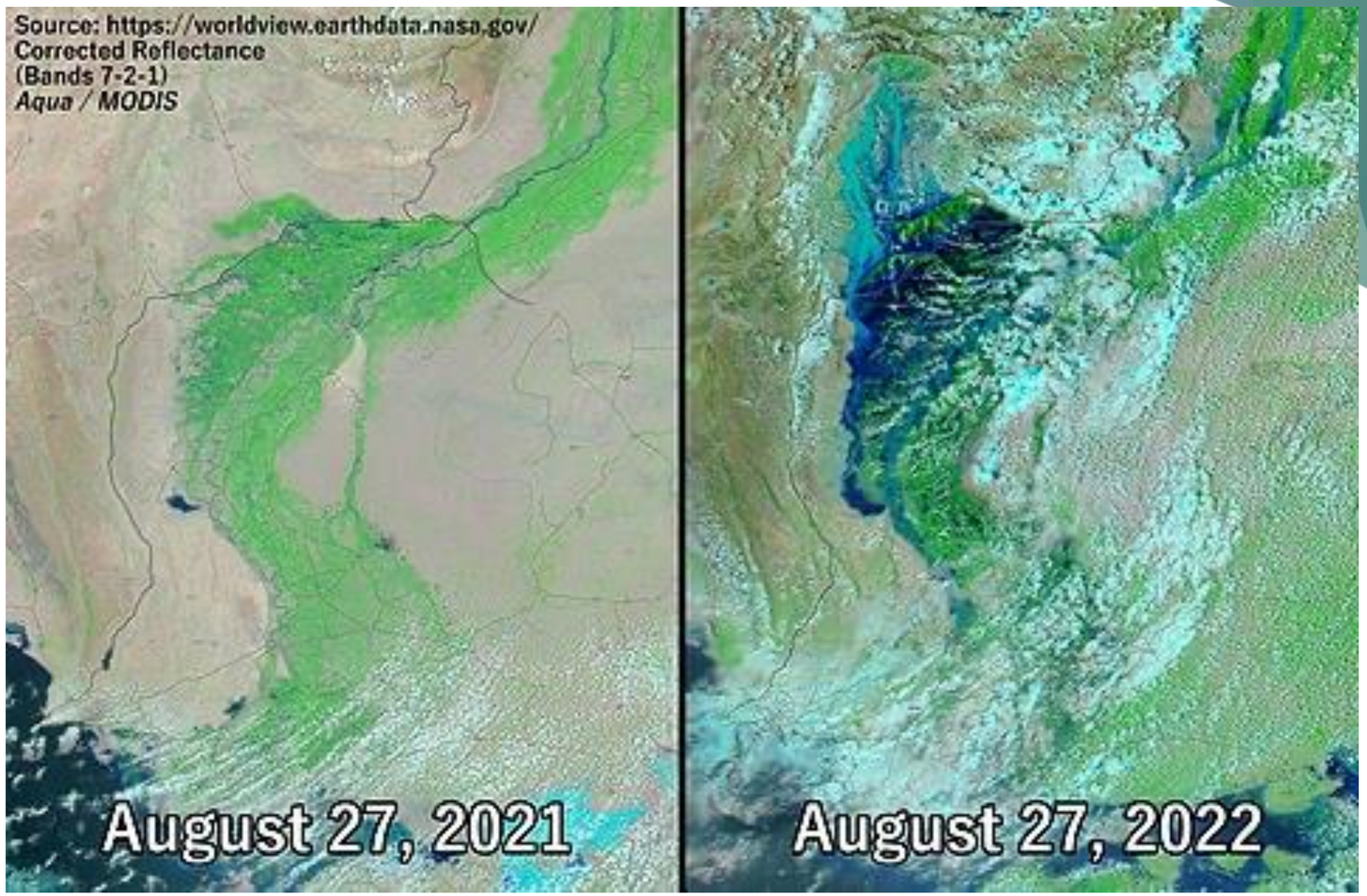
- Exceptionally heavy monsoon rains led to unprecedented flooding
- 1,700 deaths
- 7.9 million displaced
- 2.1 million homes destroyed
- $30 billion in damages

2022 Pakistan Floods

Goal: Leverage geospatial data to understand impact & recovery at granular geospatial scale

Outline

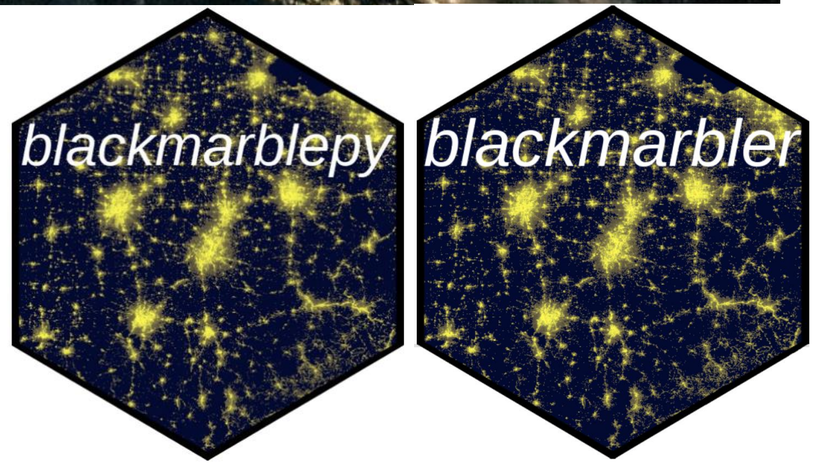
- Overview of data
- Descriptive analysis of flood damages
- Impact of floods on socio-economic outcomes
- Impact of floods on road infrastructure



Data

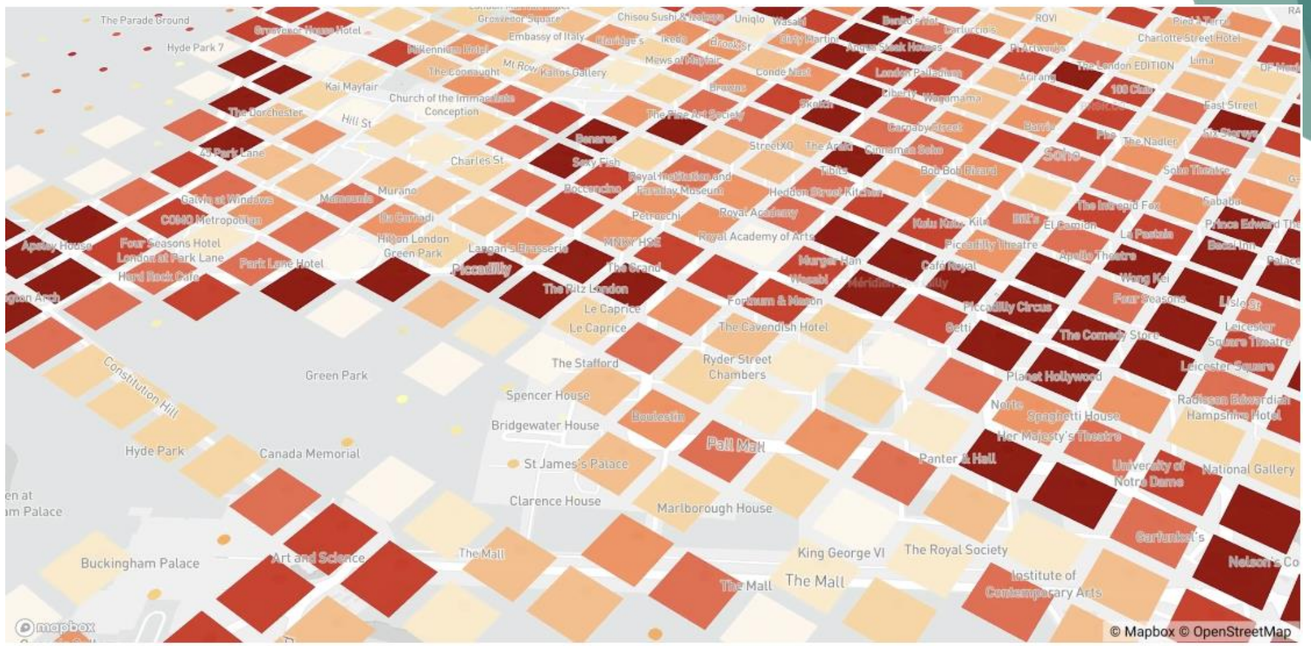
Nighttime Lights

- Commonly used proxy for economic activity
- VIIRS Black Marble (NASA)
- 500m resolution
- Daily/monthly/annual since 2012



Mapbox Movement

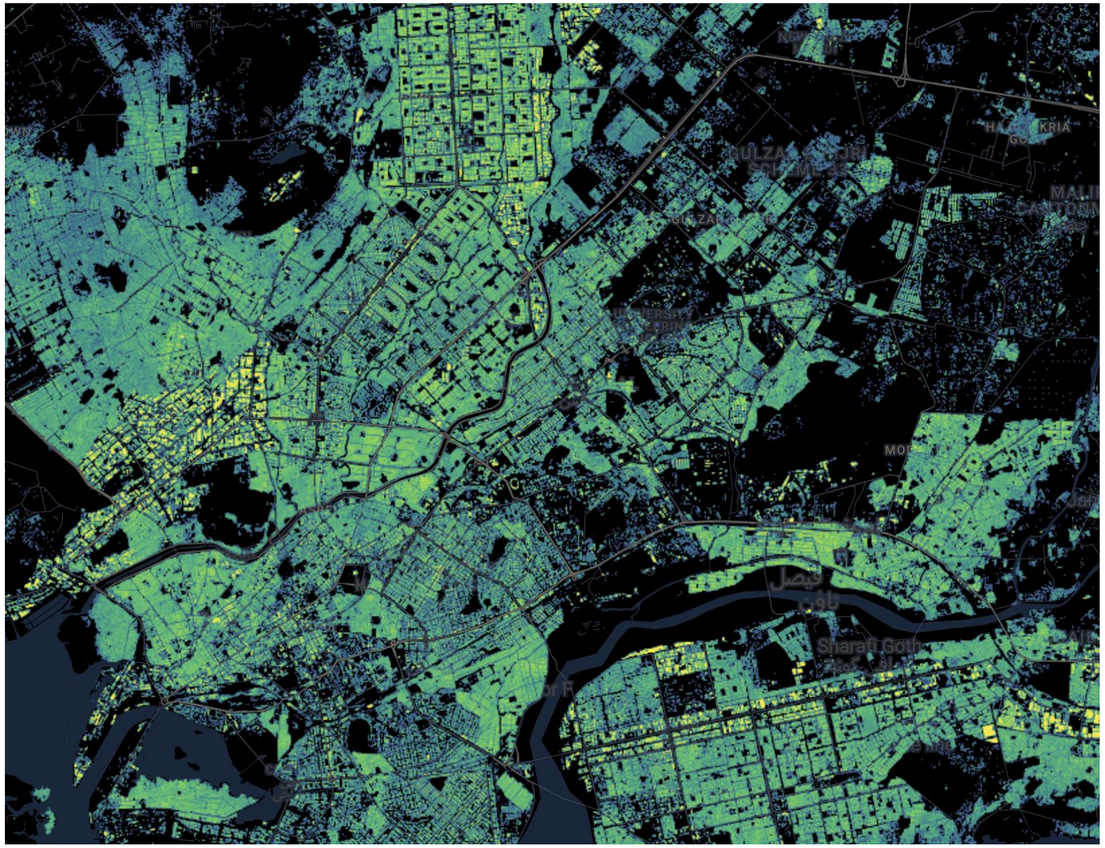
- Activity index derived from mobile phone data
- 100 meter grid cells
- Monthly, Jan 2022 – June 2023



