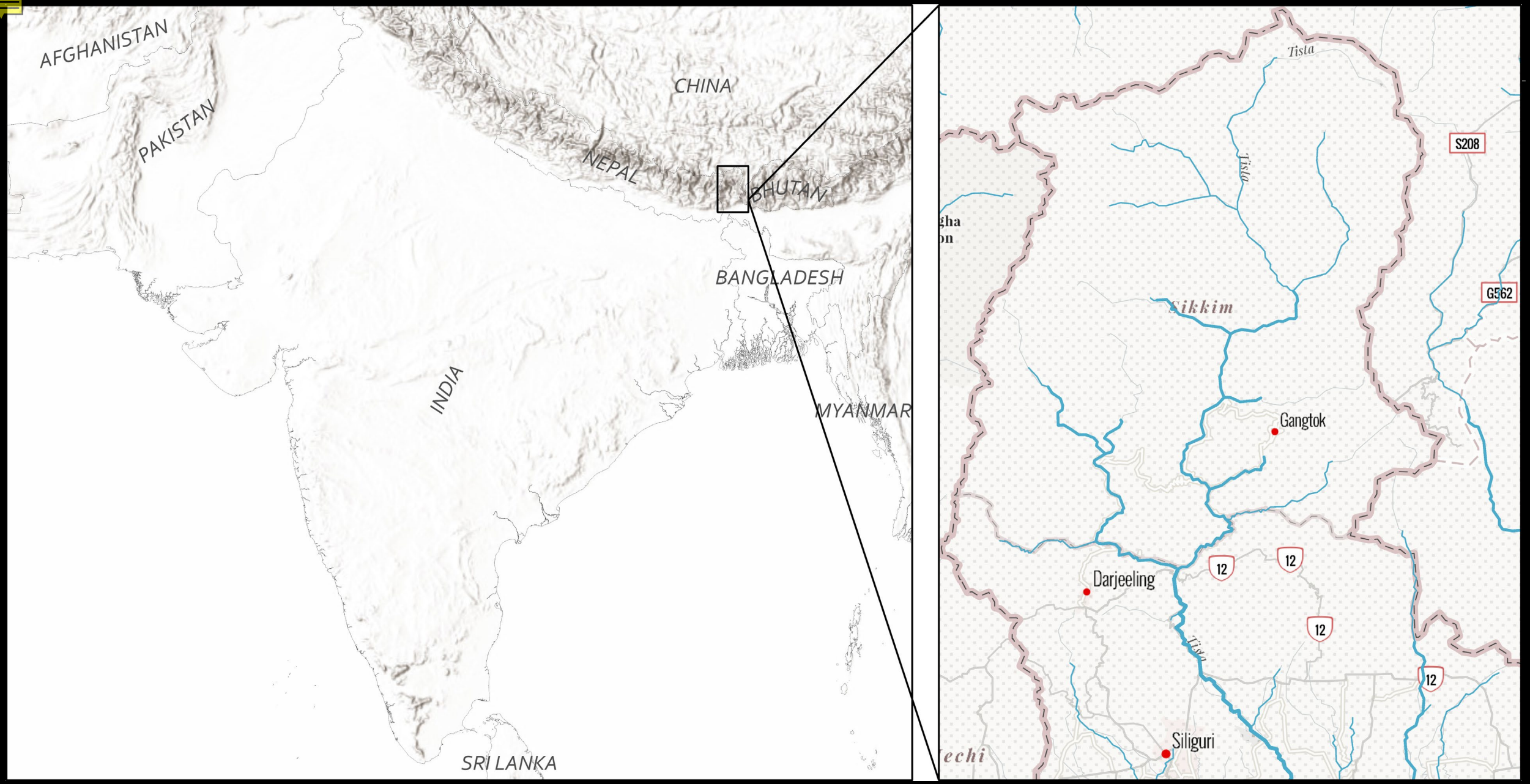
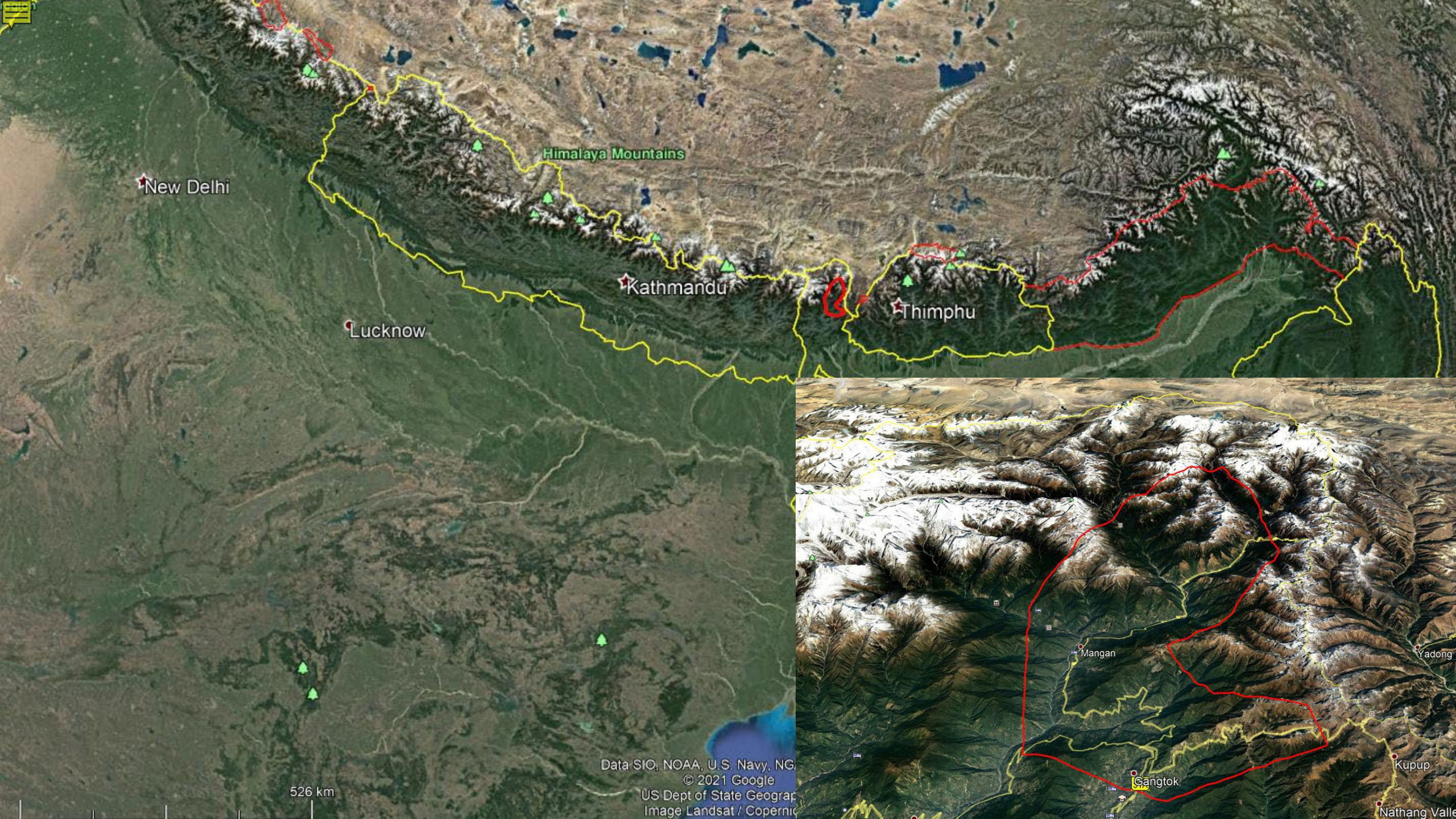
