Landslide Early Warning in a Data Sparse Region, Challenges and Way Forward: The case of Idukki, Western Ghats, India

Thomas Oommen Ph.D.

Professor, Department of Geological and Mining Engineering and Sciences,
Director, Computational Science and Engineering Doctoral Program
Michigan Technological University, Houghton, MI.

GEOSCIENTISTS without BORDERS®
SOCIETY OF EXPLORATION GEOPHYSICISTS
Founding Supporter Schlumberger

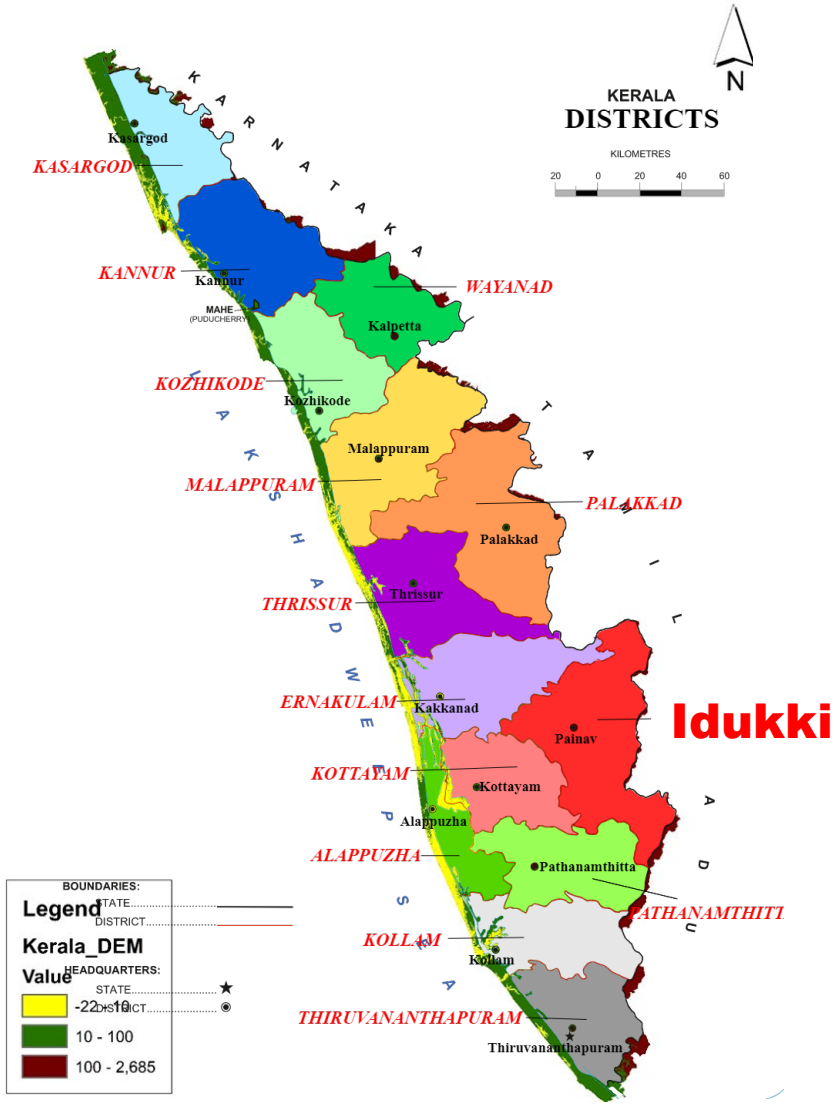
1885 Michigan Technological University

UNIVERSITY OF KERALA
कर्मणि व्यज्यते प्रज्ञा

STATE DISASTER MANAGEMENT AUTHORITY KERALA

Introduction | Kerala

Introduction | Kerala - Idukki

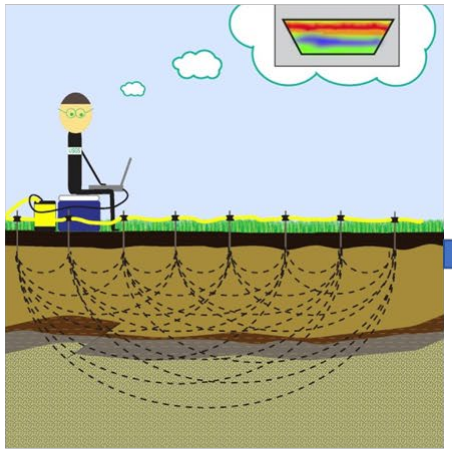


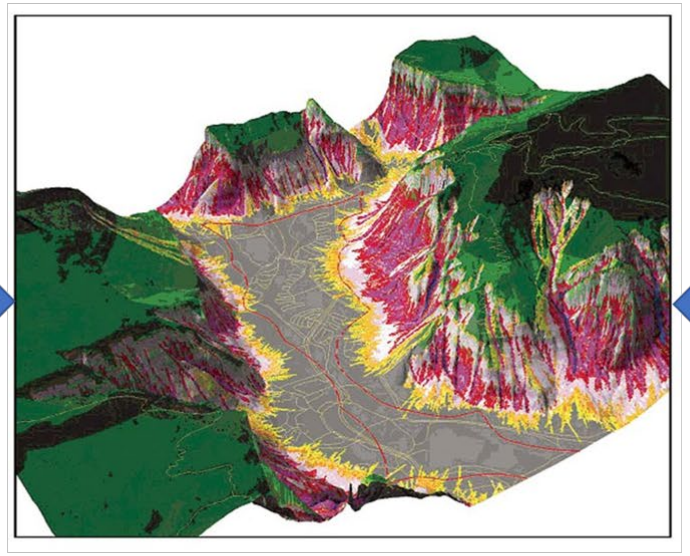
Introduction | Idukki – Landslides

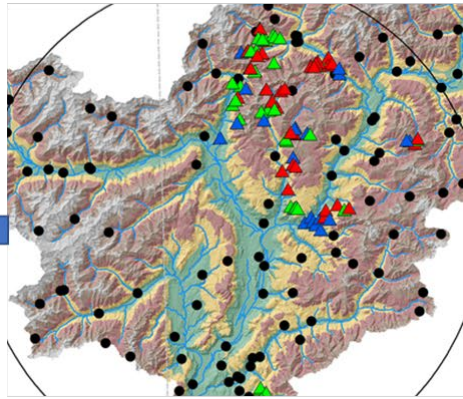
Introduction | Landslides

Objectives |