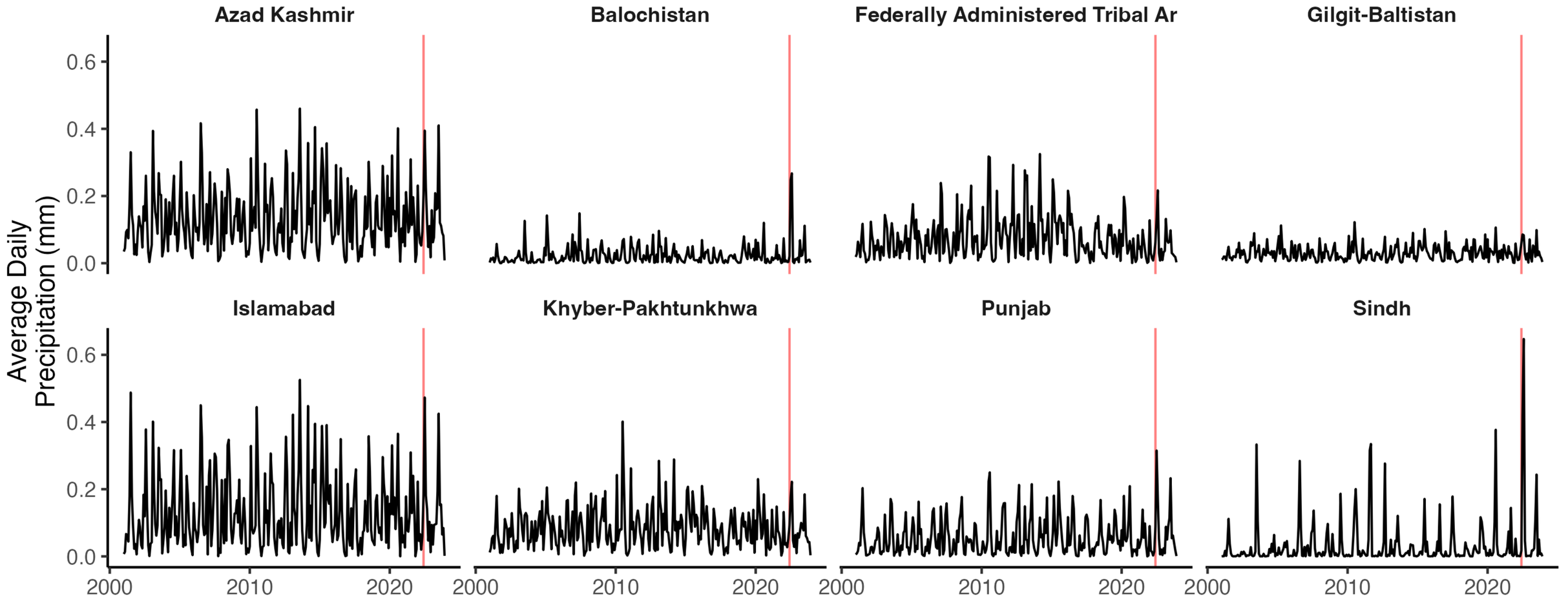
DEVELOPMENT DATA PARTNERSHIP

Google Open Buildings 2.5D Temporal Dataset

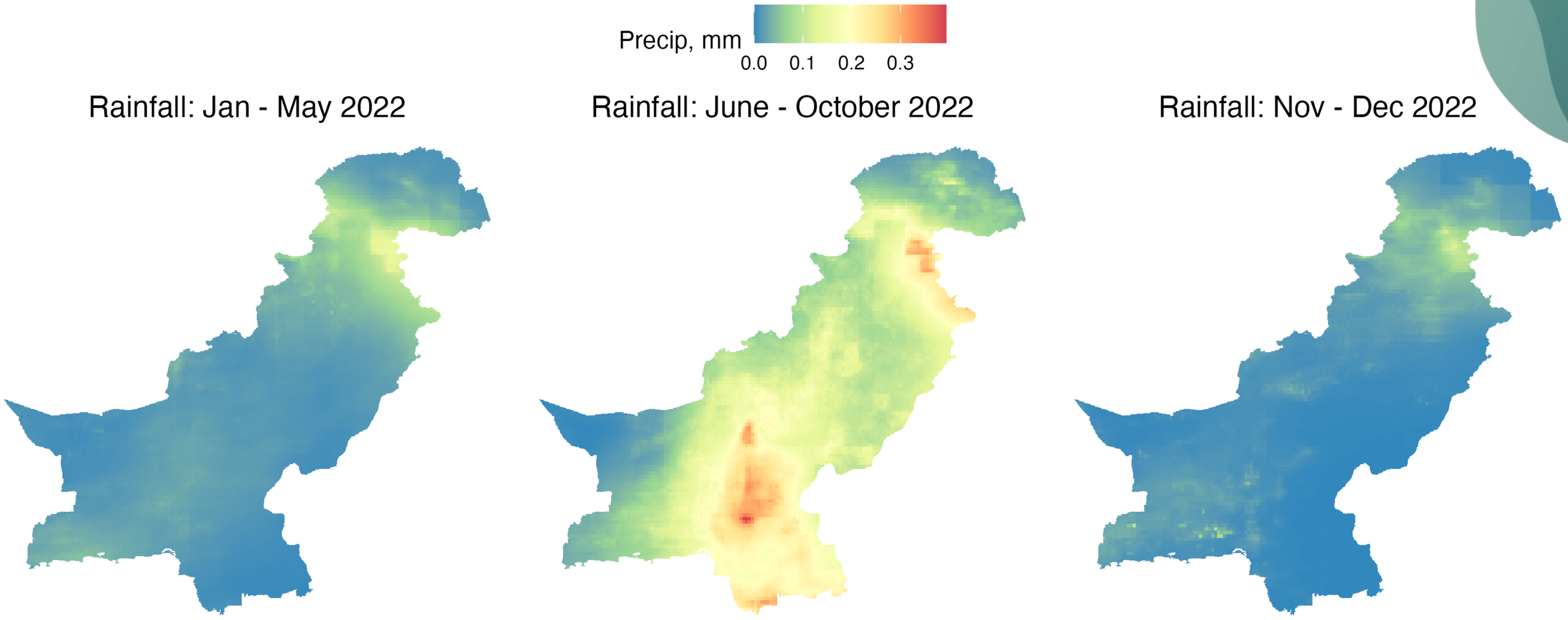
- Building presence and height
- 4m resolution
- Annually, 2016 to 2023