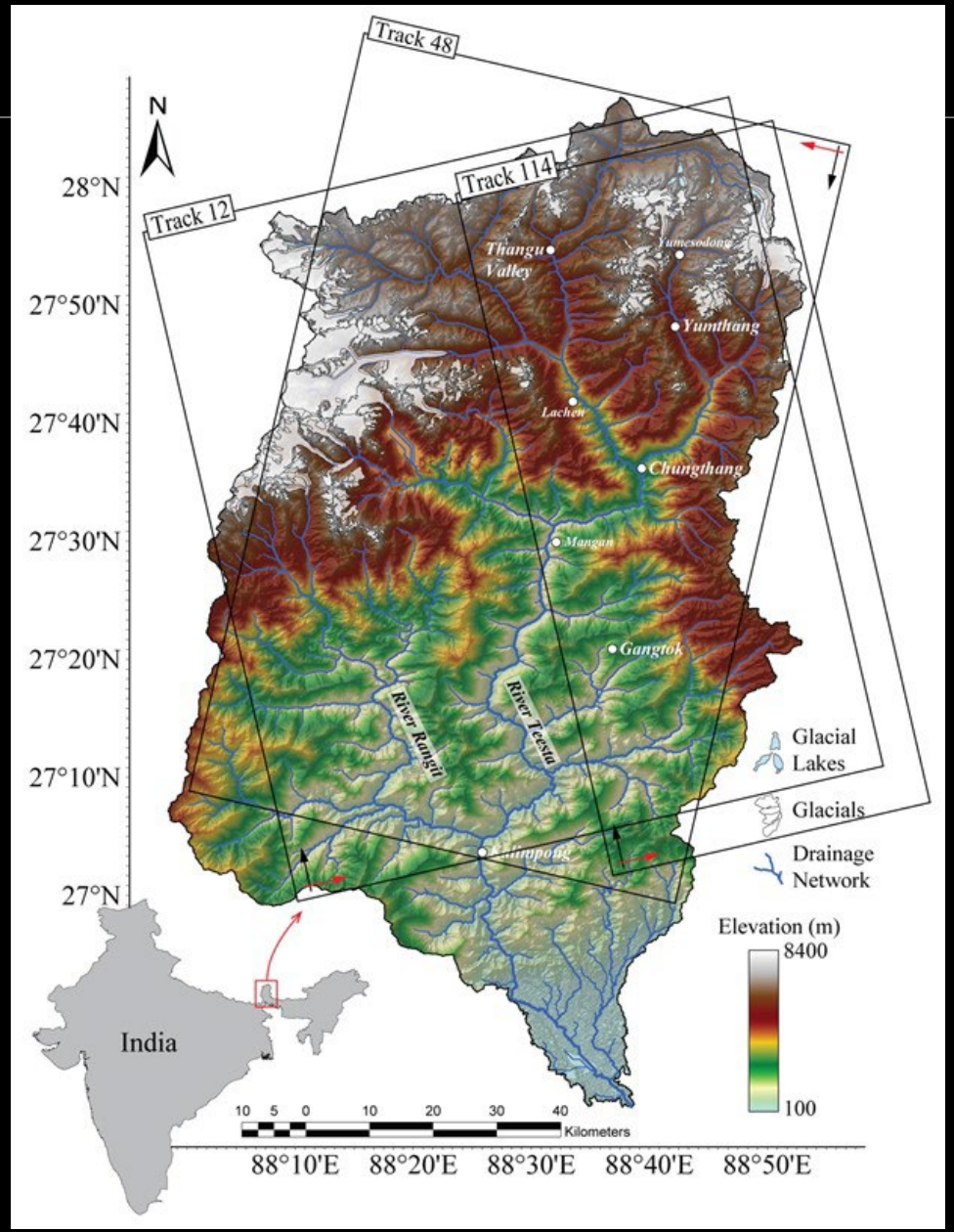
LIVING ON LANDSLIDES IN GANGTOK

