Space Enabled Water Intelligence for Ungauged Mountain Basins

HydroTwin








Antarikchya Pratisthan Nepal

Alison Shilpakar · Sujan Tyata · Surendra Bohara · Risab Shrestha · Sajan Duwal · Abhas Maskey

Antarikchya Pratisthan Nepal

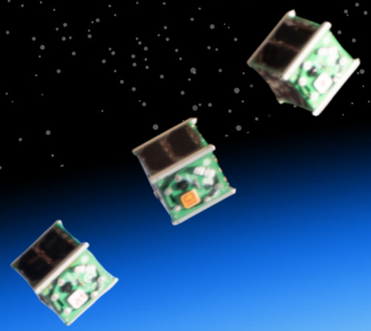
BIRDS-3
NepaliSat-1

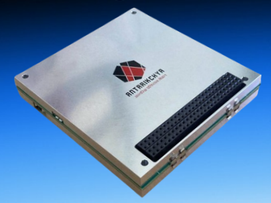
PHI-1 / DANFE

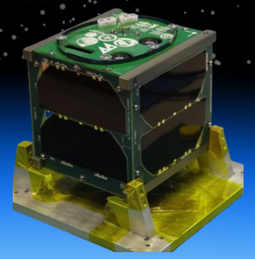
MUNAL

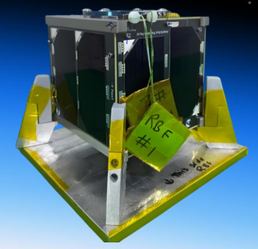
Slippers2Sat
(S2S)

REMOTE
SENSING









SATELLITES → GROUND STATIONS → REMOTE SENSING → INTELLIGENCE

Space Enabled Water Intelligence for Ungauged Mountain Basins

HydroTwin





The Problem

Steep, remote terrain

gauges are costly to build and maintain; ground networks have not kept pace

Dynamic flow

discharge in montain basins swings hard and fast, driven by monsoon rainfall and snow or glacier melt

Limited Connectivity

cellular and Wi-Fi networks are sparse in the rigged mountain areas

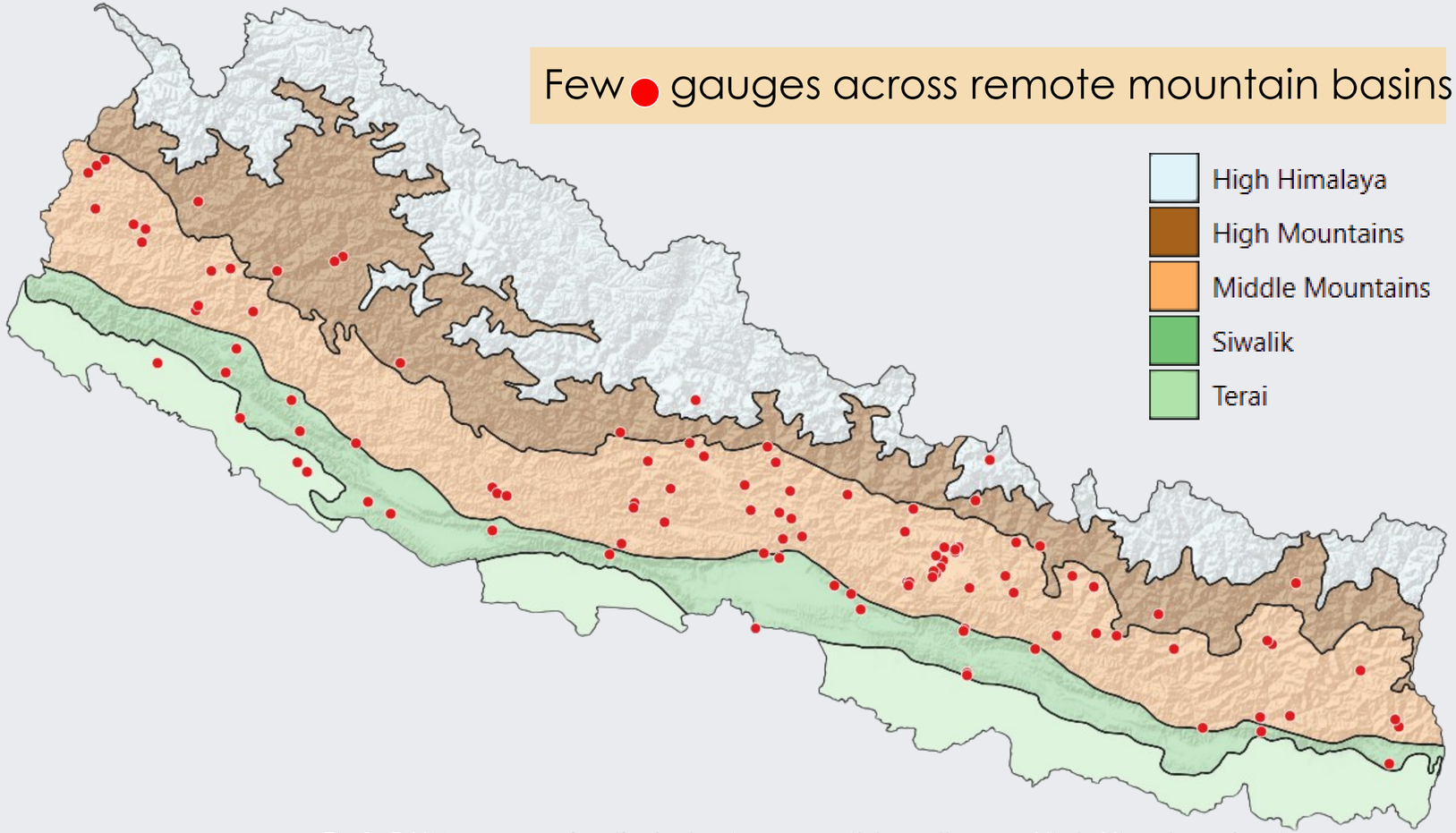


Fig1: DHM gauges (red) cluster in accessible valleys — High Himalaya basins are mostly ungauged