Landslide Nowcasting System







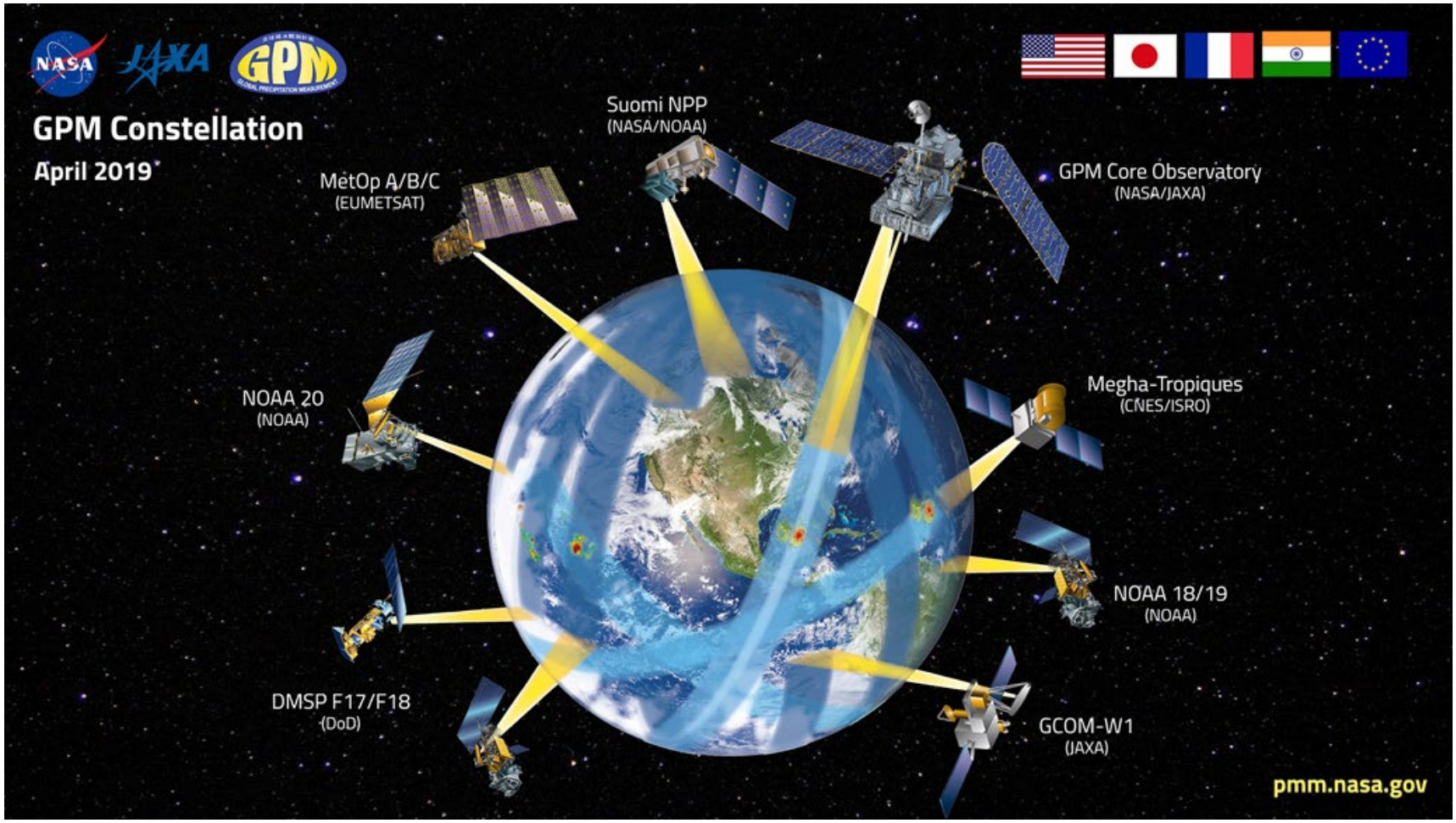
Geophysical data

Geotechnical & Groundwater

Rainfall Data

Dense Rain Gauge Network

Rainfall |

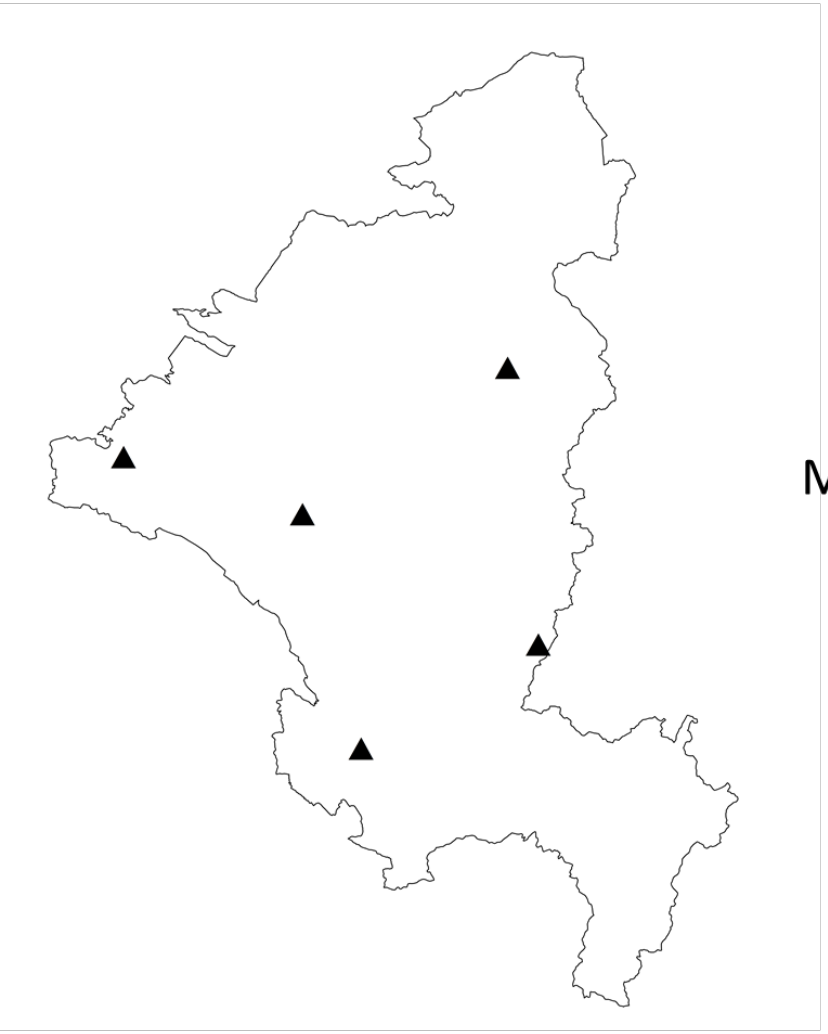

GPM Constellation
April 2019*
Suomi NPP
(NASA/NOAA)
MetOp A/B/C
(EUMETSAT)
GPM Core Observatory
(NASA/JAXA)
NOAA 20
(NOAA)
Megha-Tropiques
(CNES/ISRO)
NOAA 18/19
(NOAA)
DMSP F17/F18
(DoD)
GCOM-W1
(JAXA)
pmm.nasa.gov