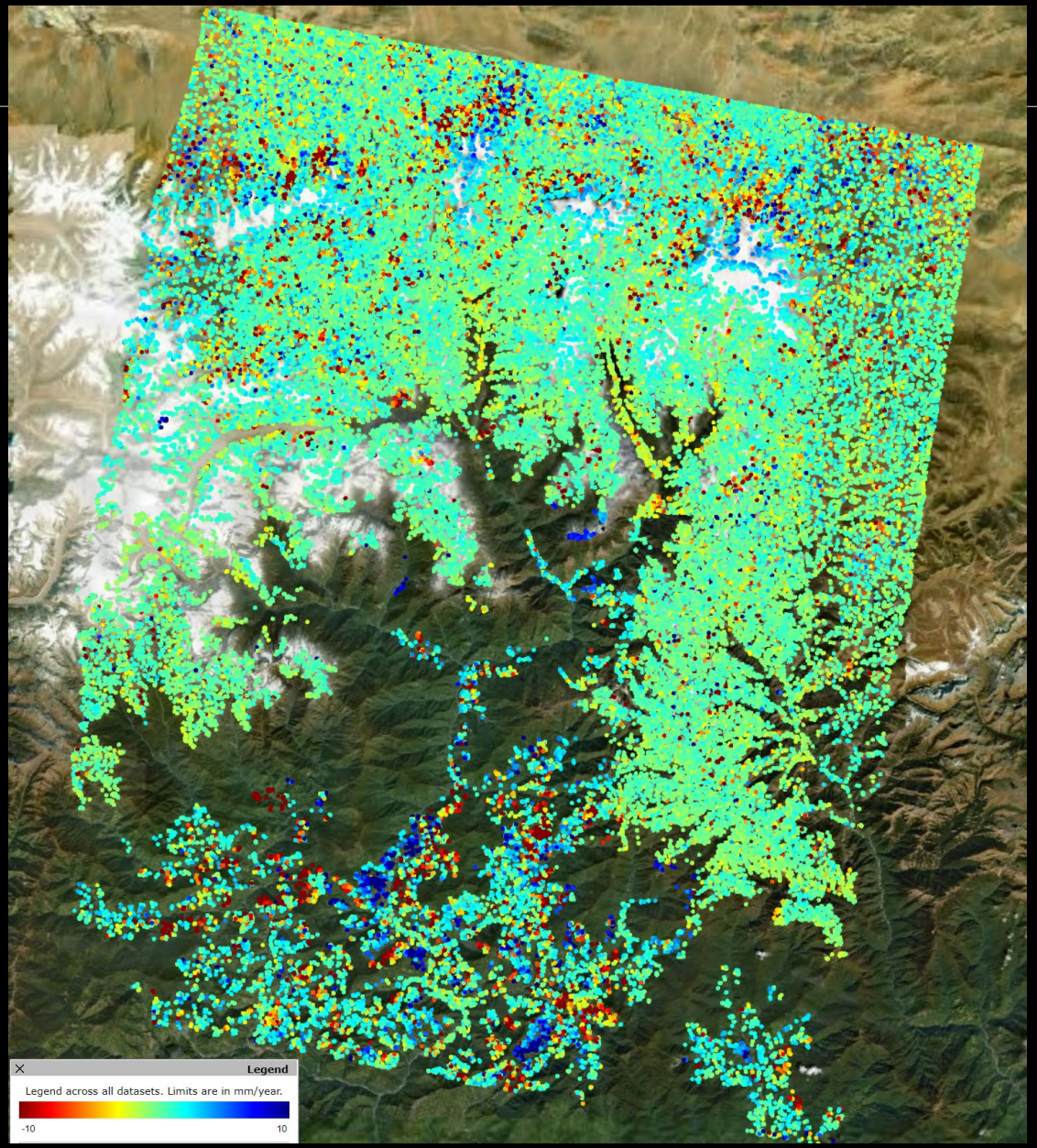
JOHN DEHLS, GEOLOGICAL SURVEY OF NORWAY

RAJINDER BHASIN, NORWEGIAN GEOTECHNICAL INSTITUTE


AFGHANISTAN
PAKISTAN
CHINA
NEPAL
BHUTAN
BANGLADESH
INDIA
MYANMAR
SRI LANKA
Tista
S208
G562
Sikkim
Gangtok
Darjeeling
12
Siliguri