Flood Risk

Downstream communities get little or no flood warning

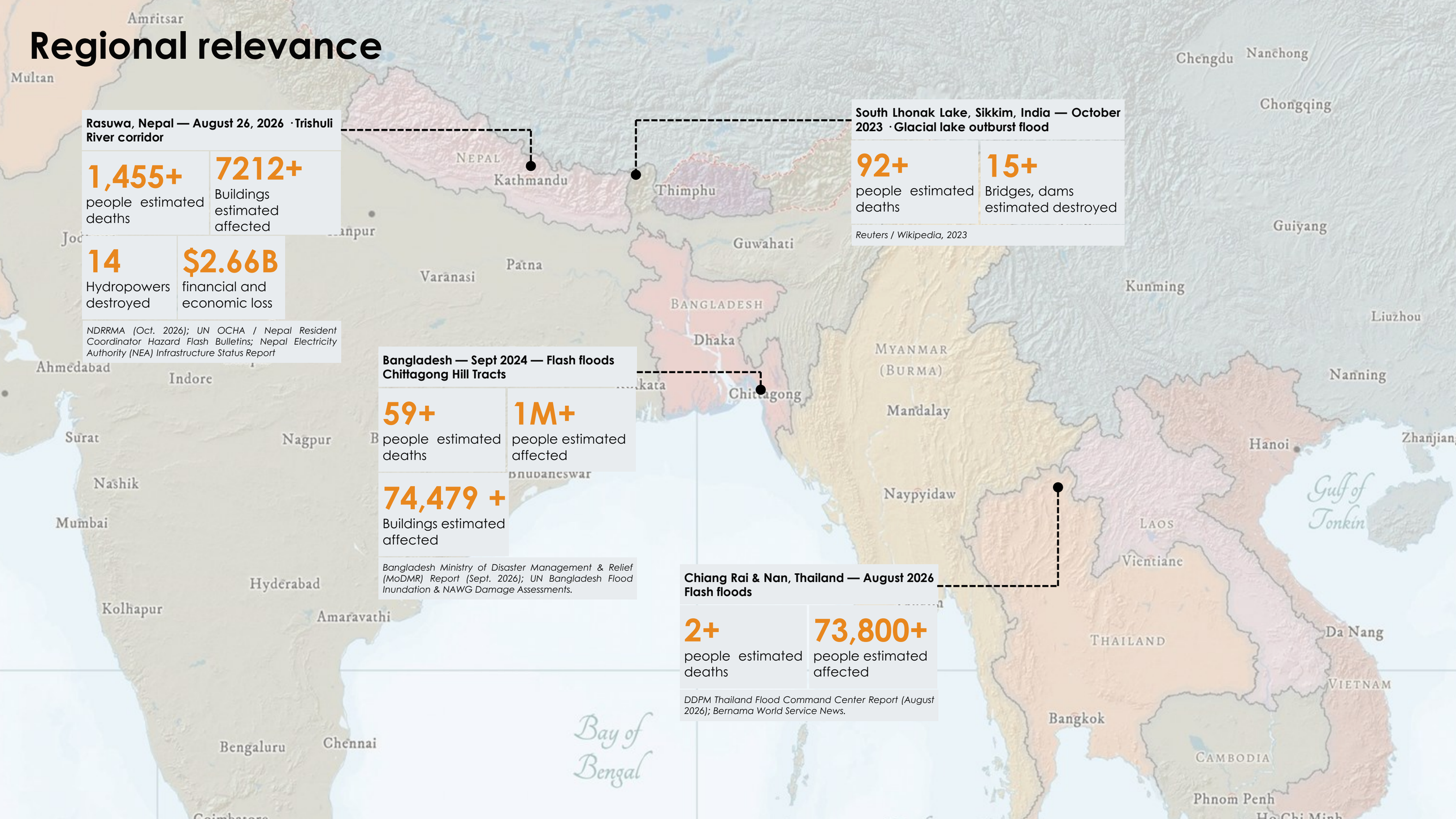
Hydropower uncertainity

Hydropower operators can't plan generation with confidence

Water resource uncertainity

water managers are unable to make informed decisions regarding irrigation and drought planning

Regional relevance



Rasuwa, Nepal — August 26, 2026 · Trishuli River corridor

1,455+
people estimated deaths

7212+
Buildings estimated affected

14
Hydropowers destroyed

$2.66B
financial and economic loss

NDRRMA (Oct. 2026); UN OCHA / Nepal Resident Coordinator Hazard Flash Bulletins; Nepal Electricity Authority (NEA) Infrastructure Status Report

South Lhonak Lake, Sikkim, India — October 2023 · Glacial lake outburst flood

92+
people estimated deaths

15+
Bridges, dams estimated destroyed

Reuters / Wikipedia, 2023

Bangladesh — Sept 2024 — Flash floods Chittagong Hill Tracts

59+
people estimated deaths

1M+
people estimated affected

74,479 +
Buildings estimated affected

Bangladesh Ministry of Disaster Management & Relief (MoDMR) Report (Sept. 2026); UN Bangladesh Flood Inundation & NAWG Damage Assessments.

Chiang Rai & Nan, Thailand — August 2026 Flash floods

2+
people estimated deaths

73,800+
people estimated affected

DDPM Thailand Flood Command Center Report (August 2026); Bernama World Service News.

Why this needs Satellites

Ground gauges alone can't cover ungauged mountain basins

ERA5 REANALYSIS

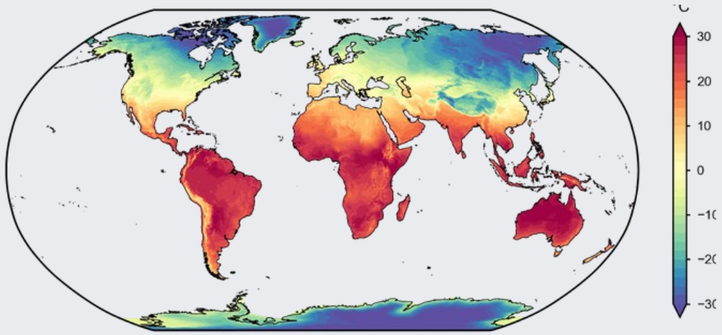


Fig: ERA5 temperature map

SATELLITES PROVIDE

Basin-scale rainfall input for forecasting

GROUND ALONE CAN'T

Cover catchments with no gauges

SENTINEL-1 SAR

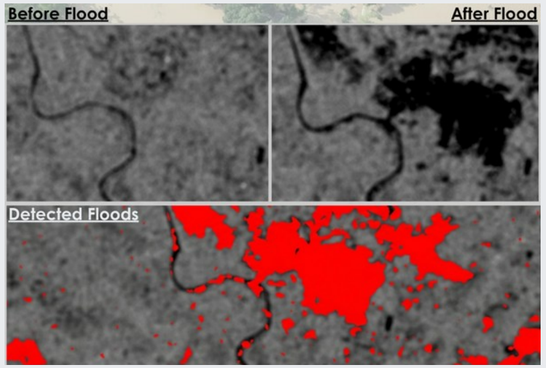


Fig: SAR before/after flood extent

SATELLITES PROVIDE

Flood extent through monsoon cloud

GROUND ALONE CAN'T

Map floods where gauges are sparse or lost

MERIT-HYDRO DEM

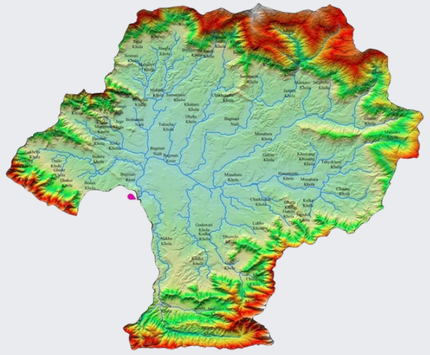


Fig: DEM-derived watershed map

SATELLITES PROVIDE

One-click watershed delineation

GROUND ALONE CAN'T

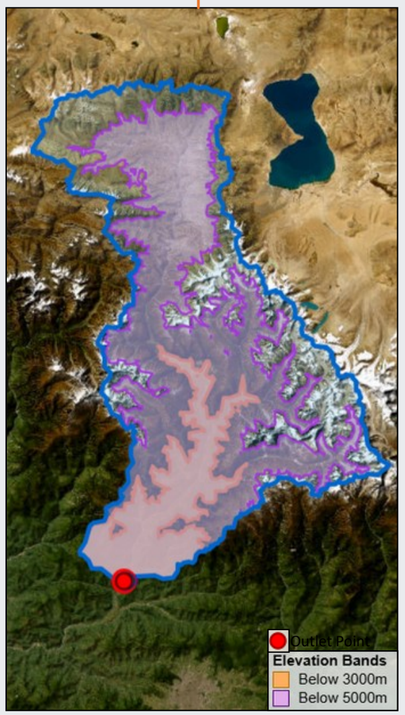
Survey steep, remote terrain

Trishuli, Aug 2026: Ground Stations were lost to the flood. Space based observations do not depend on ground infrastructure and continue

Gauges calibrate and validate; space data provides coverage

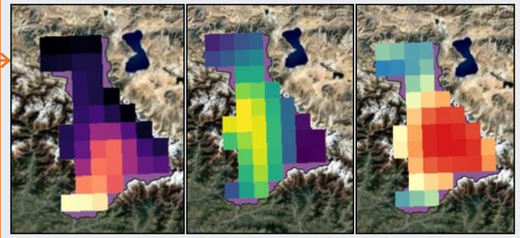
HydroTwin: space data + ground sensing + AI