Magnitude of Flooding



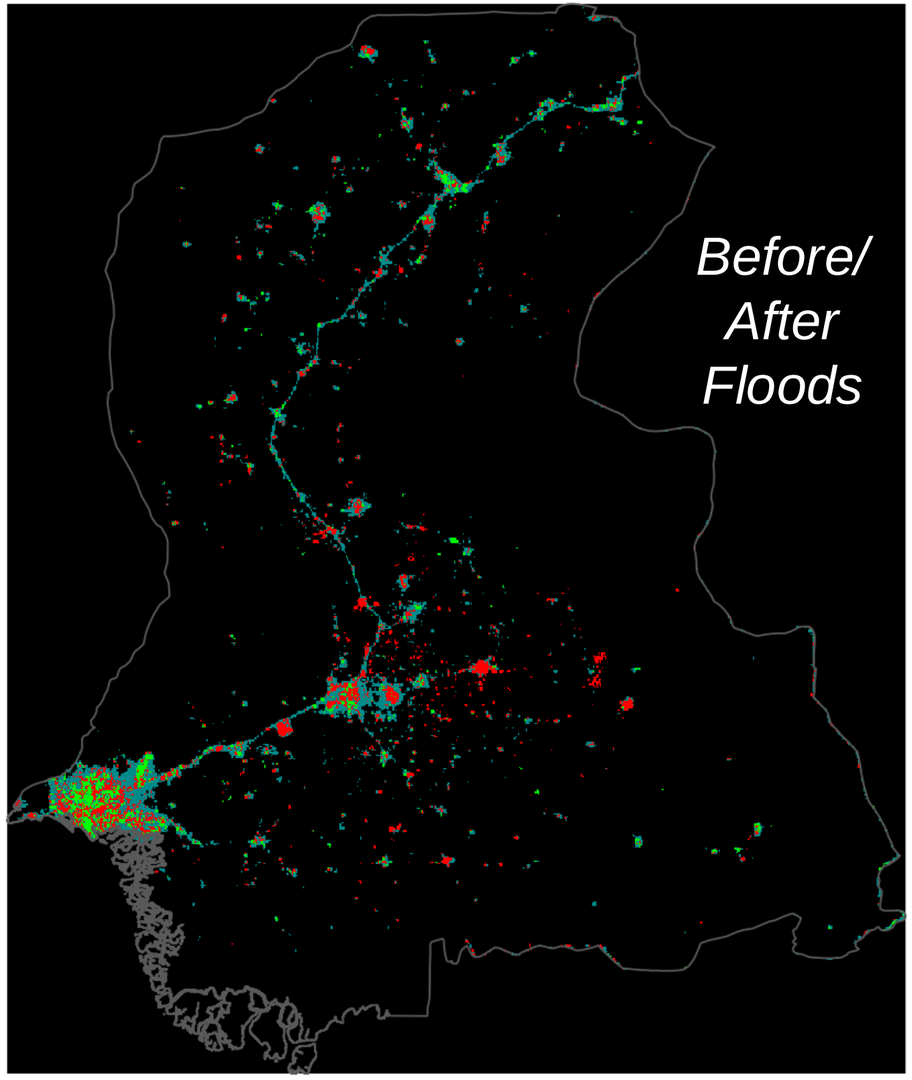
Magnitude of Flooding



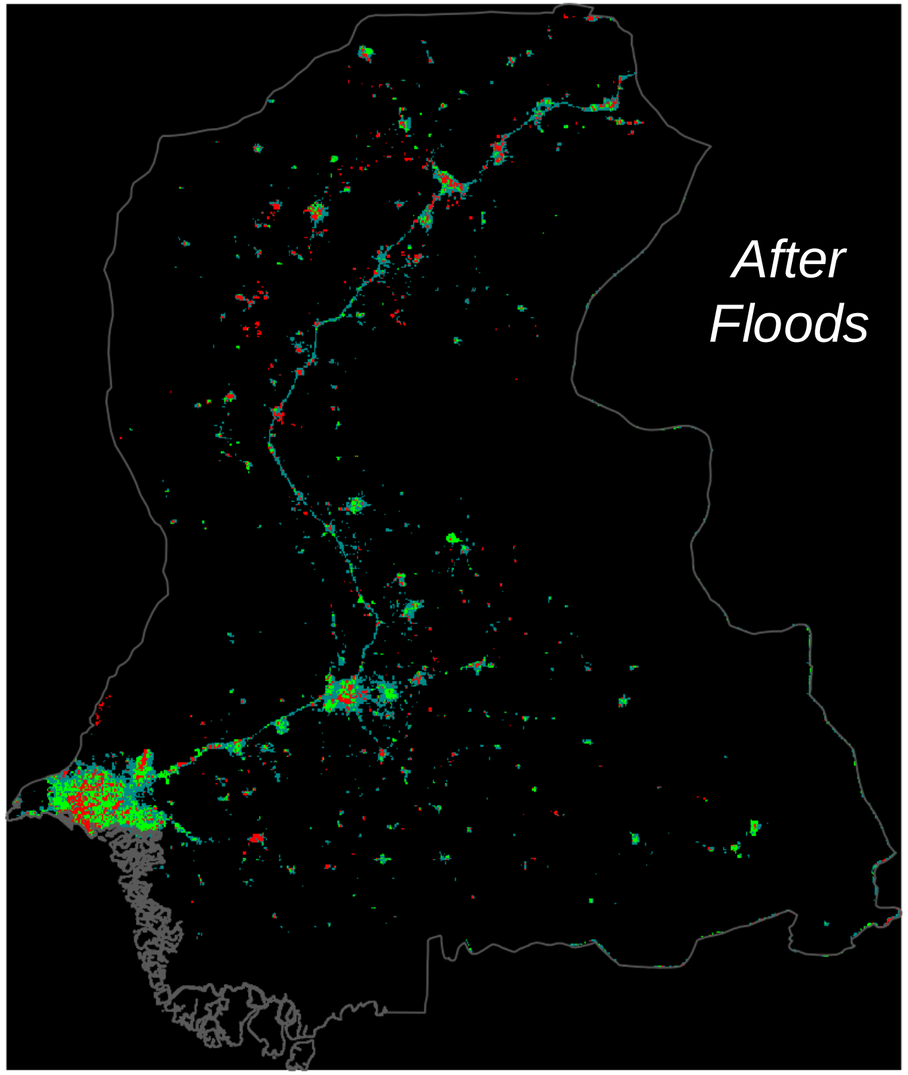
Descriptive Analysis

Impacts & Recovery from 2022 Pakistan Floods

Change in Nighttime Lights
Nov & Dec: 2021 to 2022



Change in Nighttime Lights
Nov & Dec: 2022 to 2023

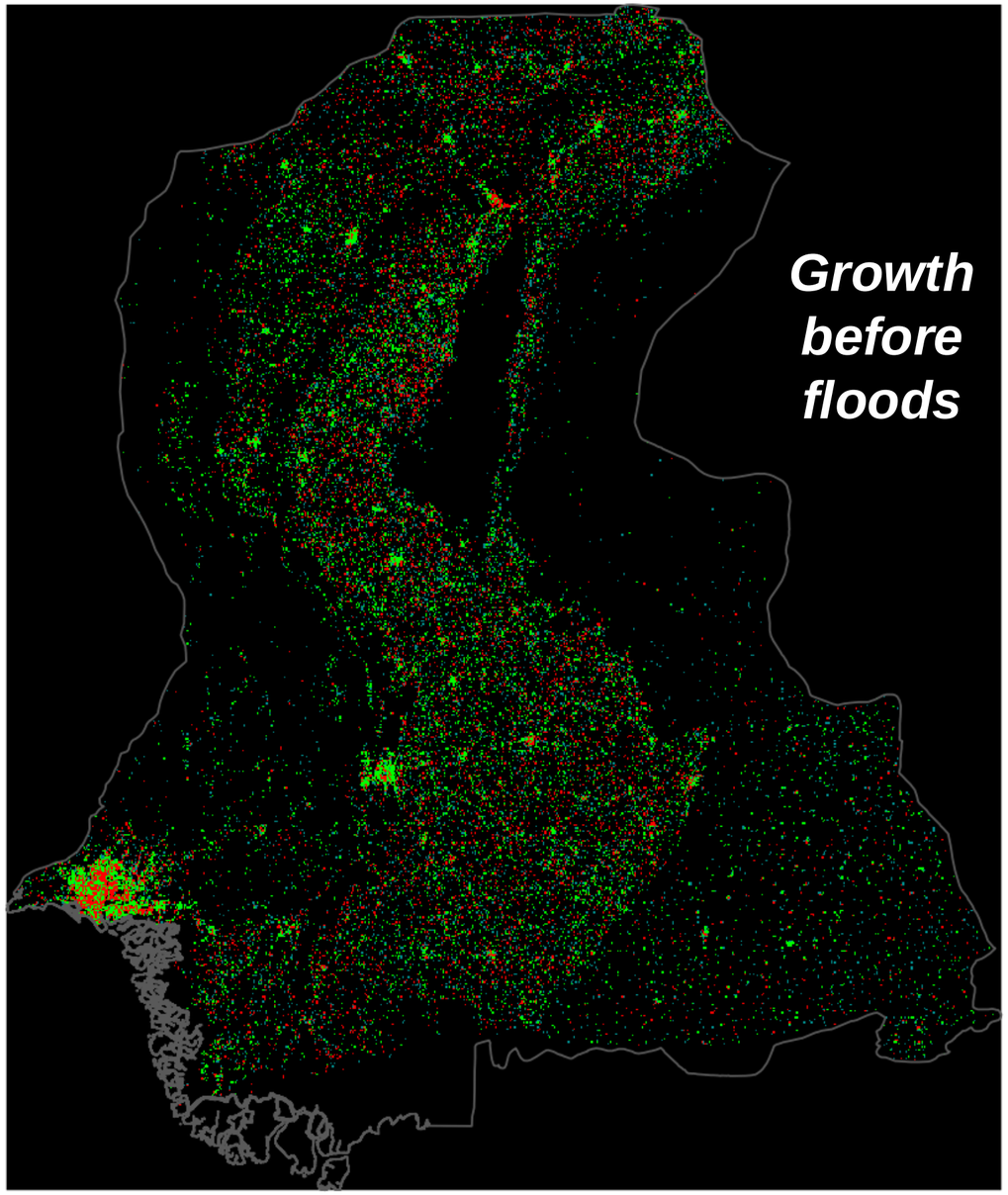


Decrease

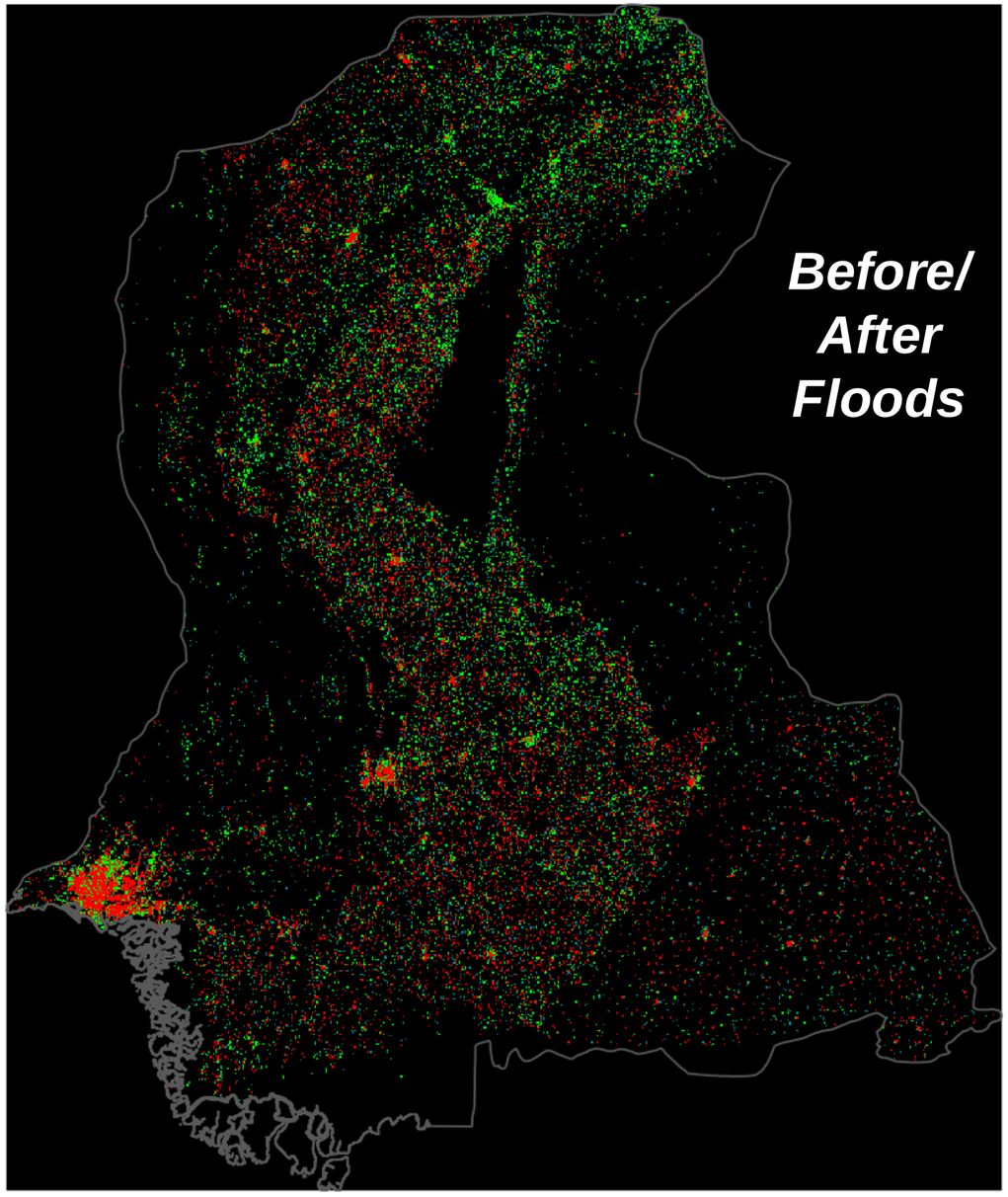
Increase

No Change

Change in Building Height Index 2019 to 2021



Change in Building Height Index 2021 to 2023