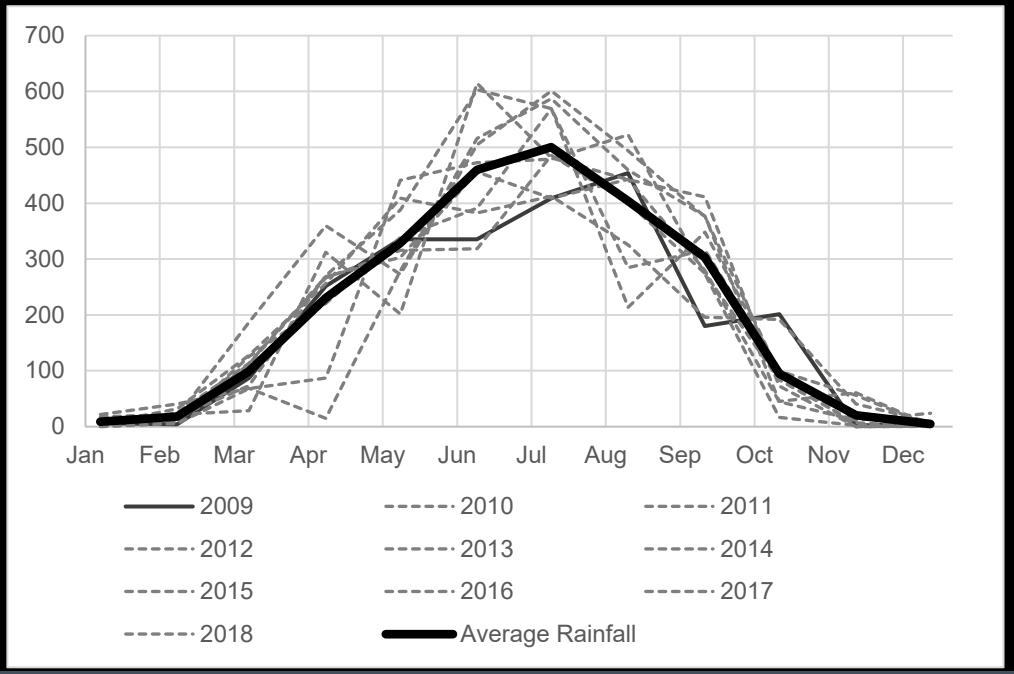

Himalaya Mountains
New Delhi
Kathmandu
Lucknow
Thimphu
Mangan
Yadong
Gangtok
Kupup
Nathang Valle
526 km
Data SIO, NOAA, U.S. Navy, NG
© 2021 Google
US Dept of State Geograp
Image Landsat / Copernic

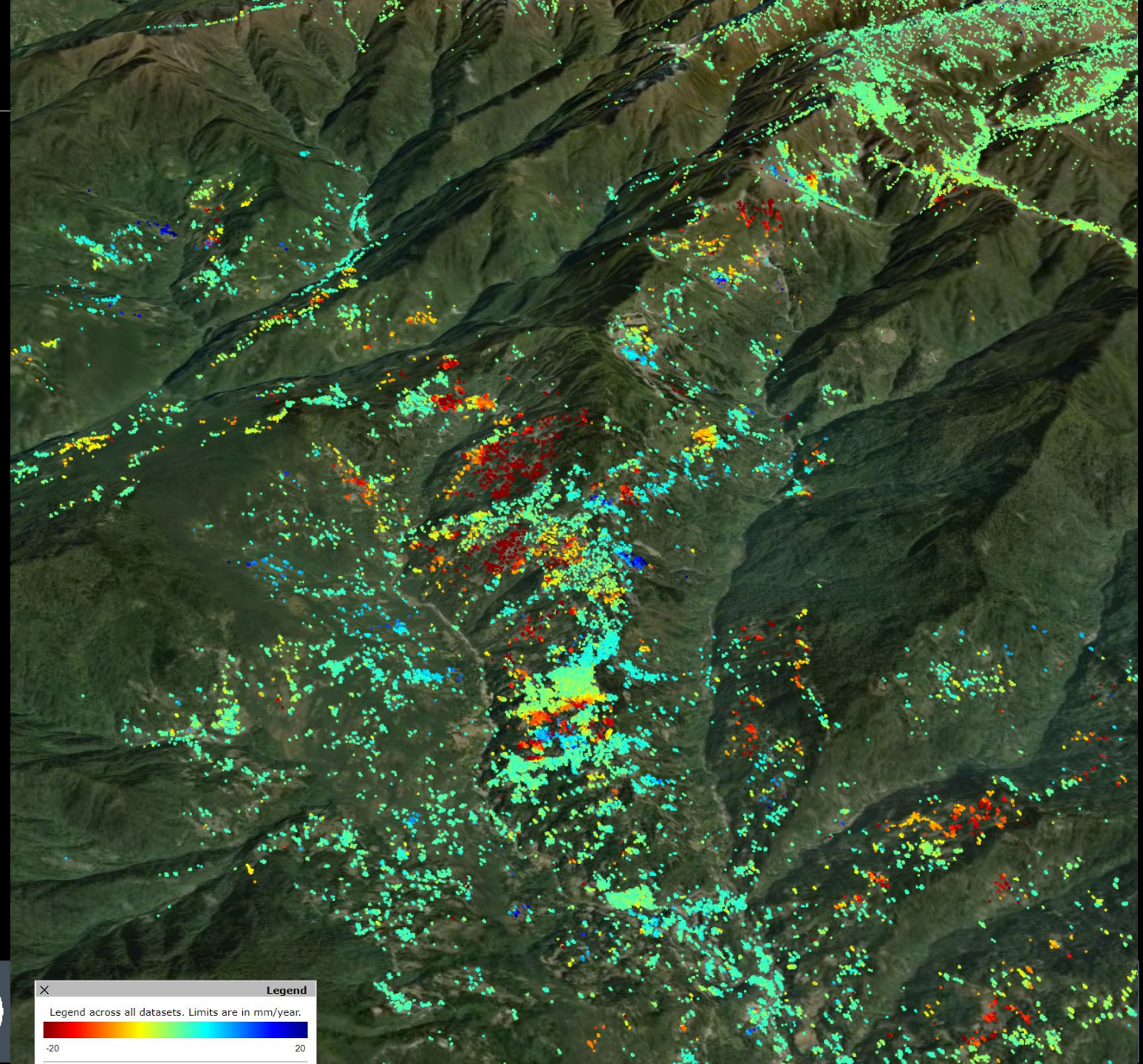

Track 48
Track 114
Track 12
N
28°N
27°50'N
27°40'N
27°30'N
27°20'N
27°10'N
27°N
Thangu Valley
Yumesodong
Yumthang
Lachen
Chungthang
Mangan
Gangtok
River Rangit
River Teesta
Glacial Lakes
Glacials
Drainage Network
Elevation (m)
8400
100
India
10 5 0 10 20 30 40
Kilometers
88°10'E
88°20'E
88°30'E
88°40'E
88°50'E