BASIN

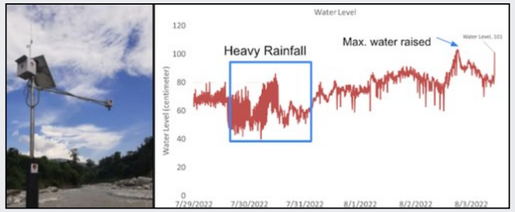


MERIT-Hydro DEM
delineated catchment

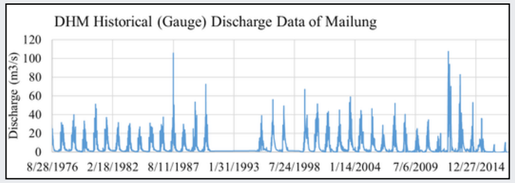
INPUTS



ERA5, area-weighted
rain, temp, humidity, wind, soil moisture

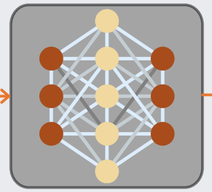


GST: real-time water level
also shown live on dashboard



DHM historical discharge
training and input

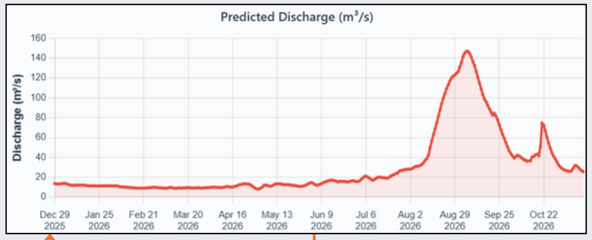
AI MODEL



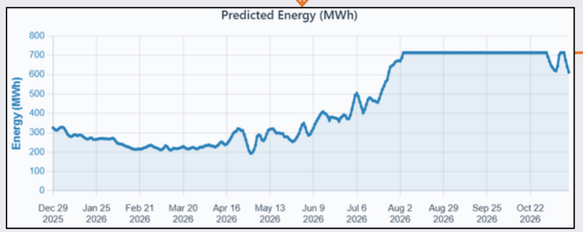
past | today | +7 d | +15 d

past inputs to forecast

FORECASTS



Discharge forecast
(1 to 2 weeks) ahead

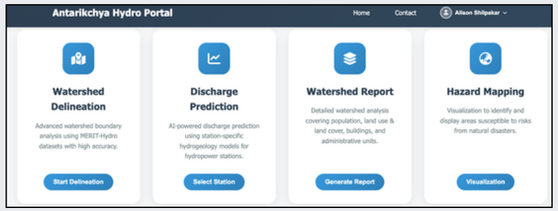


Energy generation forecast
plant parameters: head, design discharge, efficiency

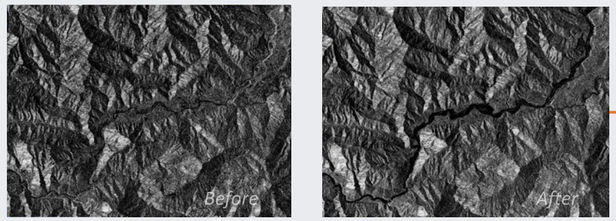
DASHBOARD



Live water level



Monitor → Forecast → Decide
includes live GST water level



Sentinel-1 SAR

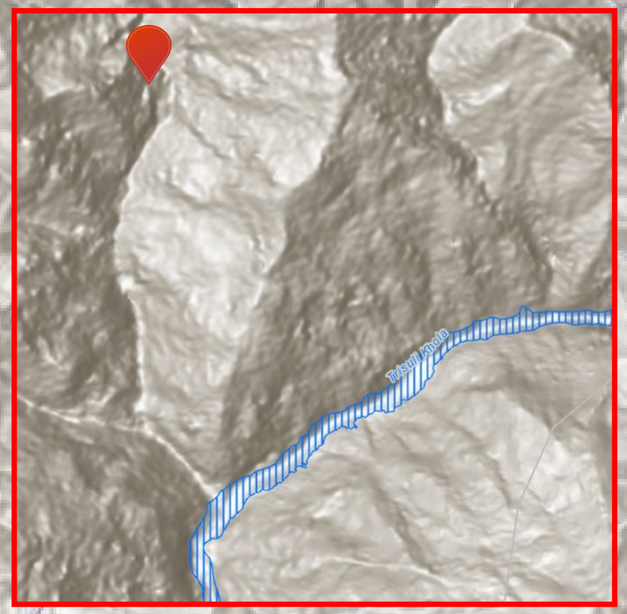