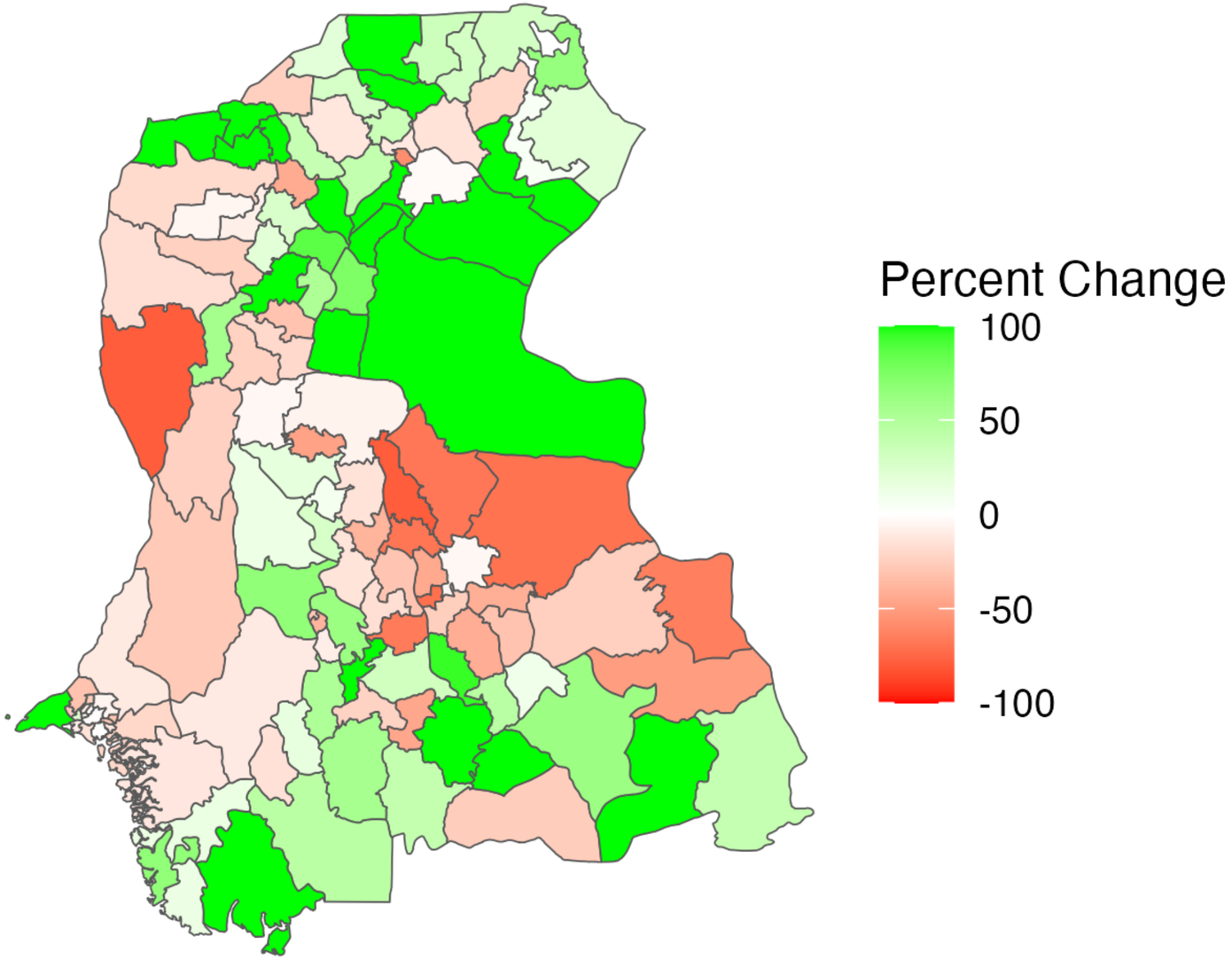


Decrease

Increase

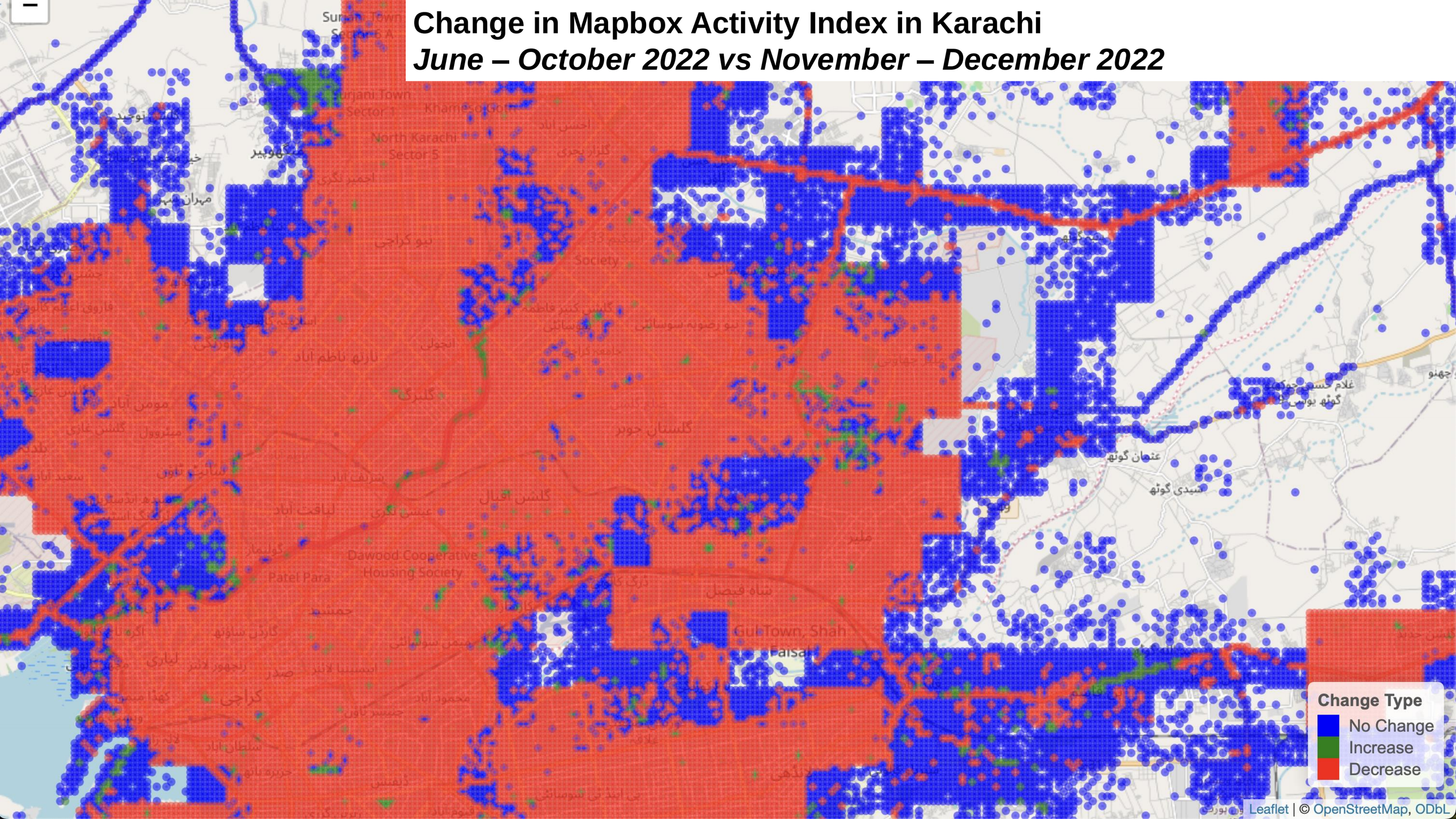
No Change

Change in Mapbox Activity Index in Sindh
June – October 2022 vs November – December 2022



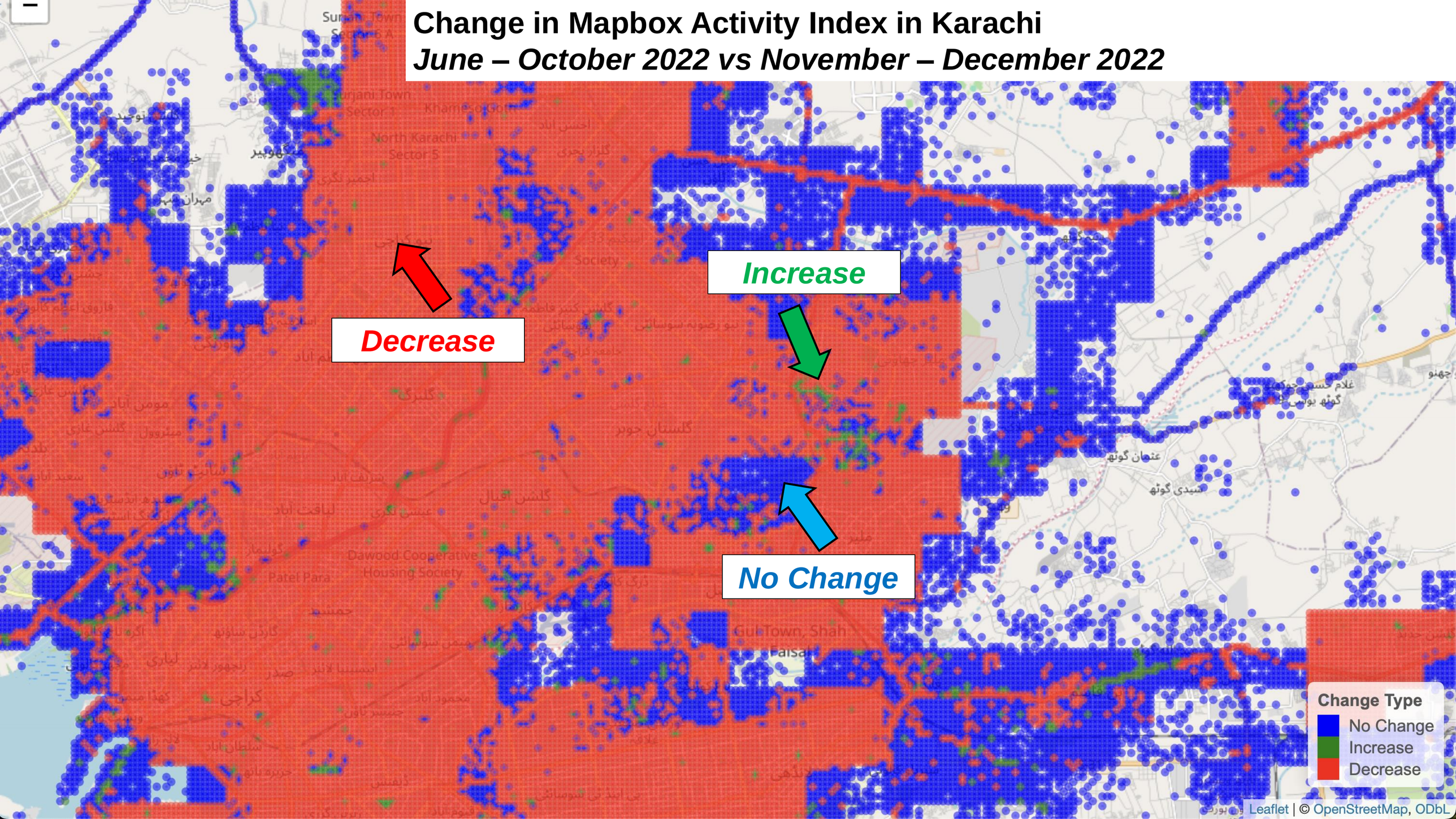
Change in Mapbox Activity Index in Karachi

June – October 2022 vs November – December 2022



Change in Mapbox Activity Index in Karachi

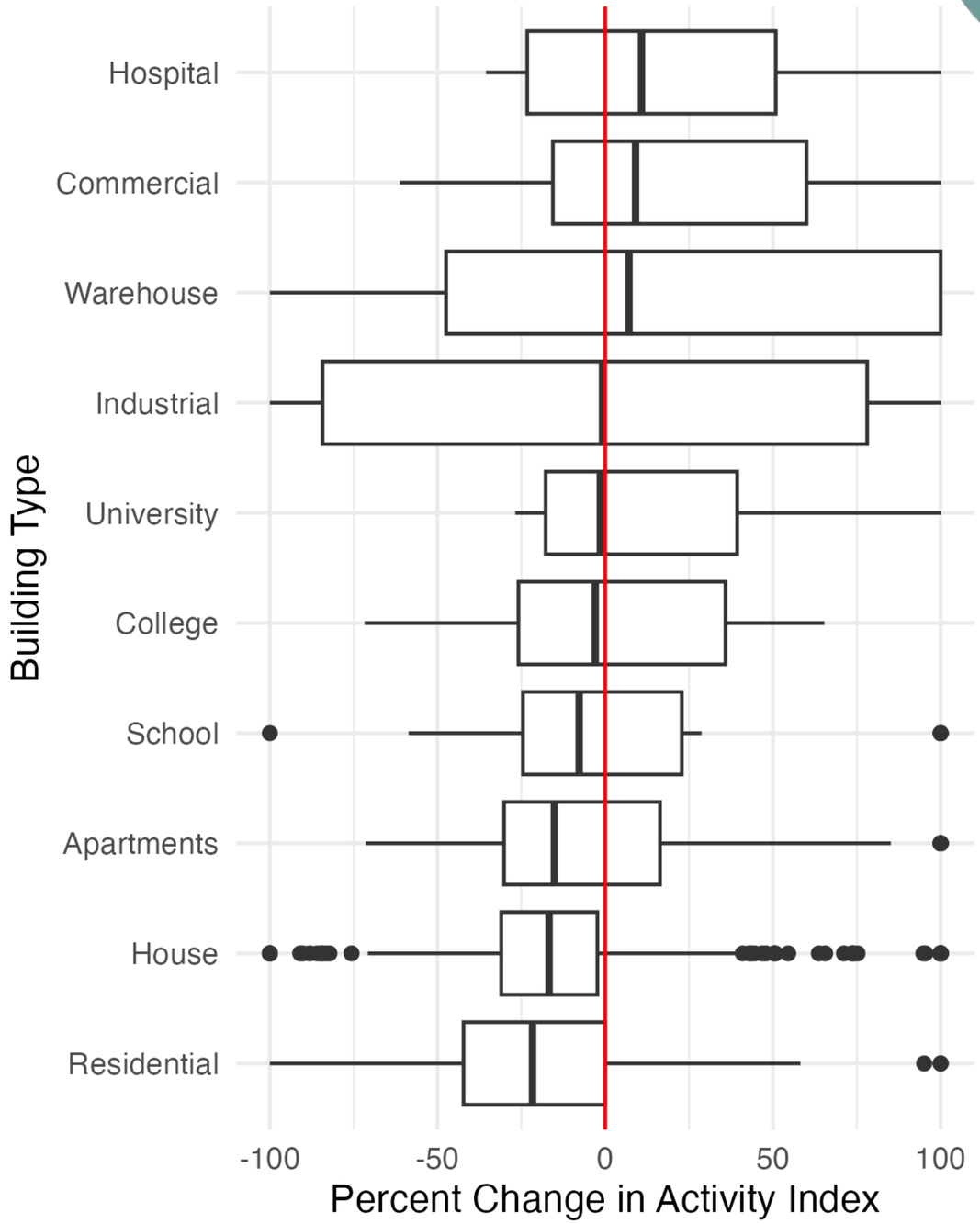
June – October 2022 vs November – December 2022