Legend
Legend across all datasets. Limits are in mm/year.
-10
10

Gangtok, Sikkim

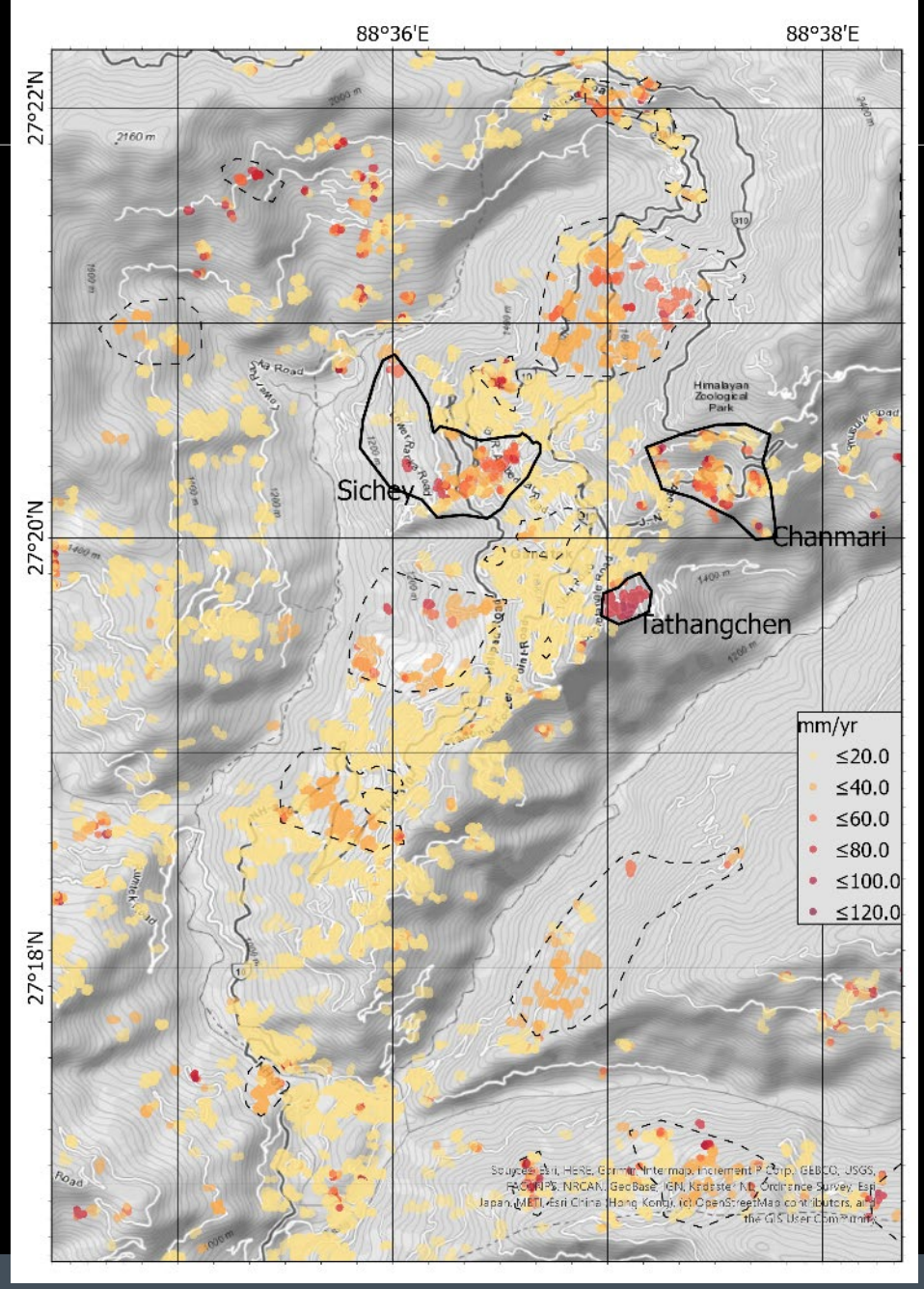
- Population is just over 200,000.
- Annual rainfall of up to 3,500 mm, peaking during the monsoon season.