Flood extent mapping
used when flooding occurs

https://hydro.antarikchya.org.np/discharge-prediction/

Proof of Concept





Trisuli Khola

Tadi Khola

BAGMATI

2026 August Flood Extent

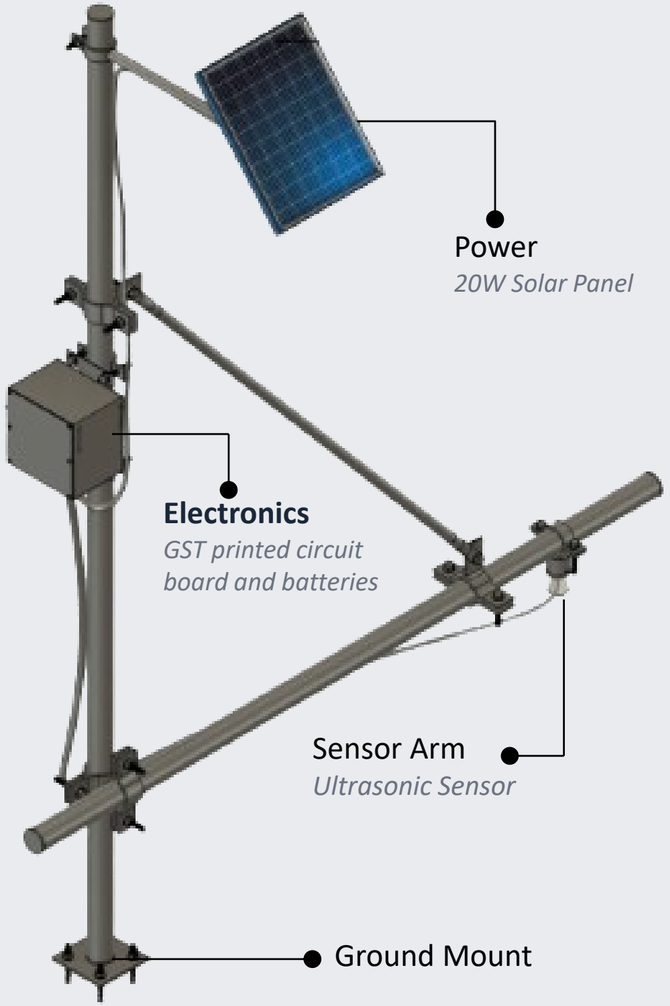
GST location

Kathmandu

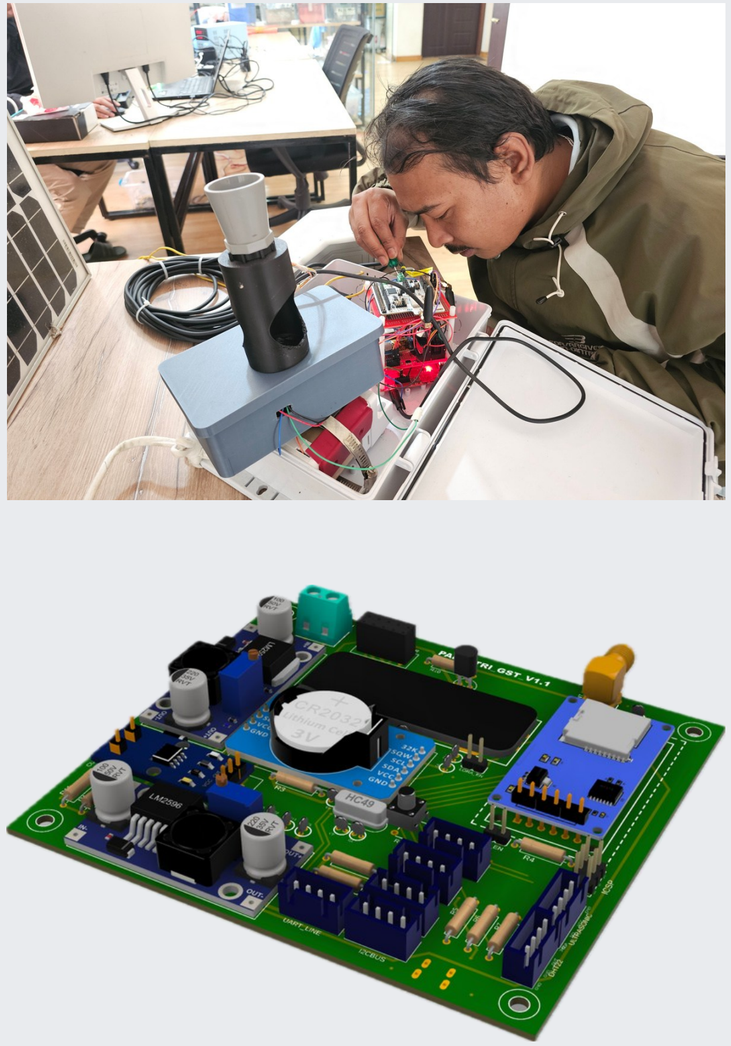
2334 m

Innovation

Ground Sensor Terminal (GST)



3D model of GST structure



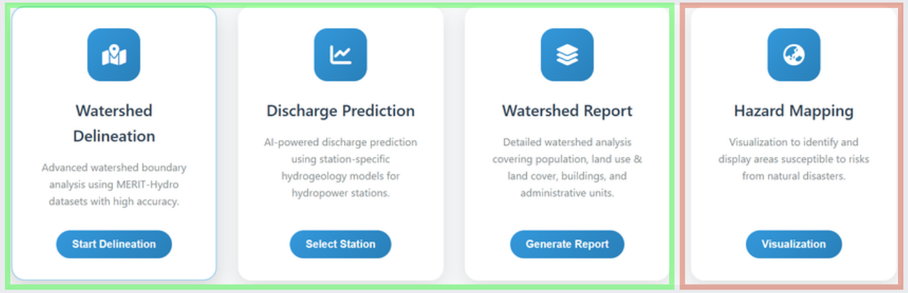
PCB design photo



GST installed at Upper Mailung

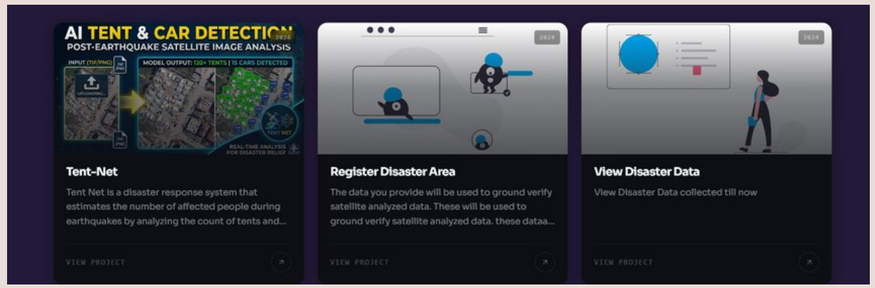
Designed, built and tested in-house at APN

One WebGIS, multiple services



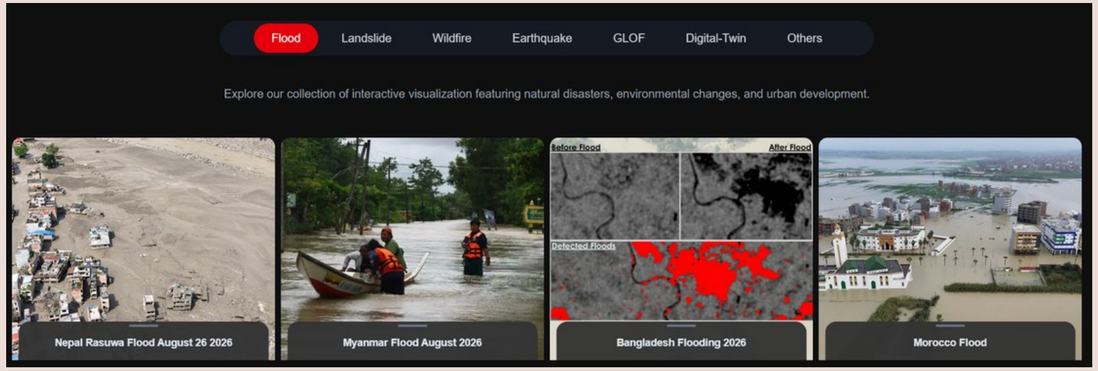
Portal home

https://hydro.antarikchya.org.np



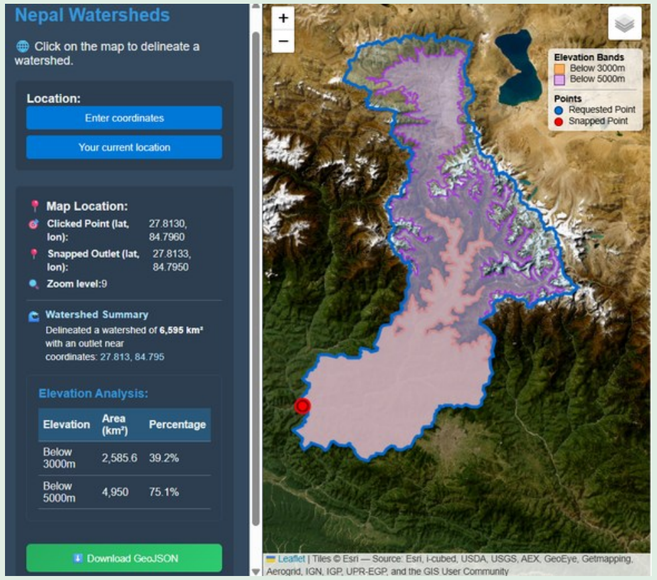
ADP portal home

https://adp.antarikchya.org.np

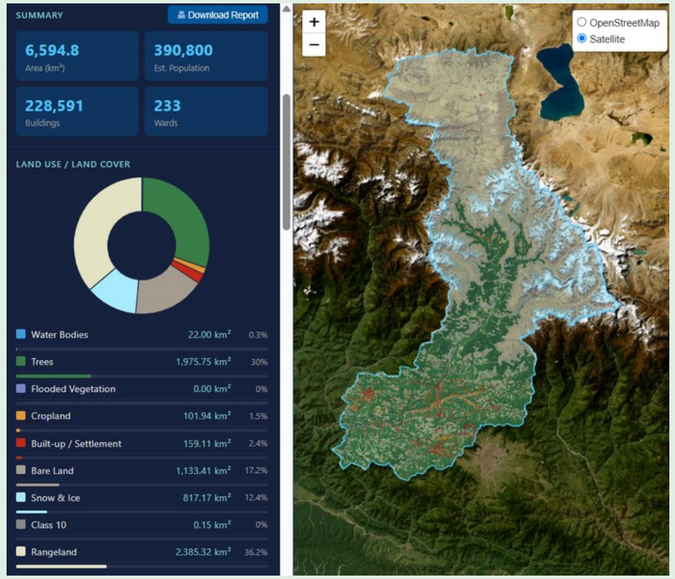


Hazard mapping (ADP)