Rainfall |

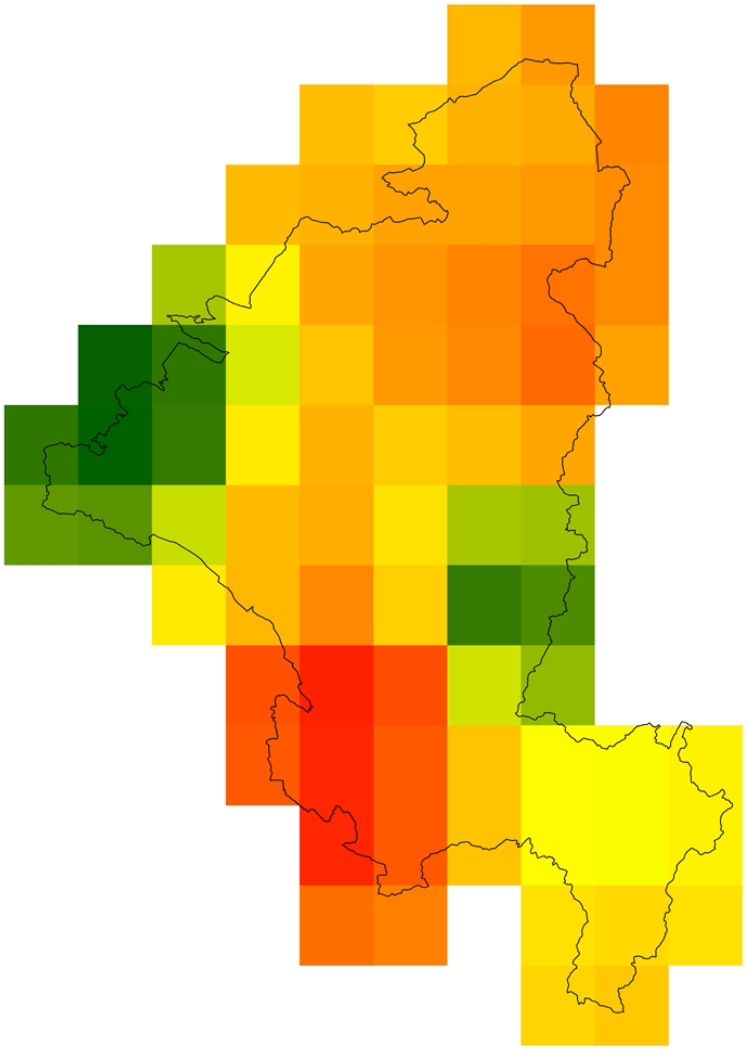
Rain Gauge vs. GPM Precipitation Comparison

Station Name	Rain Gauge value (mm)	GPM Precipitation (mm)	Difference (mm)
Peermade	1773.27	259.89	1513.38 (85%)
Thodupuzha	886.70	362.44	524.26 (60%)
Munnar	1689.00	341.05	1347.95 (80%)
Idukki	1515.6	338.32	1177.28 (78%)
Myladumpara	1045.92	250.8	795.12 (74%)

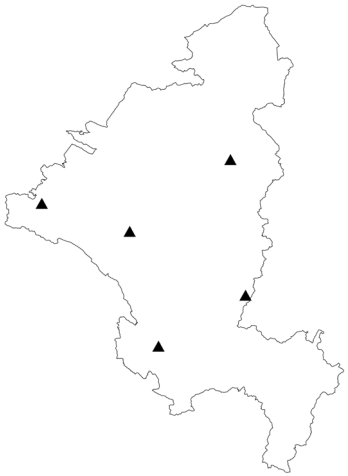
Challenge | Preserve the accuracy of Rain Gauge and spatial variability of Satellite data