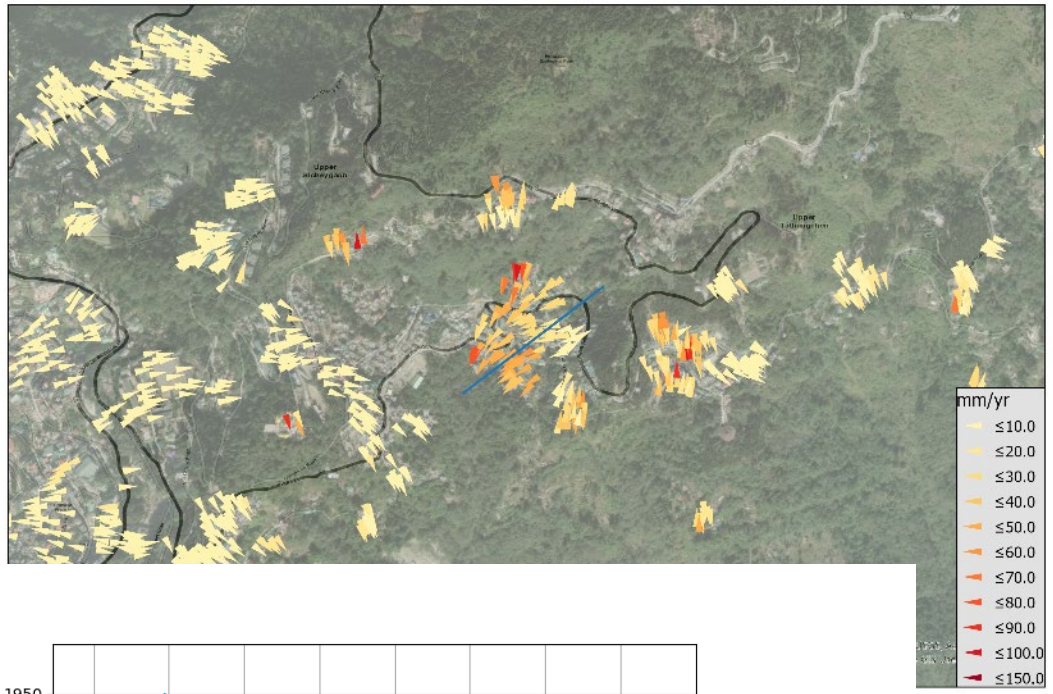
Urban landslide

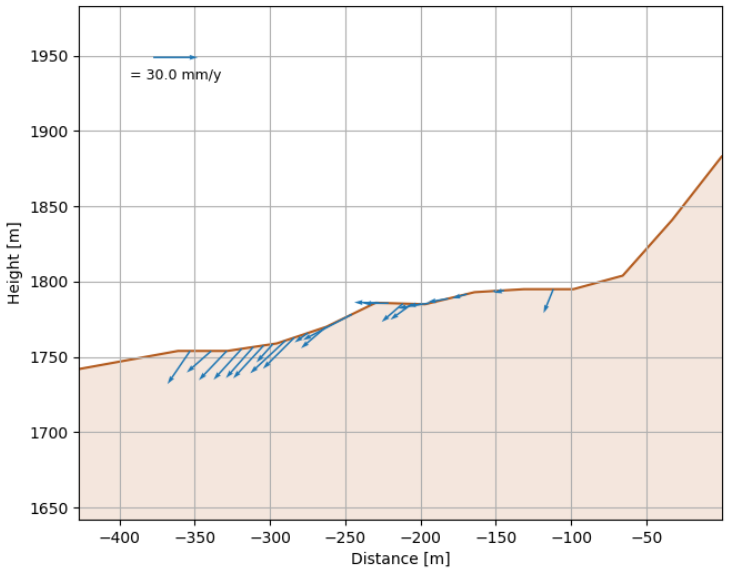
- Numerous areas of the city moving up to 10’s of cm/year.
- Even if the risk of catastrophic landslide in some of these areas is minimal, the ongoing ground movement causes great accumulated destruction of property.
- InSAR can be used to measure the ground movement and monitor it to see if mitigation efforts are successful.



Chanmari

- There have been at least nine landslides, including one in 1997 that resulted in eight fatalities and damaged several buildings and vehicles.





Upper and Lower Sichey

- Another location with a history of landslides.
- One woman killed in 2021.
- Here we can clearly see a pattern of movement consistent with the damage we see in the field.