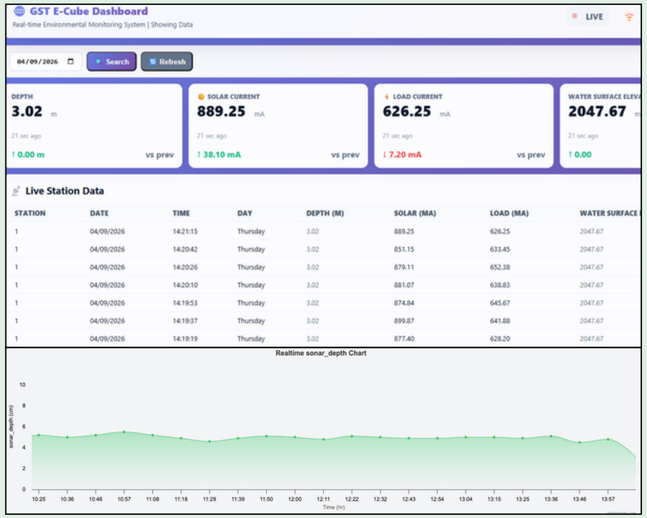
https://antarikchya.org.np/visualization



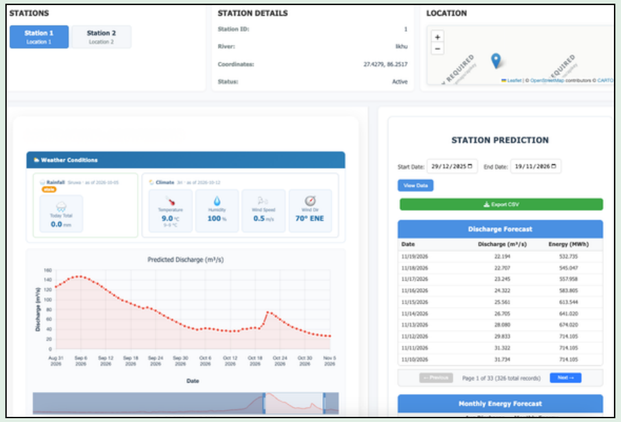
Watershed Delineation



Watershed Report

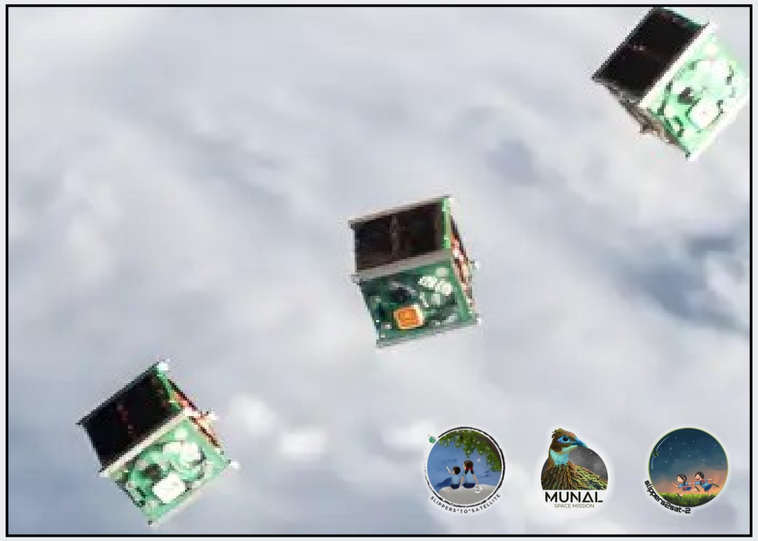


Live water depth from GST



Discharge Prediction

What works today, and what comes next





Chandragiri Hills





Nepal Academy of Science and Technology (NAST) Building

GS at NAST



Operational today (Upper Mailung)

GST water-level monitoring *(1 site)*

Discharge forecast *(pipeline ready)*

Energy generation forecast *(pipeline ready)*

WebGIS: watershed delineation, basin report

In development

GST-to-satellite link
(ground-tested, not flight proven)

Sentinel-1 flood extent mapping
(manual analysis today)

Additional basins
(more sensors, model retraining)

Planned

Threshold based flood notifications
(early warning systems)

Automated SAR flood pipeline

Remote basin deployments via satellite link

From one river to a regional platform

WHAT IS AT STAKE

Disaster risk

Days

of lead time is what flood response needs

- Basin monitoring
- Flood extent mapping (prototype)
- Foundation for early warning

Hydropower

28.5 GW

hydropower targeted by 2035, from about 3.4 GW installed today

- Generation planning
- Operational planning
- Water-release decisions

Water management

Hundreds

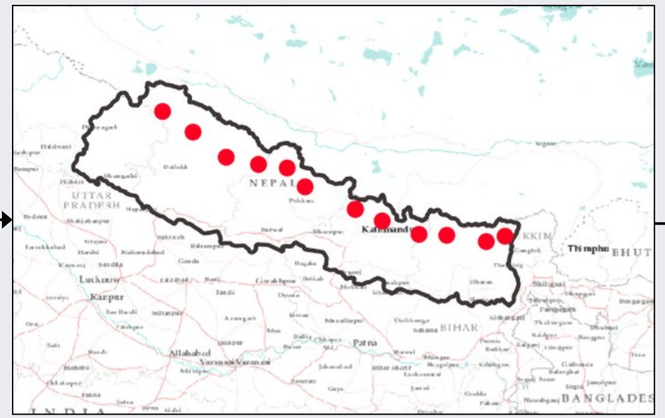
of mountain catchments without ground monitoring

- Irrigation and drought planning
- Climate-resilient water management



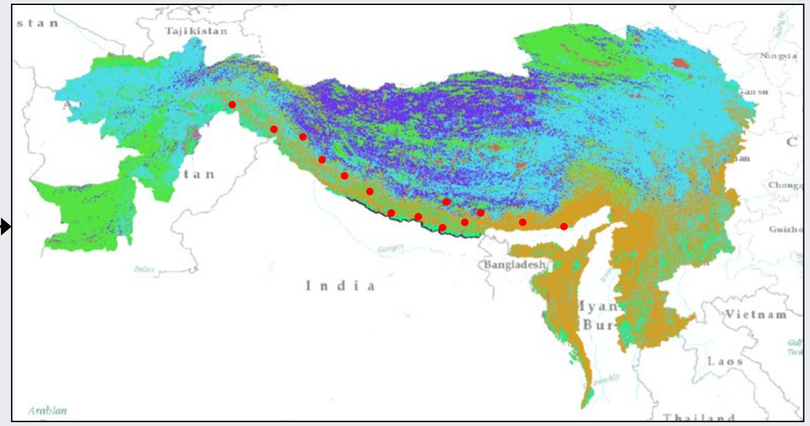
Upper Mailung

Today: 1 site



Nepal

Next: more basins in Nepal



Asia-Pacific

Vision: other mountain regions

Same platform, same models, new data.