Change in Mapbox Activity Index by Building Type in Sindh

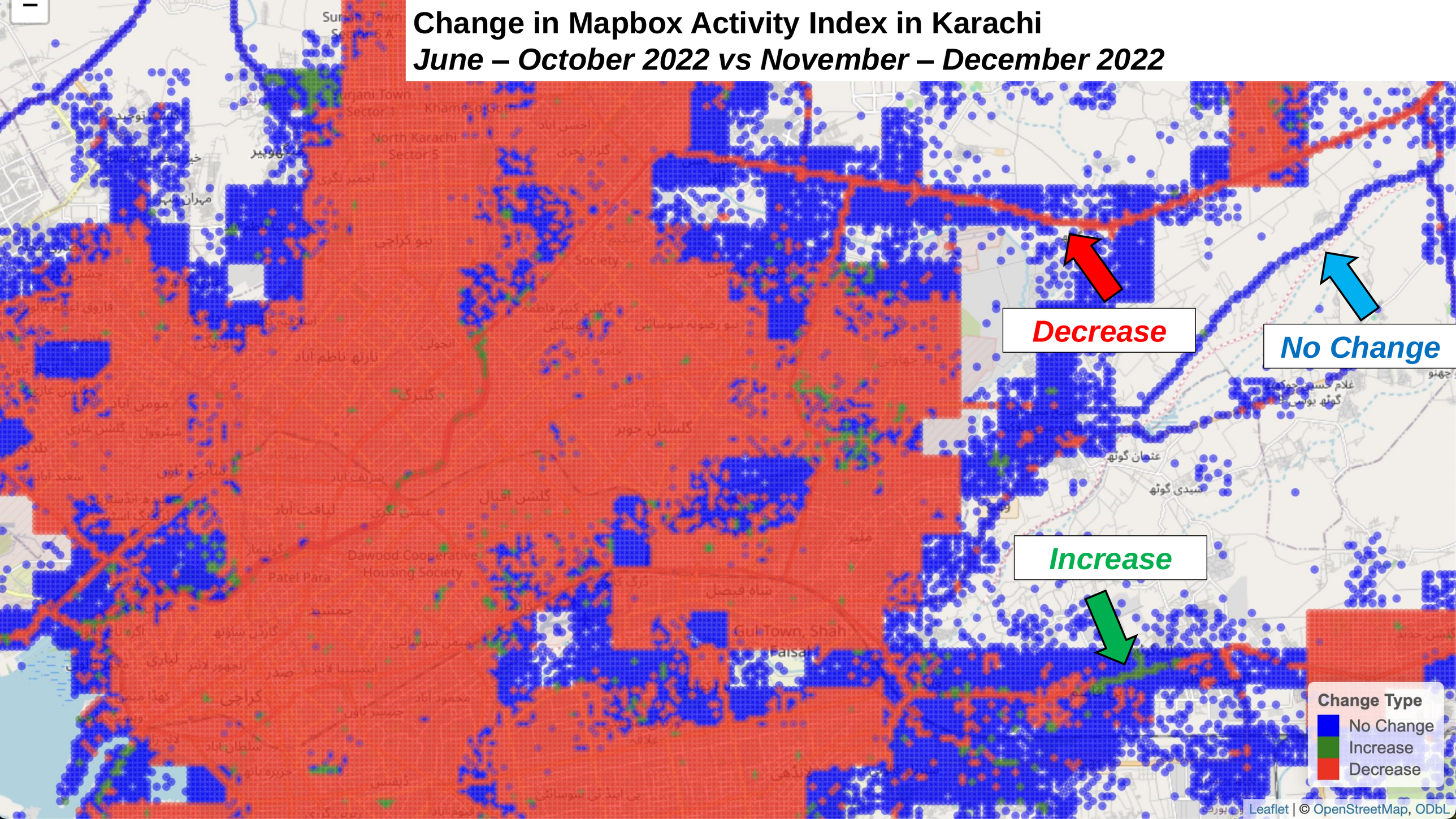
June – October 2022 vs
November – December 2022

Building data from OpenStreetMaps



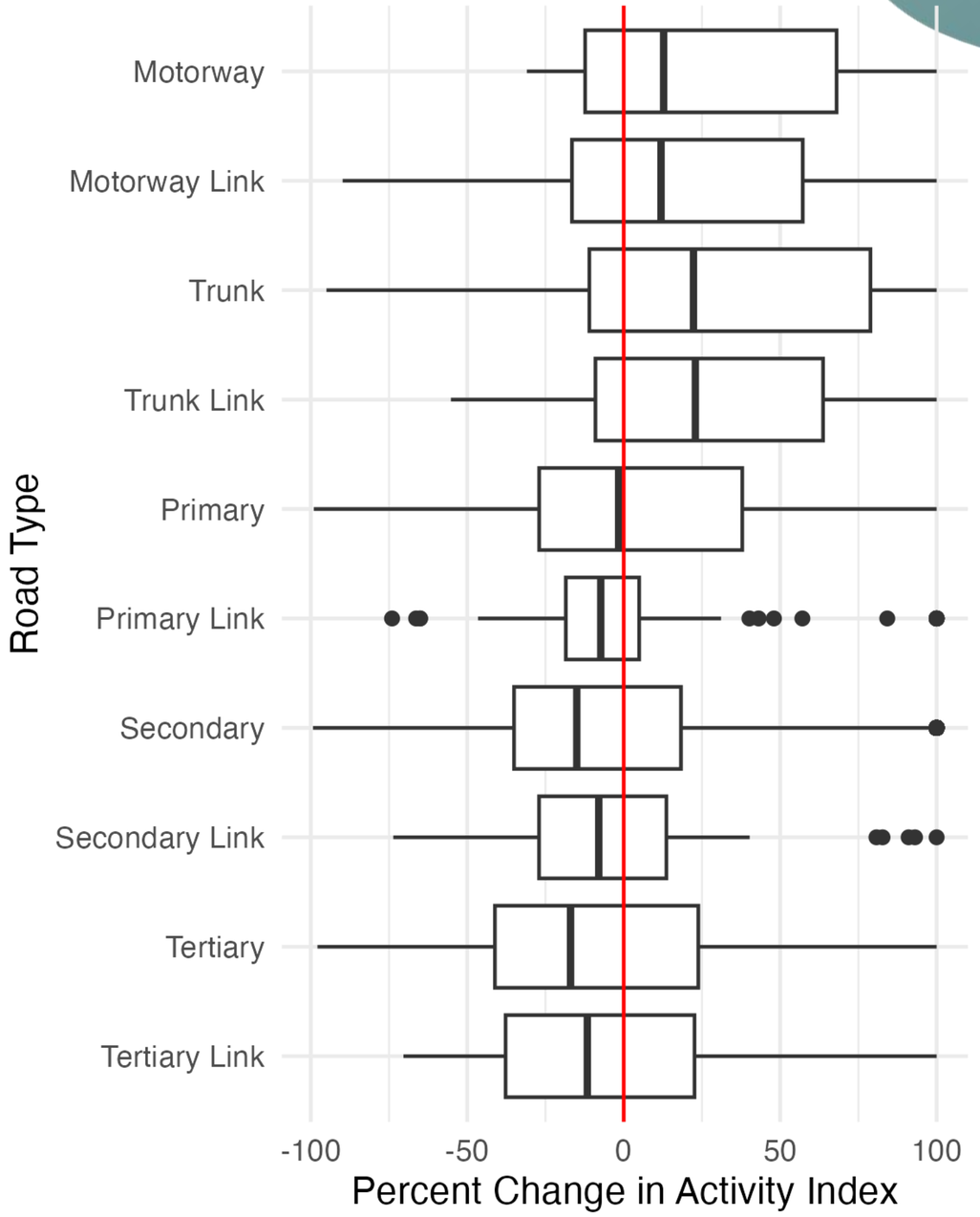
Change in Mapbox Activity Index in Karachi

June – October 2022 vs November – December 2022



Change in Mapbox Activity Index by Road Type in Sindh

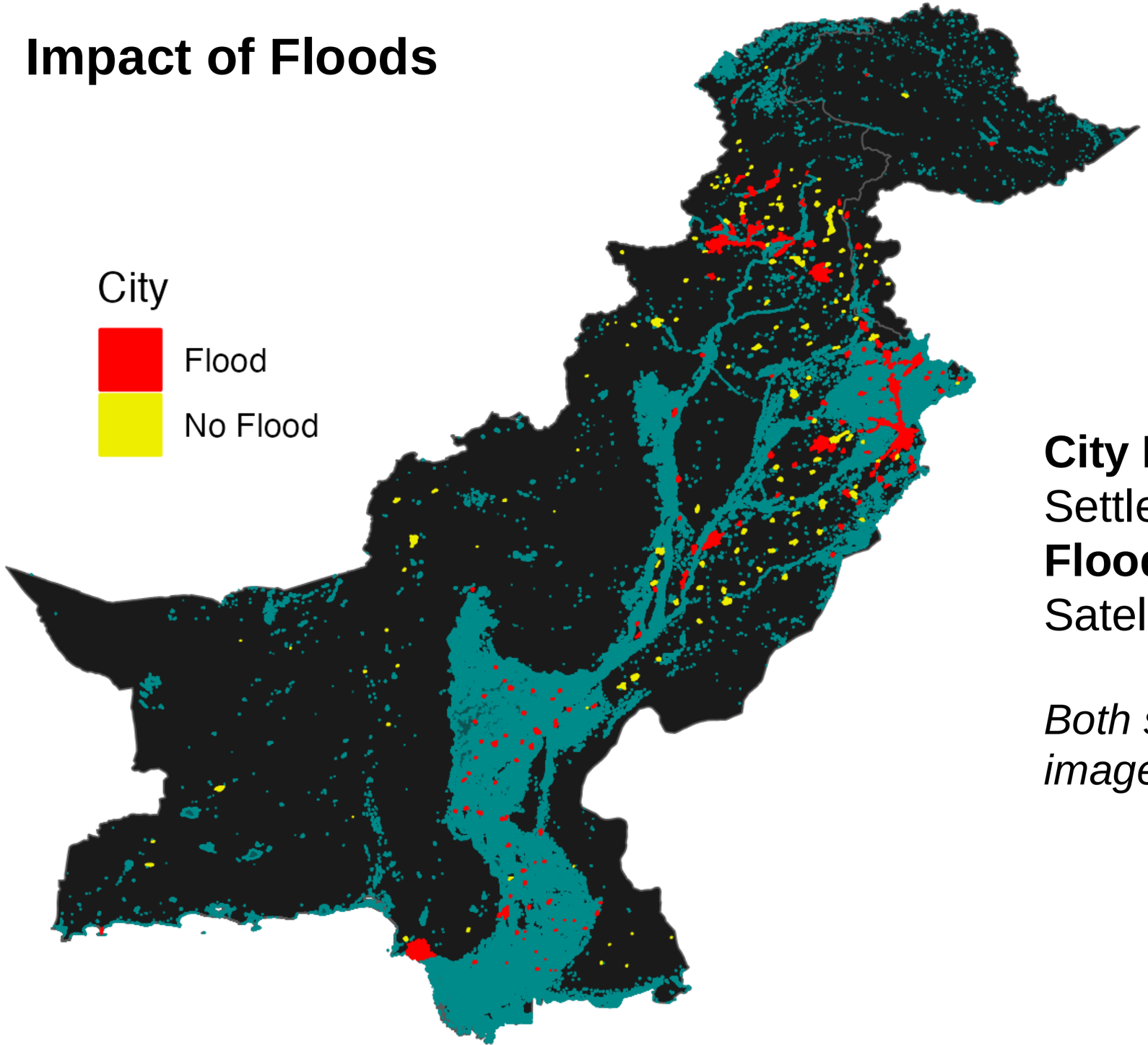
June – October 2022 vs
November – December 2022