Woman buried alive in Gangtok landslide

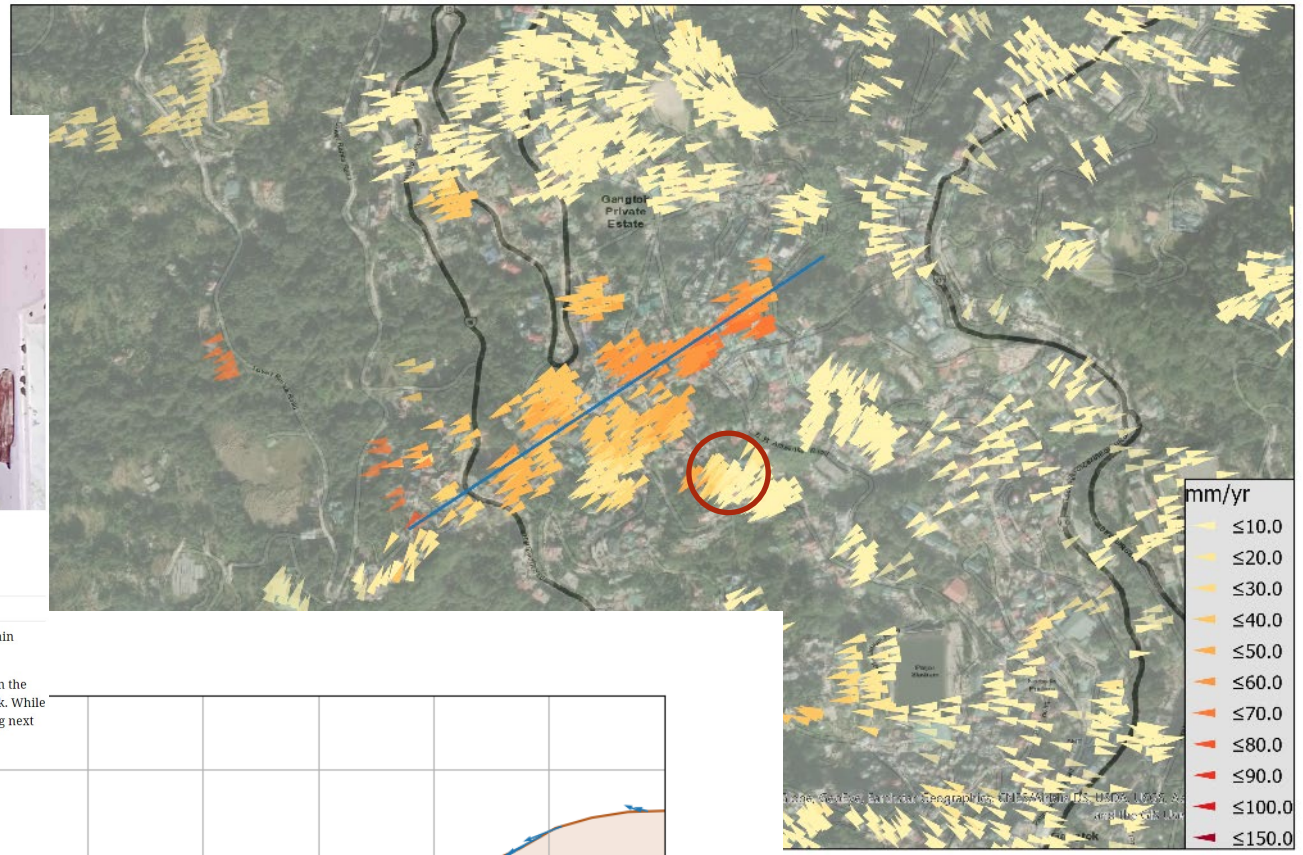
Three injured and several homes damaged

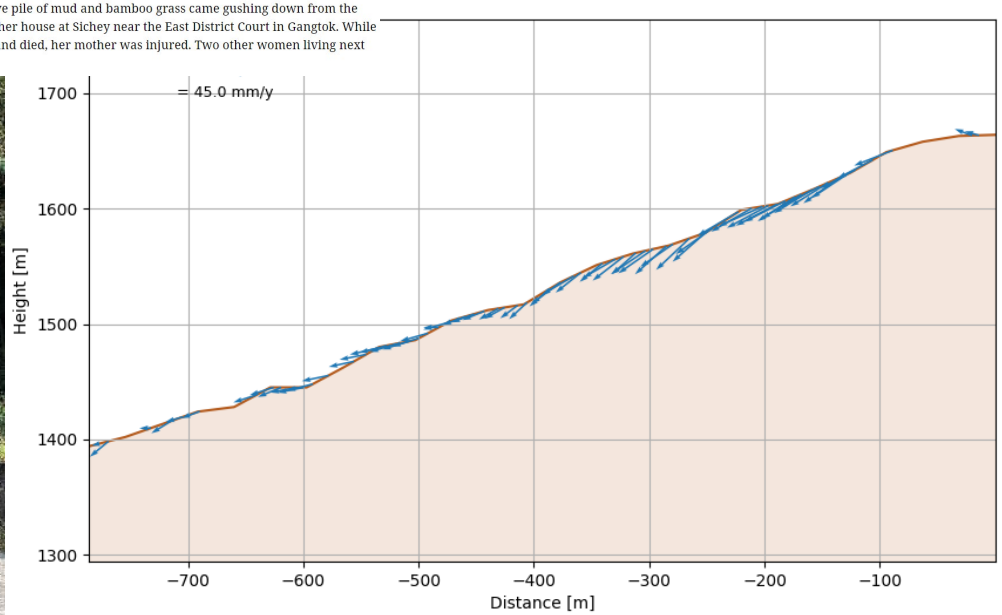
A building hit by a landslide at Sichey in Gangtok on Wednesday
Telegraph picture

Rajeev Ravidas | Siliguri | Published 10.06.21, 03:04 AM

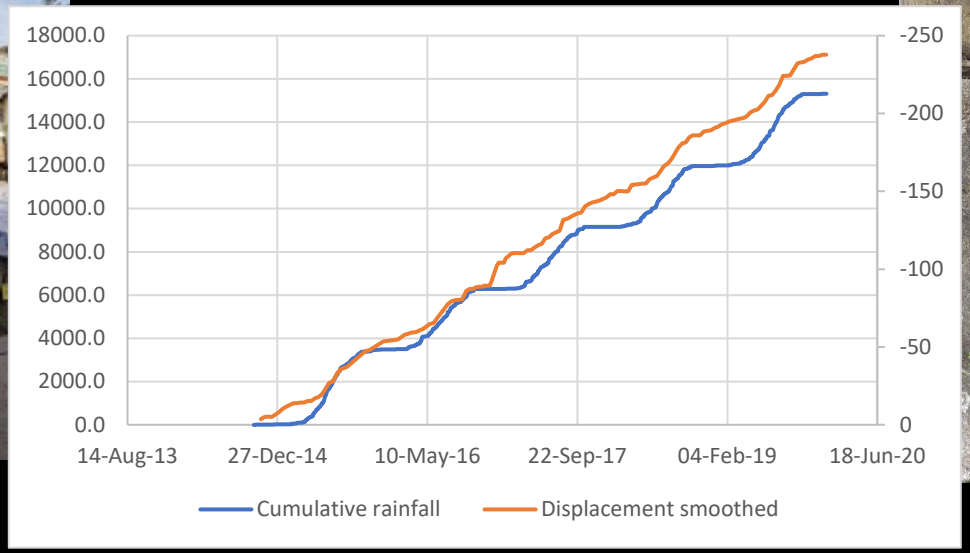
One person died, three received injuries and a number of houses suffered damage as heavy rain triggered landslides at numerous places in and around Gangtok on Tuesday night.