Sources: NEA Energy Development Roadmap 2024; US Commercial Service, Nepal Country Commercial Guide

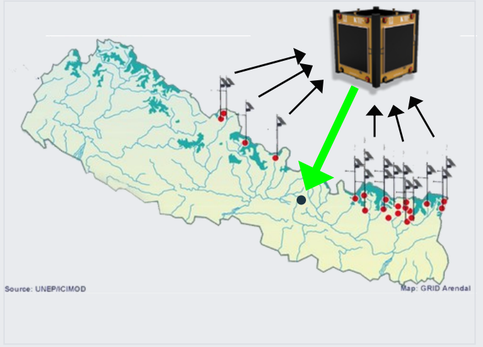
FUTURE OBSERVATION

01 Low-power satellite connectivity

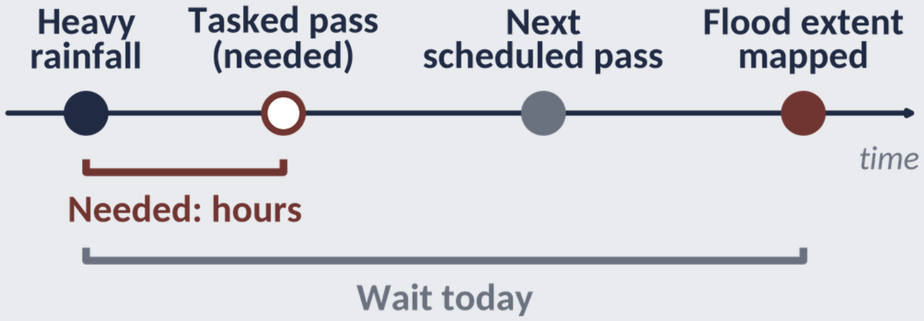
GST → Satellite → Ground station → HydroTwin