Impact of Floods

Difference-in-Difference Analysis

Impact of Floods



City Dataset: Global Human Settlement Layer [N = 301]
Flooding Extent: United Nations Satellite Centre

Both sources derived from satellite imagery

Impact of Floods

$$Y_{it} = \beta_0 + \beta_1 Treatment_i + \beta_2 Post_t + \beta_3 (Treatment_i \times Post_t) + \gamma_i + \delta_t + \epsilon_{it}$$

Annual

- ***Variables:*** Buildings, NTL
- ***Pre:*** Through 2021
- ***Post:*** 2023

Monthly

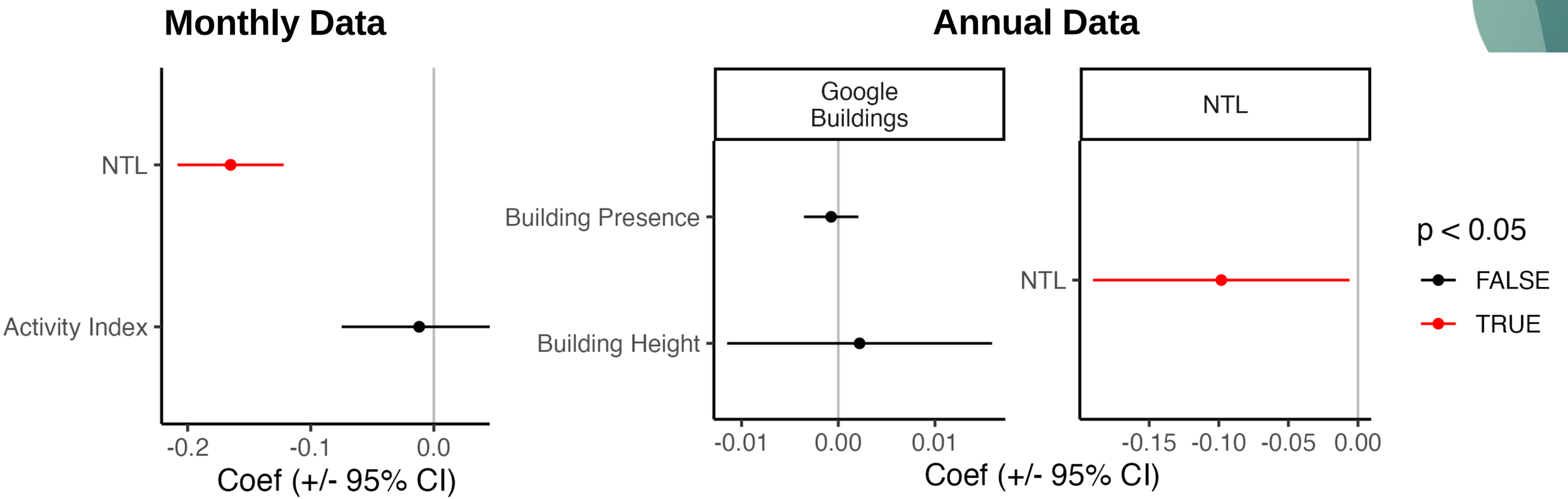
- ***Variables:*** Activity, NTL
- ***Pre:*** Through May 2022
- ***Post***
  - June 2022 onwards
  - June – Oct 2022
  - Nov – Dec 2022
  - …
  - May – June 2024

Interaction

- Baseline nighttime lights (below/above median lights)