Merge

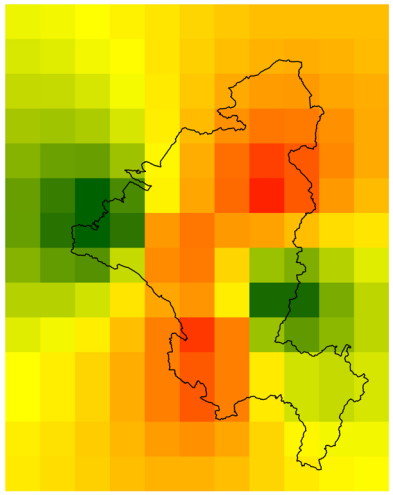


Conditional Merging

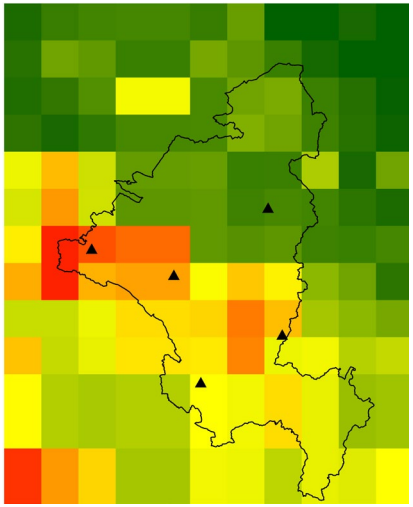


Rain Gauge

Interpolate

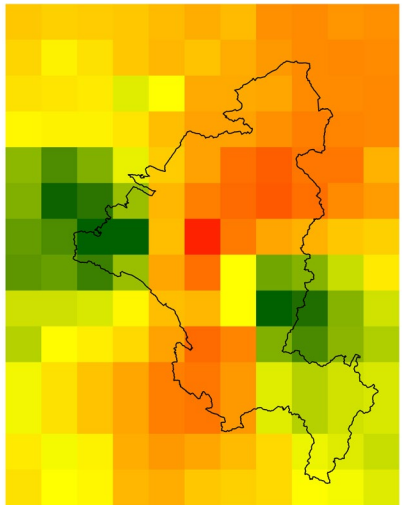


I_{RG}



Extract GPM @ RG

Interpolate



I_{GPM}

Conditional Merging

$$CM = GPM - I_{GPM} + I_{rg}$$

Conditional Merging|

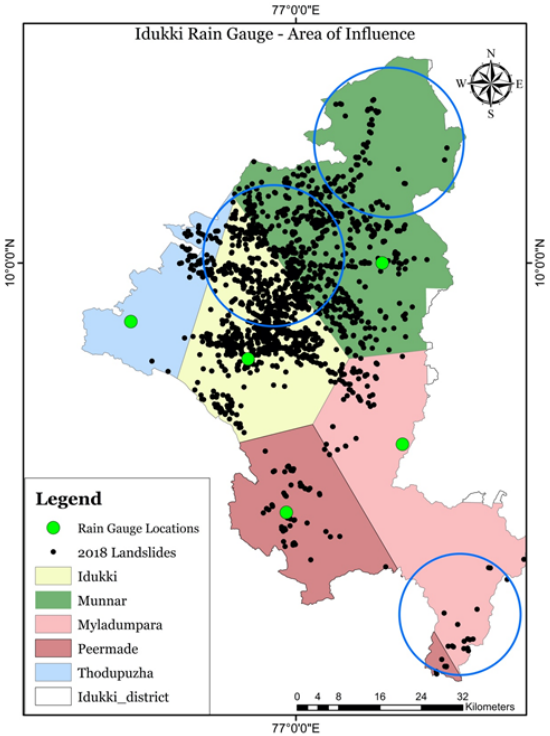
Rain Gauge vs. GPM after Conditional Merging

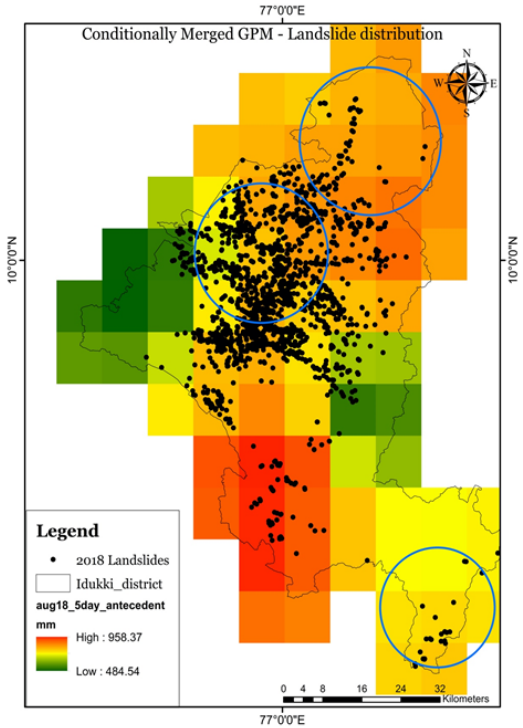
Station Name	Rain Gauge value (mm)	GPM Before Conditional Merging (mm)	Difference (mm)	GPM after Conditional Merging (mm)	Difference (mm) K-Fold Cross Validation
Peermade	1773.27	259.89	1513.38	1722.84	50.43
Thodupuzha	886.70	362.44	524.26	830.53	56.17
Munnar	1689.00	341.05	1347.95	1631.92	57.08
Idukki	1515.6	338.32	1177.28	1491.69	23.91
Myladumpara	1045.92	250.8	795.12	1024.5	21.42

Vishnu, C. L., Oommen, T., Chatterjee, S., & Sajinkumar, K. S. (2022). Challenges of modeling rainfall triggered landslides in a data-sparse region: A case study from the Western Ghats, India. Geosystems and Geoenvironment, 100060.