NEED
Many Himalayan sites have no Wi-Fi or cellular coverage

ENABLES
Monitoring in basins with no terrestrial connectivity

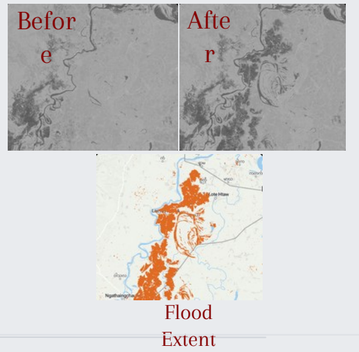


02 Faster SAR observation



NEED
Flood extent within hours, not days

ENABLES
Faster flood response

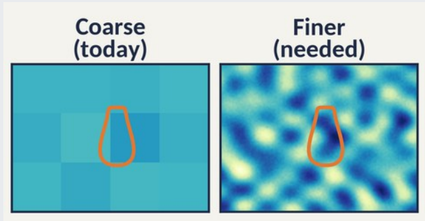


03 Finer hydrological observation

Soil moisture → Snow water equivalent → Small river altimetry

NEED
Finer resolution for small, steep catchments

ENABLES
Sharper discharge and flood estimates where gauges are scarce



The right data, in the right basin, at the right time

ANTARIKCHYA
अन्तरिक्ष प्रतिष्ठान नेपाल

Every mountain basin should be observable

OBSERVE · FORECAST · CONNECT · ACT

HydroTwin

Space-Enabled Water Intelligence for Ungauged Mountain Basins

Antarikchya Pratisthan Nepal

alison@antarikchya.org.np

ANTARIKCHYA
अन्तरिक्ष प्रतिष्ठान नेपाल



Alison Shilpakar

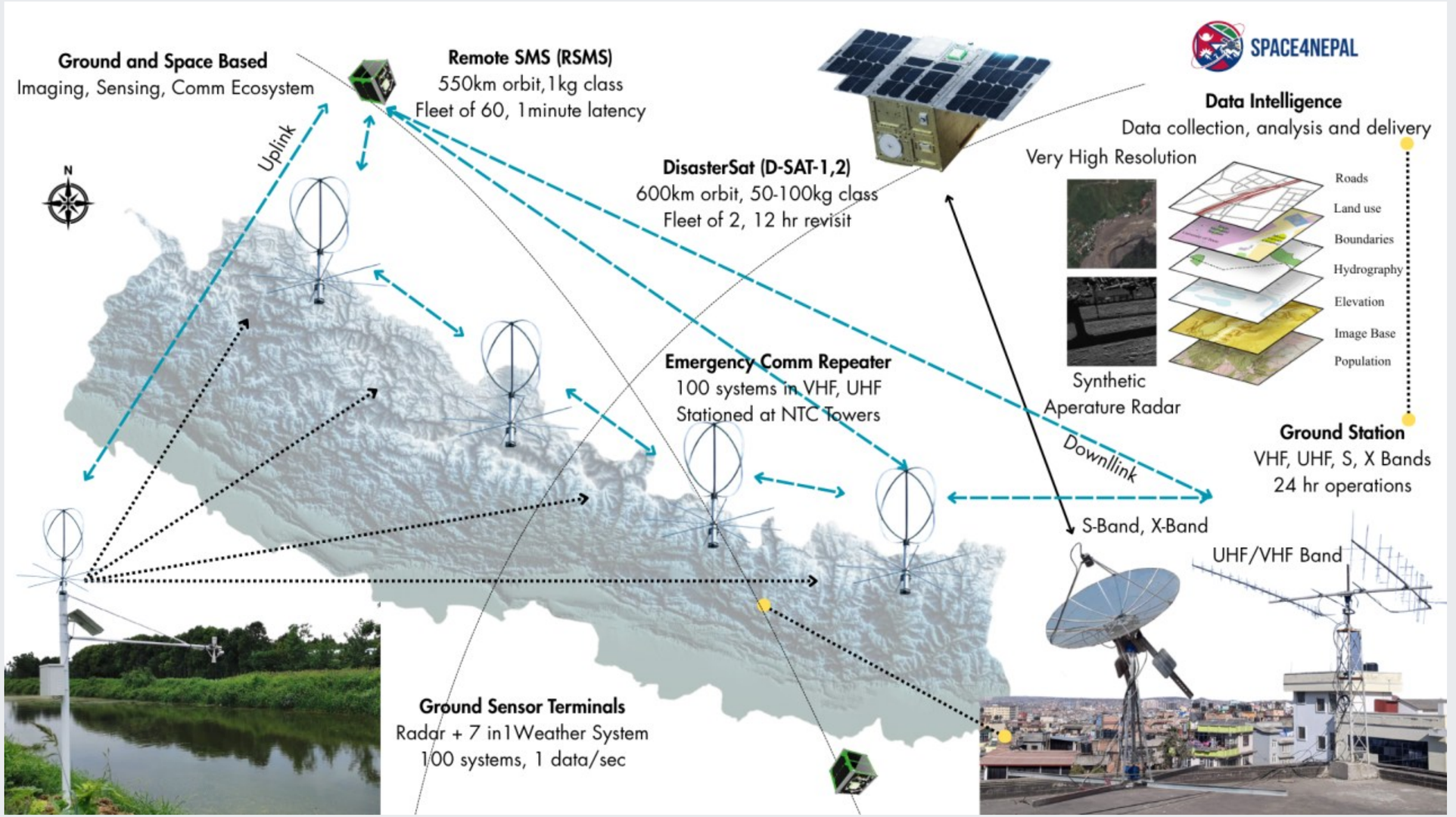
alison@antarikchya.org.np

Antarikchya Pratisthan Nepal

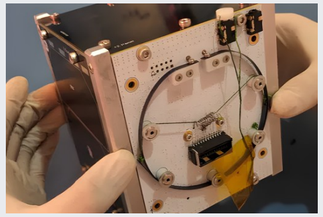
Thank you

Appendix

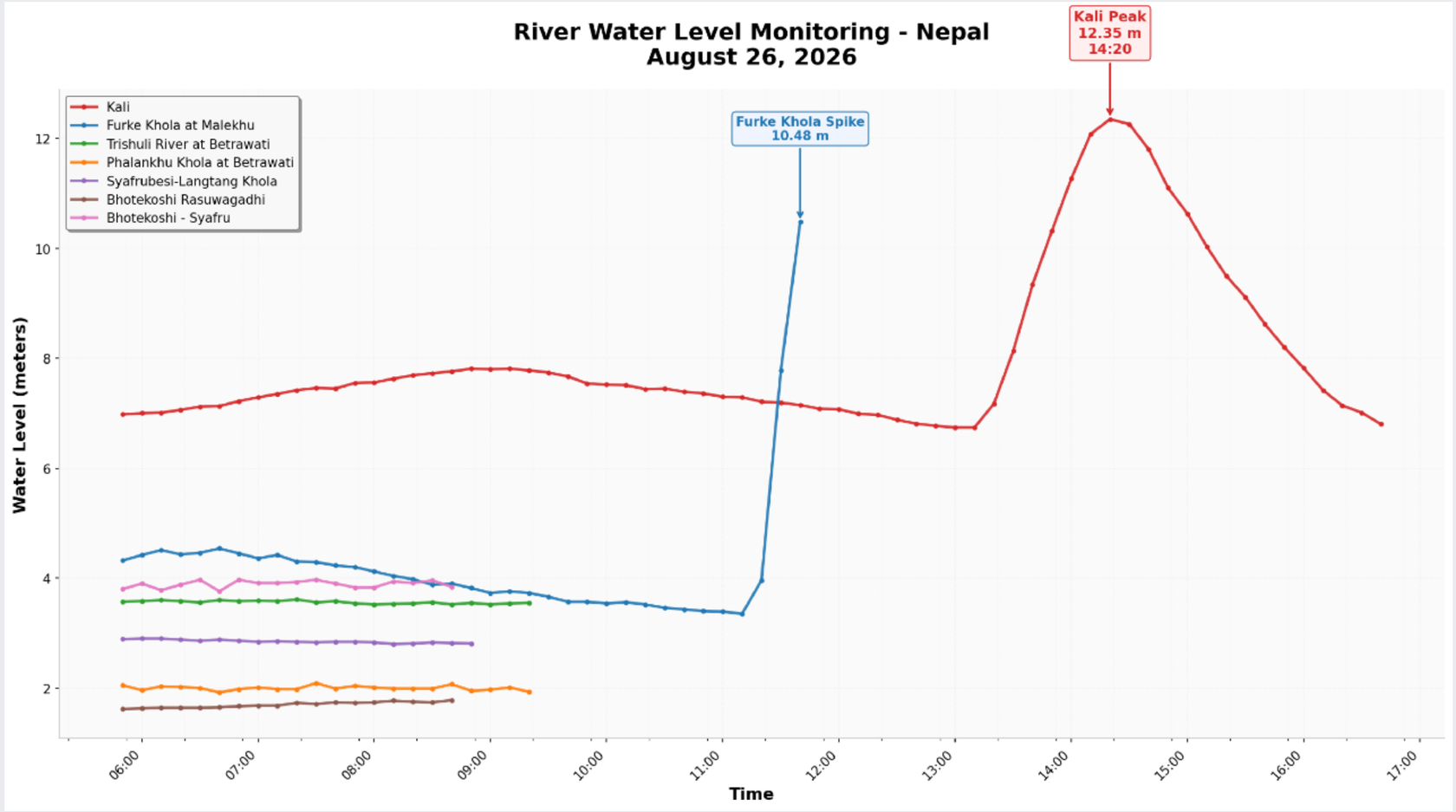
Overall concept in a frame











Trishuli, Aug 2026: DHM Ground Stations were destroyed to the flood

Affected Nagarpalikas along the Trishuli — building damage intensity

28,848 people estimated affected

7212 buildings estimated affected

NDRRMA Report, September 11

Metric	Status/Count
Confirmed Fatalities	1,386 bodies recovered
Missing Persons	5,130 unaccounted for



Syafrubesi



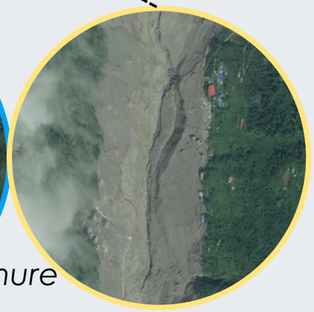
Devighat





Rasuwagadhi



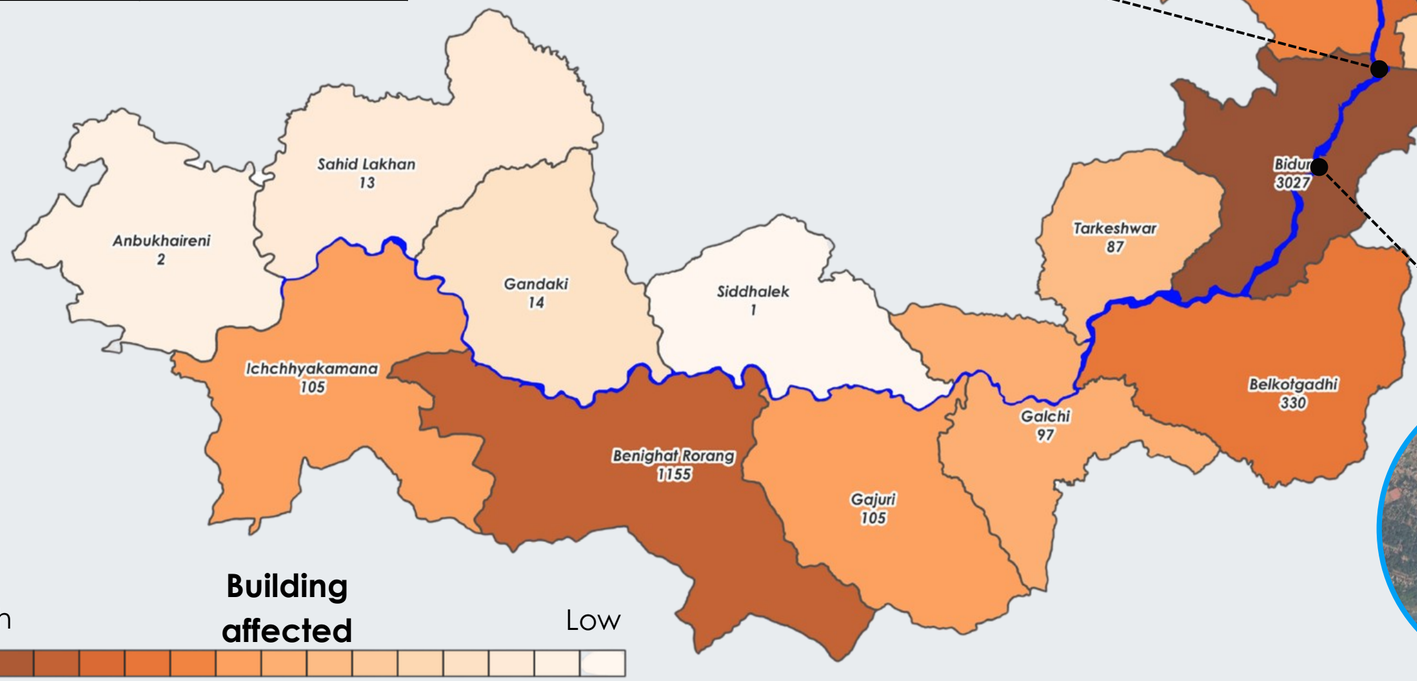


Timure





Trisuli bazar



Building affected

High — Low

Vantor

Model Development Journey

Model Version	Input variables	Catchment features	Remarks
V1	tp, t2m, u10, v10, q	Not included	Meterological variables only
V2	tp, t2m, u10, v10, q, swlv1	included	added catchment features and soil moisture
V3	tp, t2m, u10, v10, q, swlv1, Q	included	discharge inputs