Impact of Floods

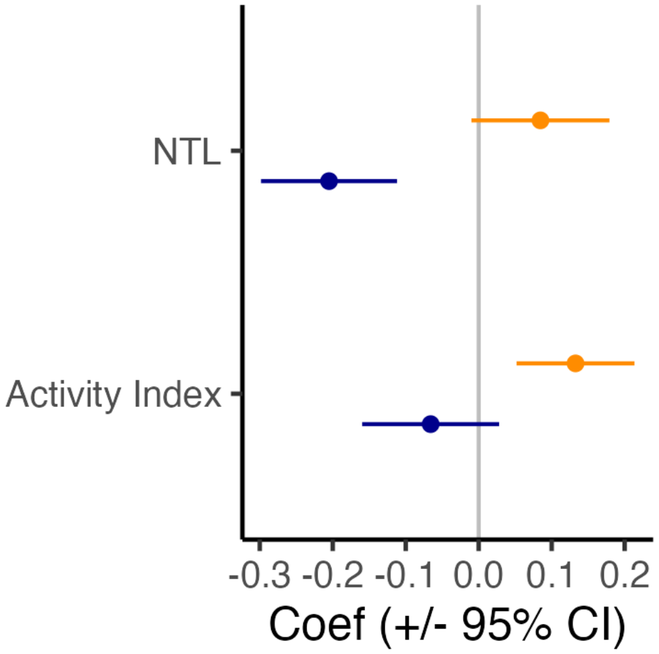
Post: June 2022 onwards



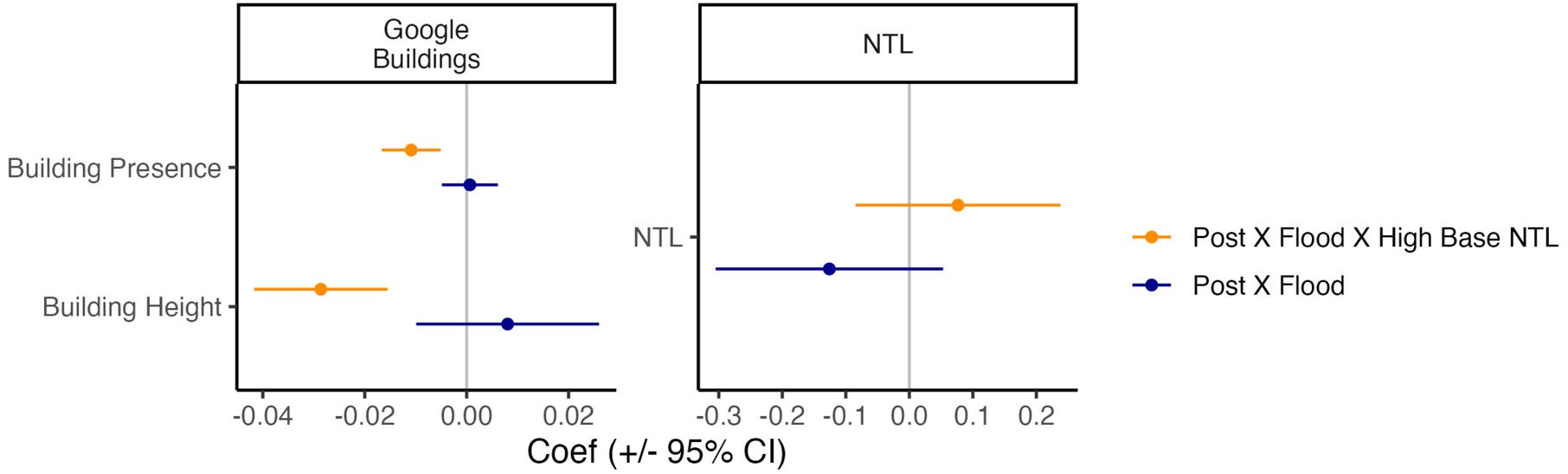
Impact of Floods

Post: June 2022 onwards

Monthly Data

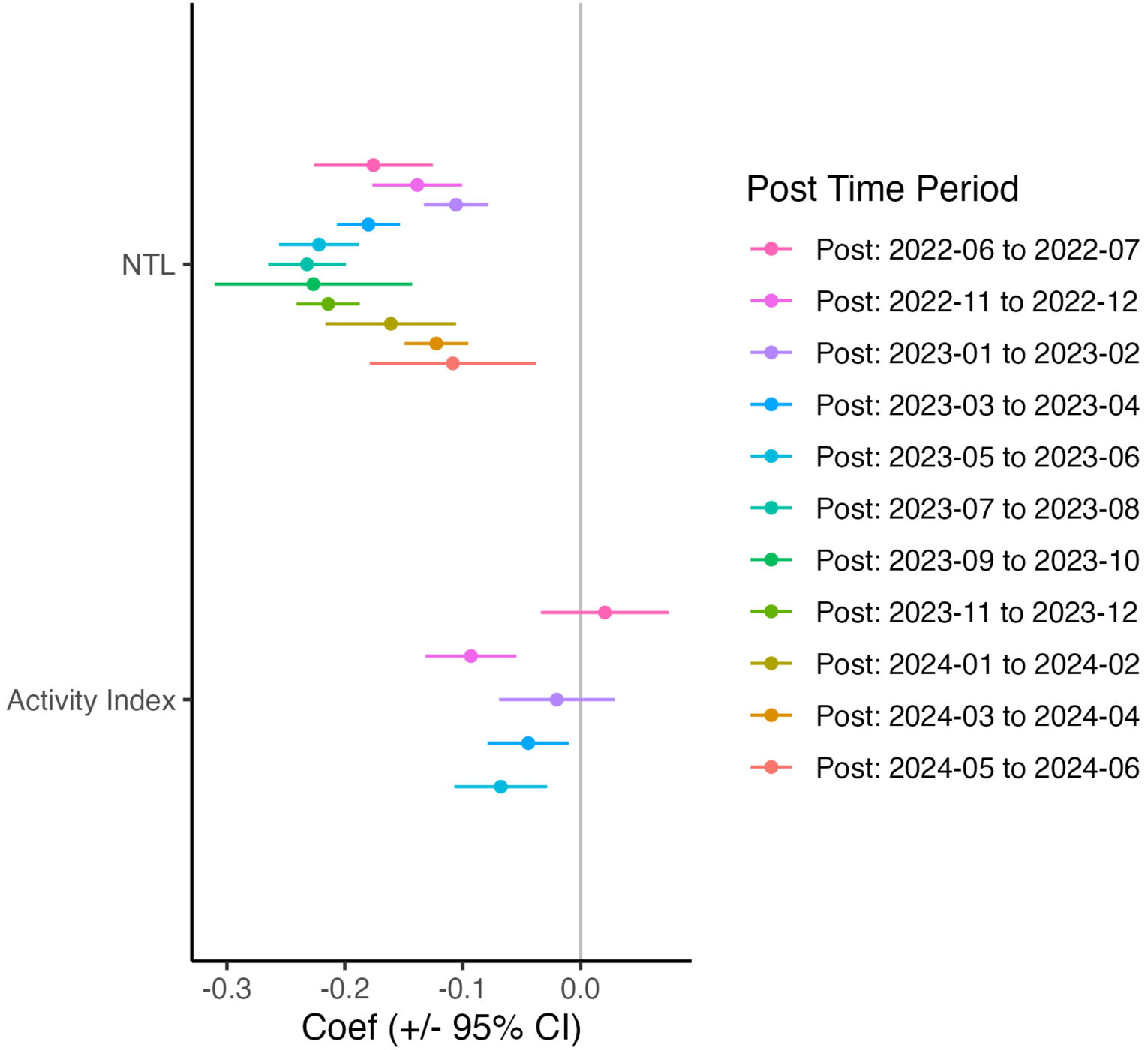


Annual Data



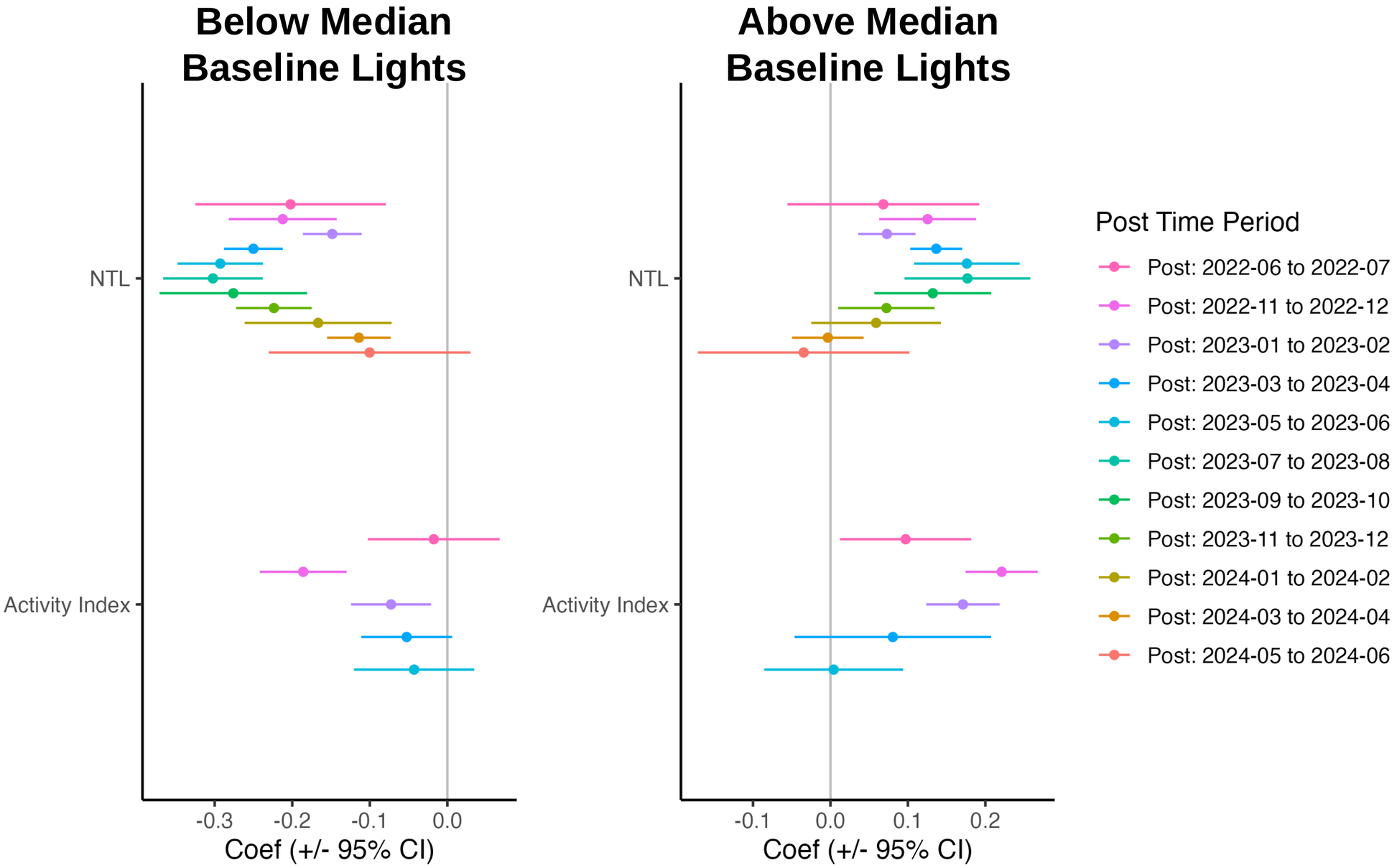
Impact of Floods

Post: Bi-Monthly



Impact of Floods

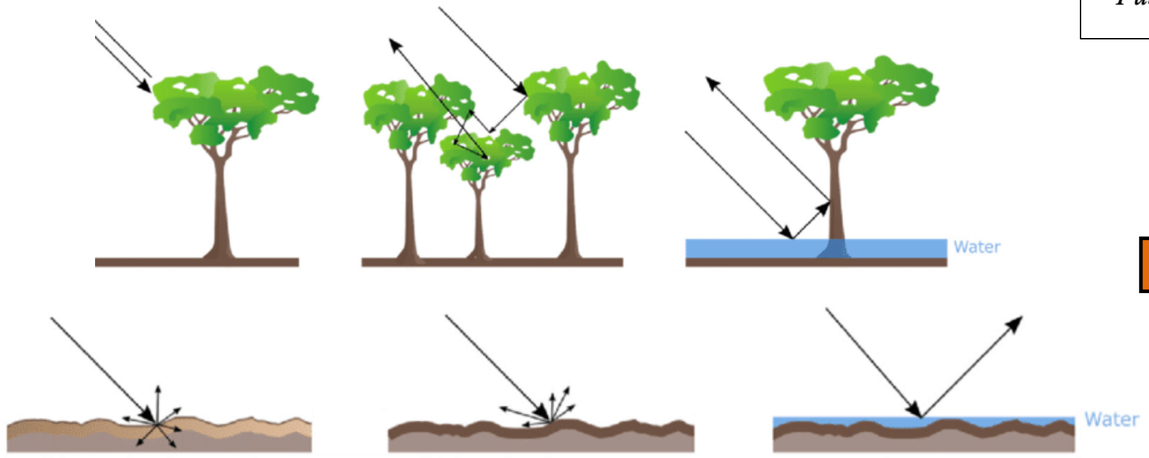
Post: Bi-Monthly



Road Damage Assessment & Impact on Market Access

Damage assessment using synthetic aperture radar (SAR) imagery from Sentinel-1

- **Radar data** is active sensor; transmit signals and records signals reflected back to sensor Can see through clouds!
- **Optical data** (eg, nighttime lights) uses passive sensors (receiving signals reflected from earth).



Remote Sens. **2014**, *6*, 4870-4906; doi:10.3390/rs6064870

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remote sensing

ISSN 2072-4292

www.mdpi.com/journal/remotesensing

Review

Rapid Damage Assessment by Means of Multi-Temporal SAR — A Comprehensive Review and Outlook to Sentinel-1

Simon Plank

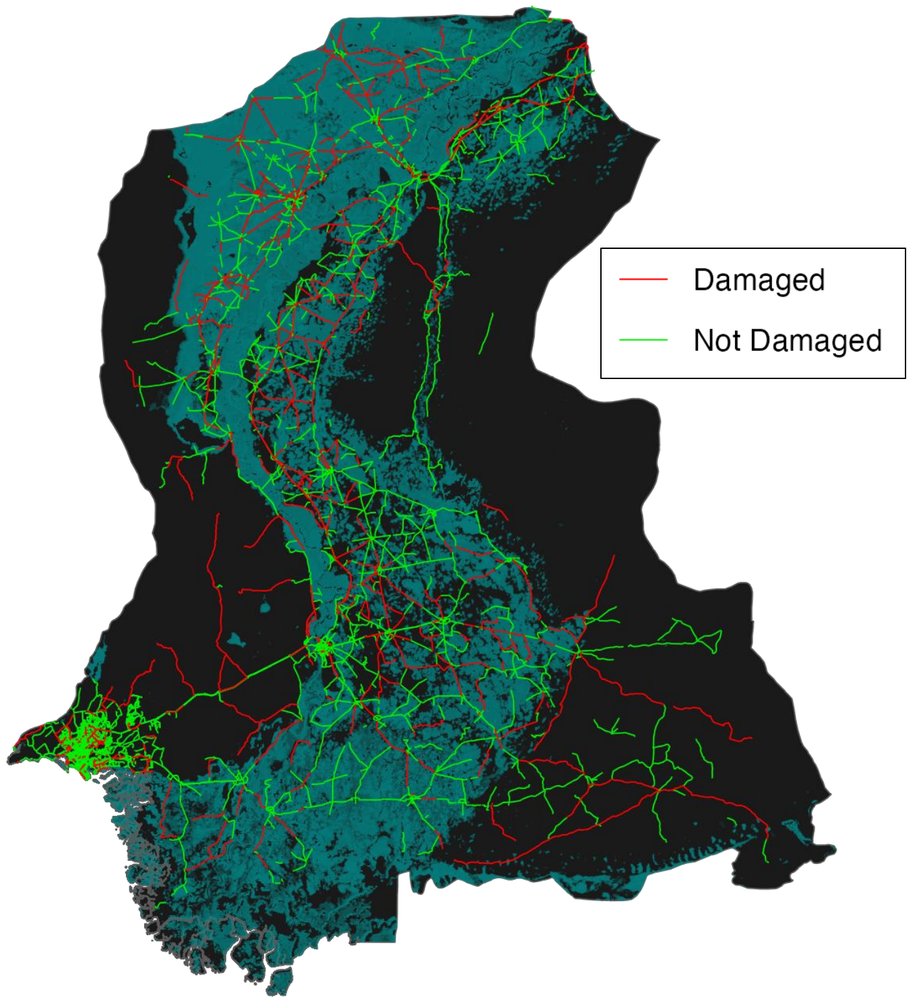
German Remote Sensing Data Center (DFD), German Aerospace Center (DLR), D-82234 Oberpfaffenhofen, Germany; E-Mail: simon.plank@dlr.de; Tel.: +49-8153-28-3460; Fax: +49-8153-28-1445

Received: 29 March 2014; in revised form: 20 May 2014 / Accepted: 20 May 2014 / Published: 28 May 2014

- Different surfaces, different signal received by sensor
- Compare data from before & after floods -> detect locations with changes

Damage assessment using synthetic aperture radar (SAR) imagery from Sentinel-l

Preliminary results



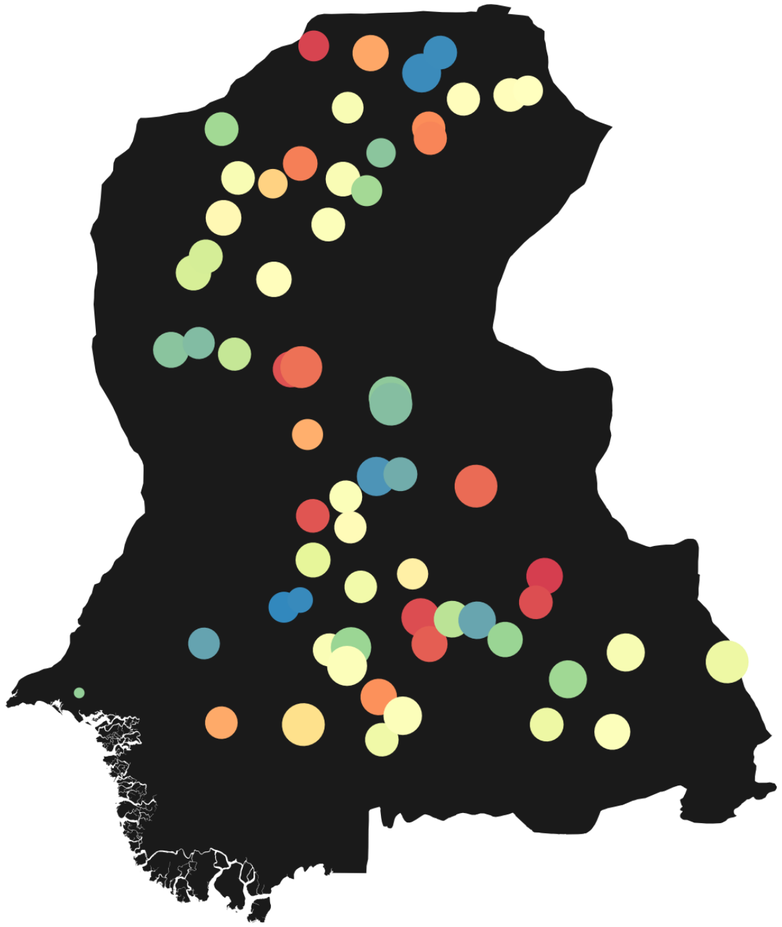
Analysis of tertiary and larger roads shows
5877 km of roads damaged