Bimla Chettri, 40, died after a massive pile of mud and bamboo grass came gushing down from the hill above and completely damaged her house at Sichey near the East District Court in Gangtok. While Bimala was buried under the slush and died, her mother was injured. Two other women living next door to them were also injured.



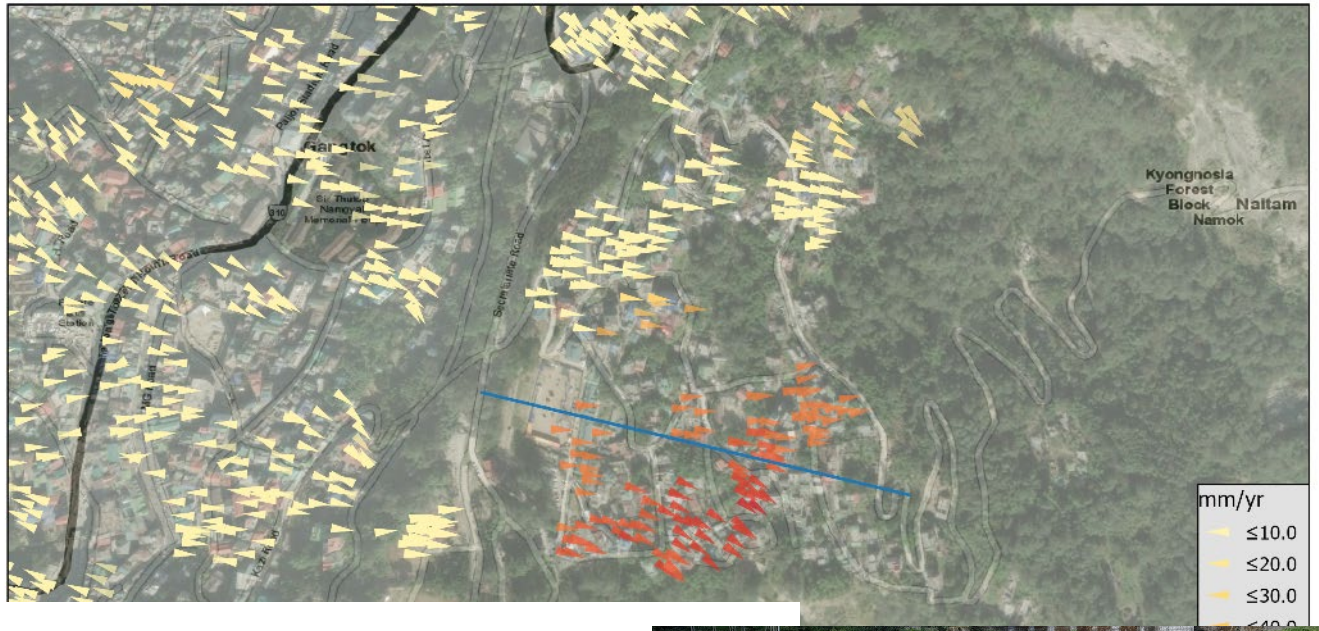


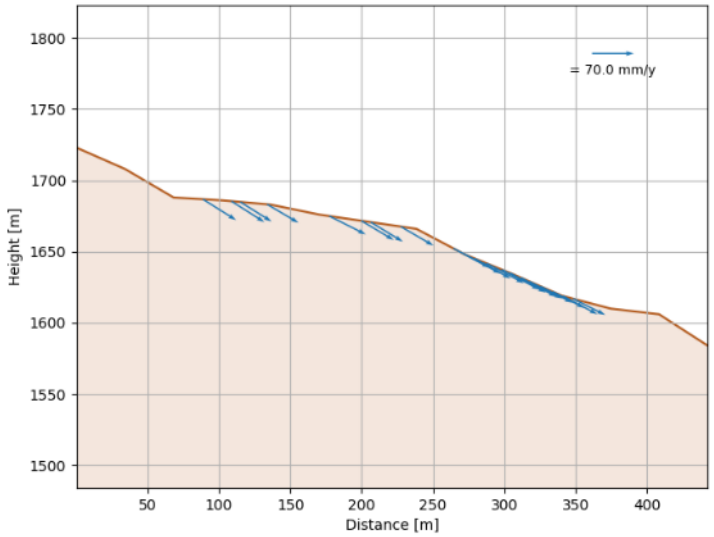
- During 2017, we found the beginning of a construction project, replacing a house destroyed by movement.
- In 2019, the site had been condemned by the city.
- Although catastrophic landslides occur, much of the movement is continuous over many years.



Tathangchen

- Perhaps the most dramatic movement we see is in the Tathangchen area.
- Throughout the city we see many examples of fresh and wastewater continuously entering the slopes.
- The clear correlation between rainfall and velocity suggests that mitigation measures include better management of water.





Conclusions

Consistent pattern: in each site we have examined, the same trends are visible.

Seasonal acceleration:

Rainfall peak in July.

Velocity peak in August.

However, while some areas reach zero velocity, most continue to have movement throughout the year.

While rainfall cannot be controlled, better drainage networks can mitigate the local effects. InSAR data can be used to quantify the effects of such mitigation measures.

In a broader perspective, the data can be used within urban development planning to identify risk areas and monitor potential zones of catastrophic collapse.