Landslide Distribution |

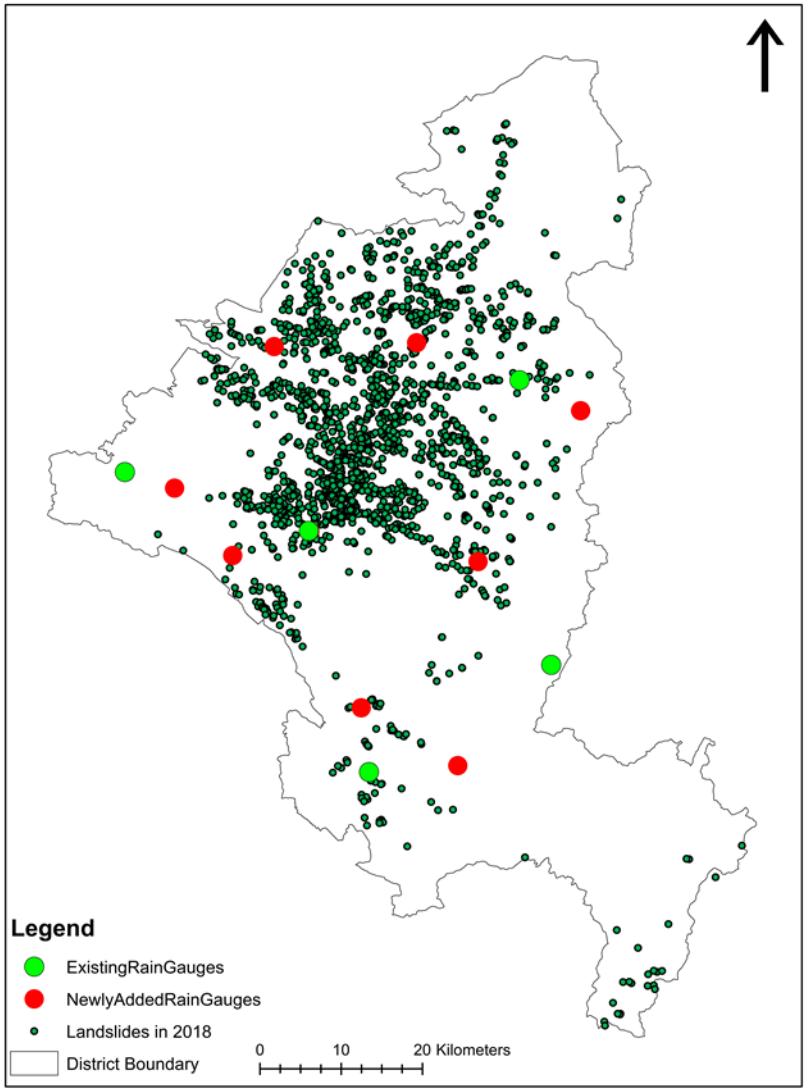
Rain Gauge and conditionally merged GPM with landslide distribution





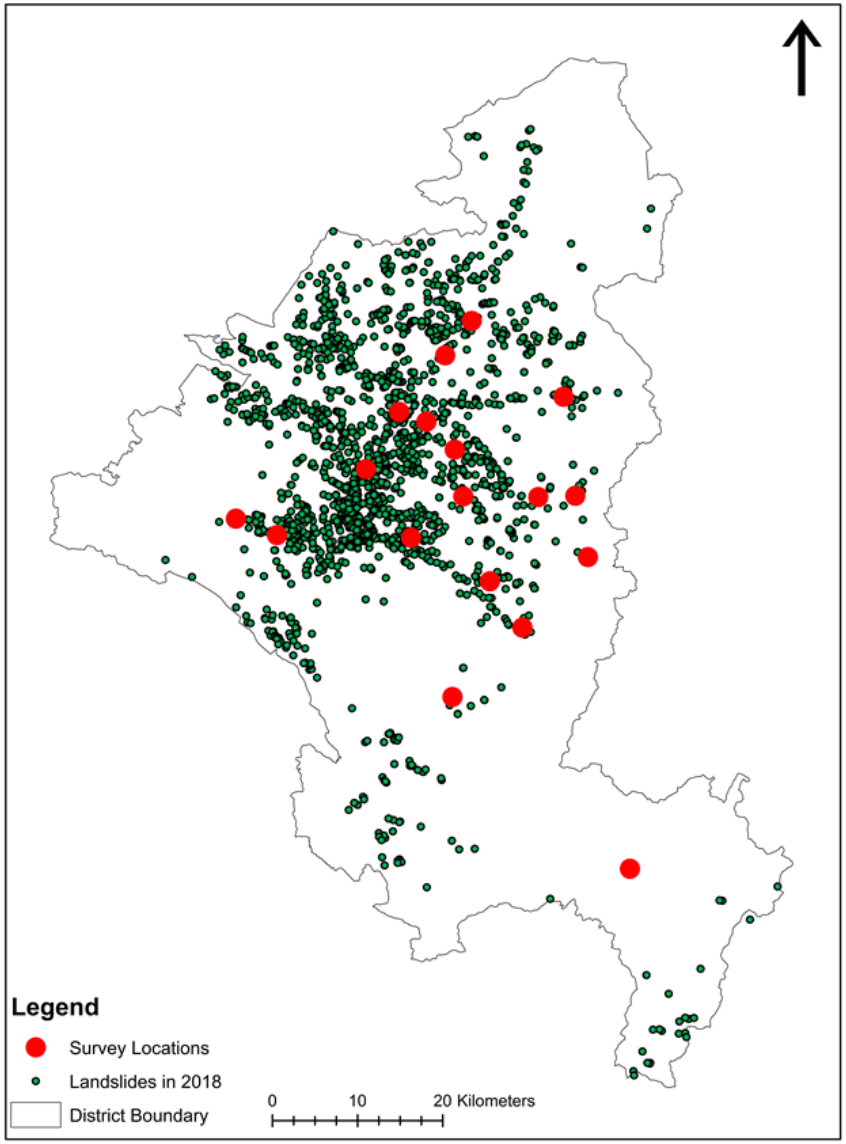
Station Name	No of Landslides	RG (mm)	GPM (mm)	Range (mm)
Idukki	1156	815.76	710.44 - 840.93	130.49
Munnar	843	869.5	761.45 - 897.63	136.18
Myladumpara	71	667.03	585.22 - 924.13	338.91
Peermade	75	952.87	791.02 - 958.36	167.34
Thodupuzha	78	484.54	578.1 - 761.46	183.36