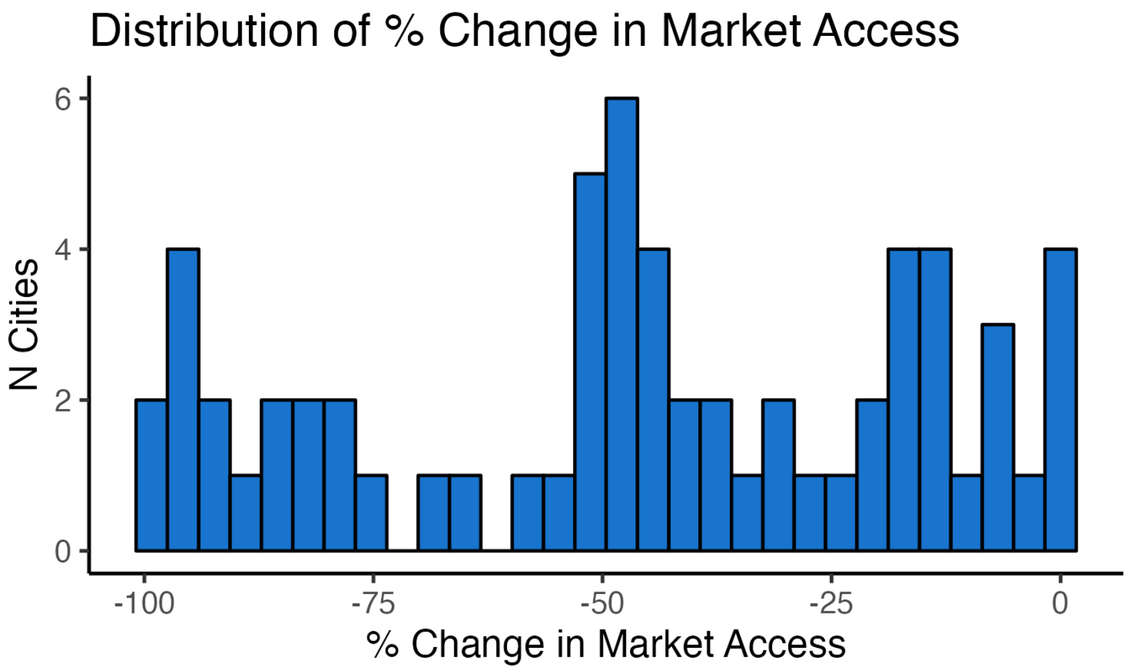
	Class	Length, Total (km)	Length, Damaged (km)	% Damaged
1	Motorway	595	133	22.36%
2	Trunk	3135	1480	47.2%
3	Primary	3374	1182	35.03%
4	Secondary	3835	1130	29.48%
5	Tertiary	7553	1952	25.85%

Damage assessment using synthetic aperture radar (SAR) imagery from Sentinel-I

Preliminary results

$$MA_{i,t} = \sum_{j,\ j \neq i} ntl_j \times tt_{ij,t}^{-\theta},$$



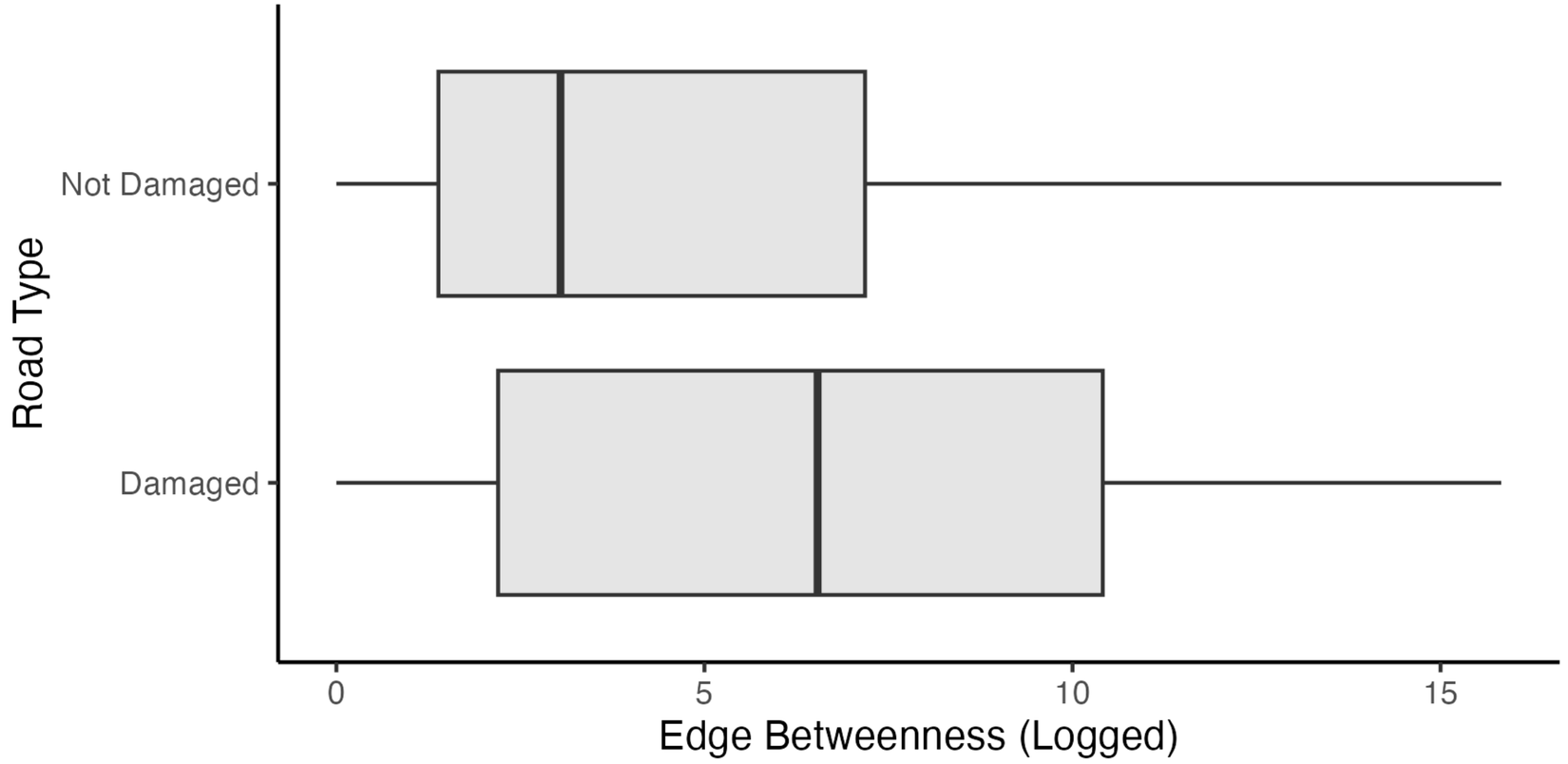


Damage assessment using synthetic aperture radar (SAR) imagery from Sentinel-l

Preliminary results

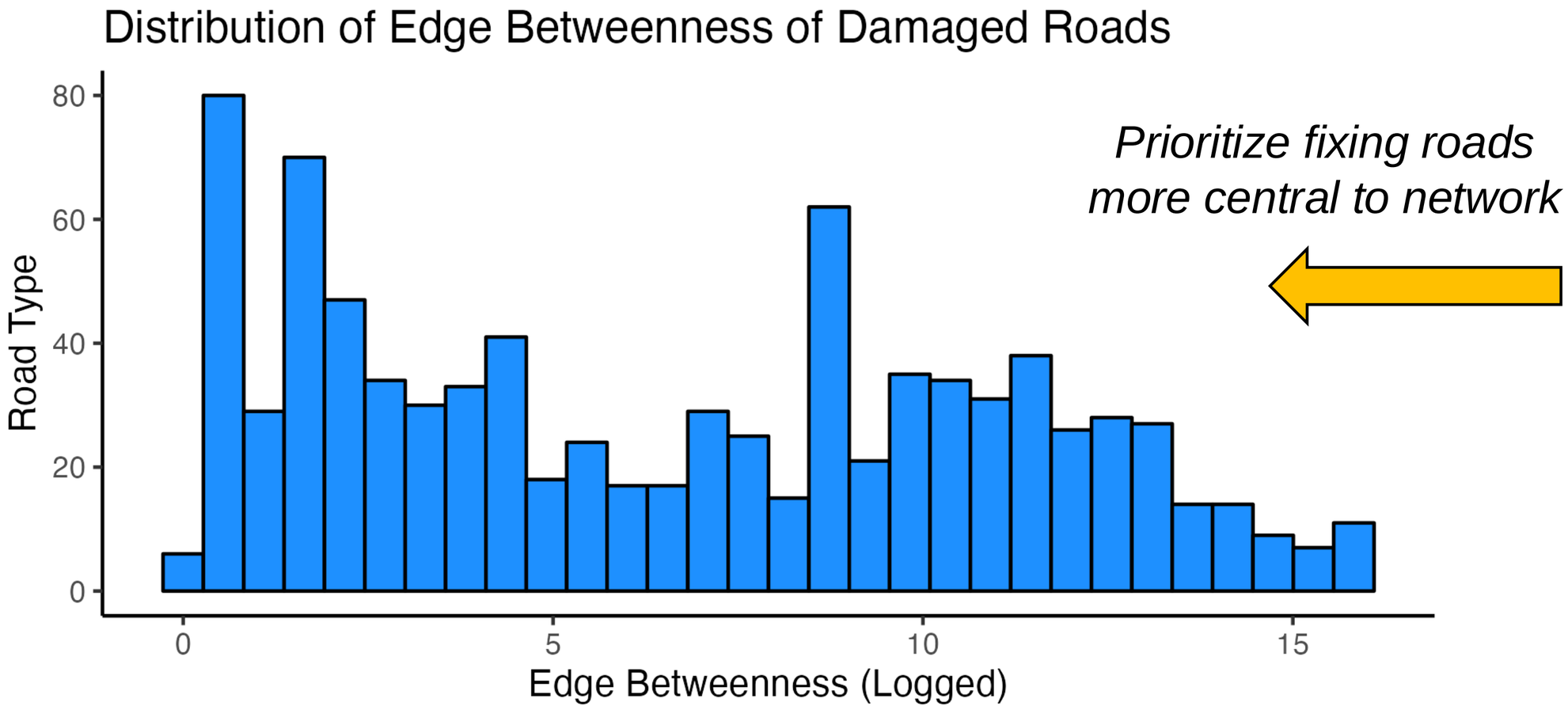
Edge Betweenness: How many shortest paths cross through a road.

Damaged roads tend to be more important to the network compared to non-damaged roads



Damage assessment using synthetic aperture radar (SAR) imagery from Sentinel-l

Preliminary results



Main Takeaways

- Big data sources can facilitate observing impacts of natural disasters (Pakistan 2022 floods)
- Damage assessment of roads reveals large reduction in market access & can inform prioritizing roads for rehabilitation

Thank you

rmarty@worldbank.org

ieConnect Webpage