New Rain Gauges |

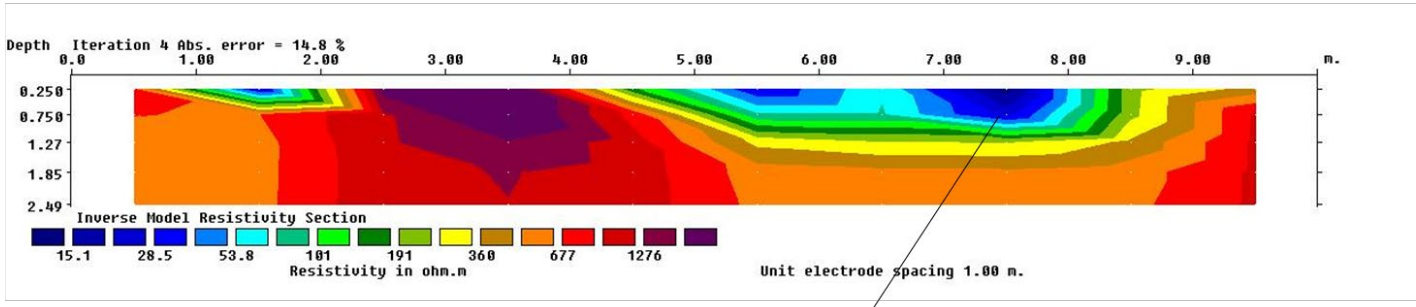


New Rain Gauges |

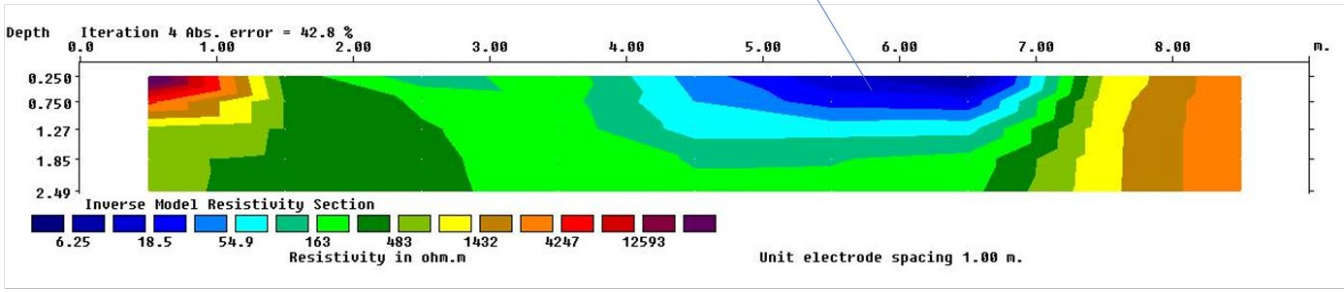
Geophysical Survey |



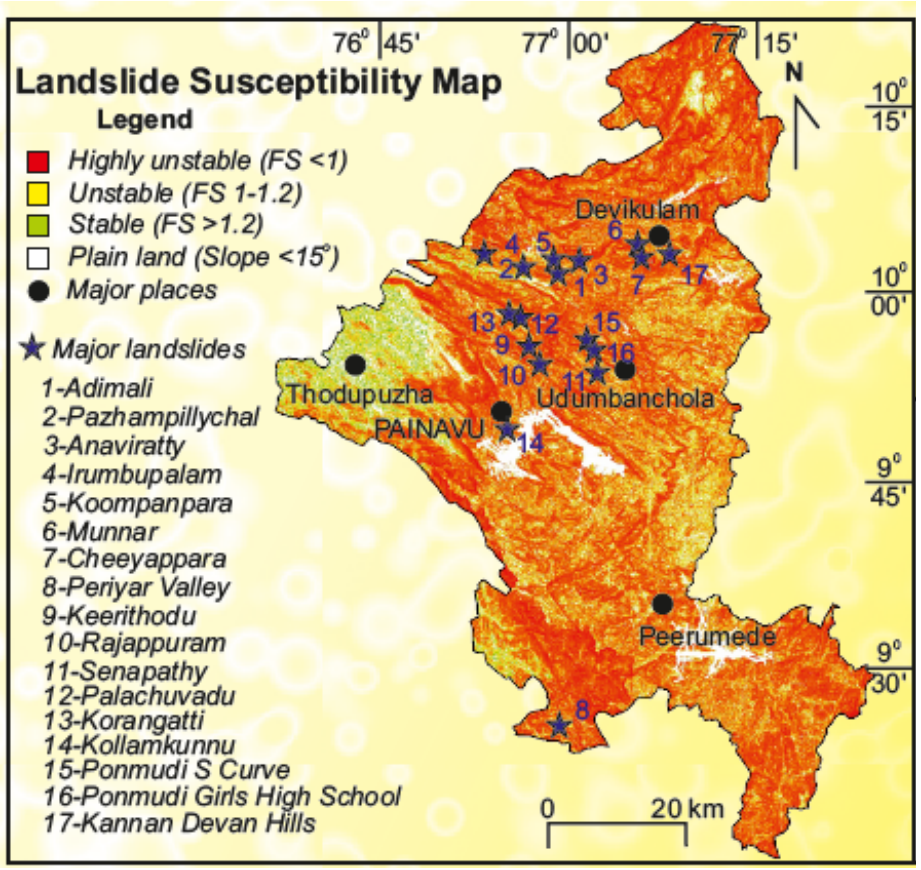
Geophysical Survey |



Low resistivity zones



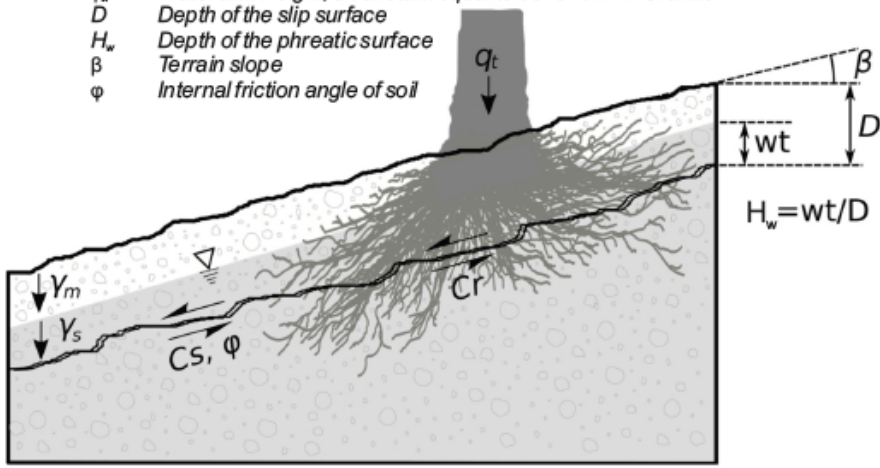
Landslide Susceptibility |



$$FS = \frac{Cr + Cs + [q_t + \gamma_m D + (\gamma_{sat} - \gamma_w - \gamma_m) H_w D] \cos^2\beta \tan\varphi}{[q_t + \gamma_m D + (\gamma_{sat} - \gamma_w - \gamma_m) H_w D] \sin\beta \cos\beta}$$

where

Cr	Contribution to the soil cohesive strength from the roots (when vegetation is considered)
Cs	Soil cohesive strength
q_t	Vegetation weight added to the slope (the surcharge)
γ_m	Unsaturated (moist, above the phreatic surface) soil unit weight
γ_{sat}	Saturated (under the phreatic surface) soil unit weight
γ_w	Water unit weight, a constant equal to 9810 N/m^3 in SI units
D	Depth of the slip surface
H_w	Depth of the phreatic surface
β	Terrain slope
φ	Internal friction angle of soil



Escobar-Wolf, R., Sanders, J. D., Vishnu, C. L., Oommen, T., & Sajinkumar, K. S. (2021). A GIS tool for infinite slope stability analysis (GIS-TISSA). Geoscience Frontiers, 12(2), 756-768.

Sajinkumar, K. S., and Thomas Oommen. "Landslide atlas of Kerala." *GSI Publications* 7.1 (2021).

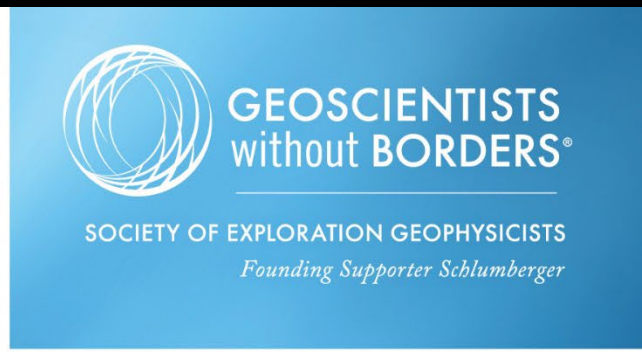
Future Work |

ERT profiles to shear strength calculations.

Develop slope stability models by incorporating shear strength.

Use the slope stability model and rainfall information to create an early warning system.

Acknowledgements



- Vishnu Chakrapani Lekha (Michigan Technological University)
- Dr. Snehamoy Chatterjee (Michigan Technological University)
- Dr. Sajinkumar K. S. (University of Kerala, India)
- Dr. Shekar Kuriakose (Kerala State Disaster Management Agency)