Stats of different version

Model Version	NSE
V1	0.582
V2	0.659
V3	**0.708**

t2m = Temperature

tp= total precipitation

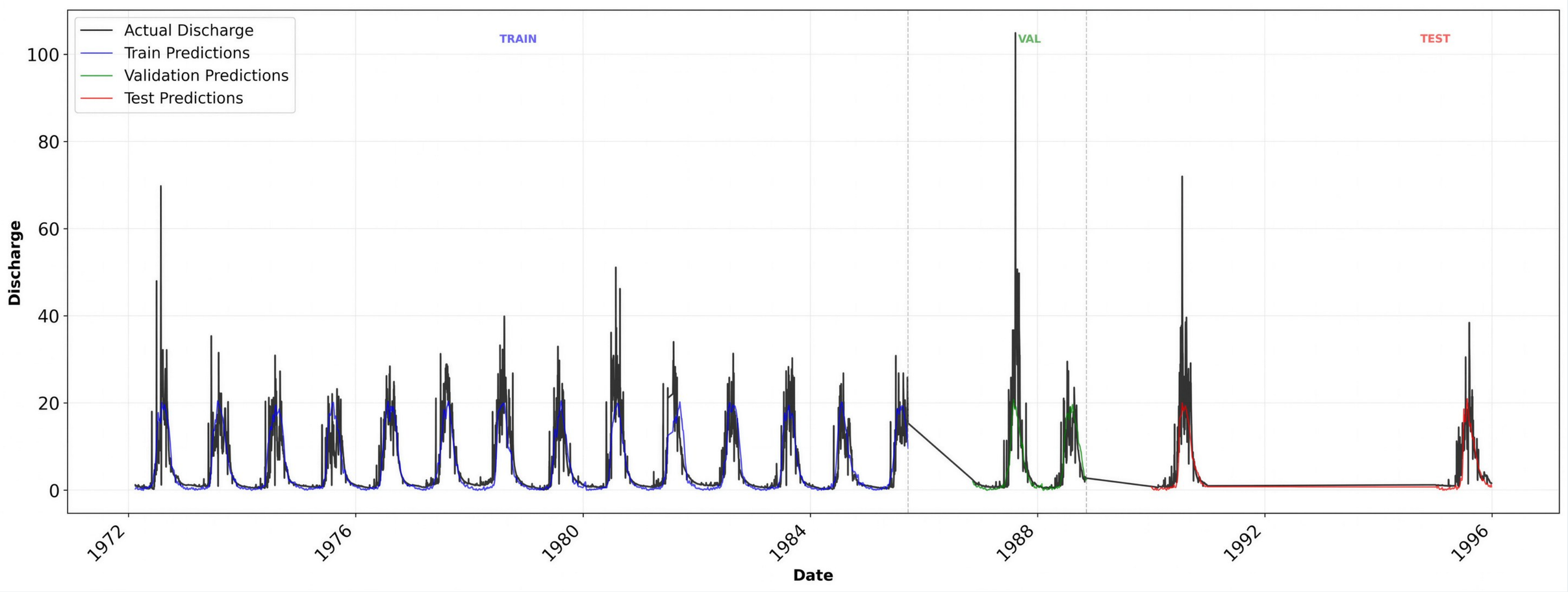
u10, v10 = wind component

q = specific humidity

swlv1 = soil moisture

Q = Discharge

Upper Mailung Model V2 Stats



Split	Train
NSE	0.732

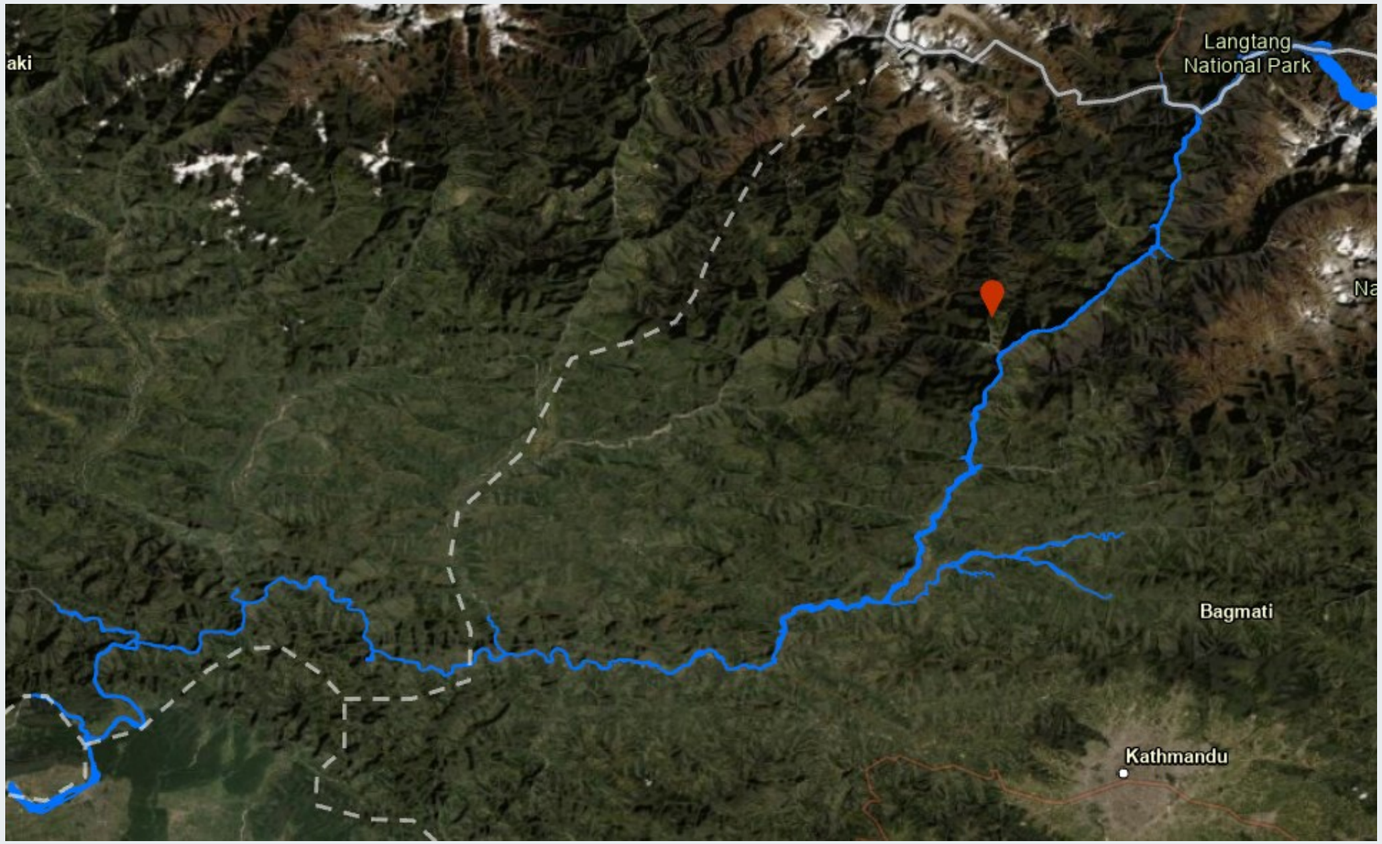
0.75-1	0.65 - 0.75	0.50-0.65	<0.5
Very Good	Good	Fair	Inadequate

Source: Salis, Hugo & da Costa, Adriana & Vianna, João & Schuler, Azeneth & Künne, Annika & Fernandes, Luís & Pacheco, Fernando. (2019). Hydrologic Modeling for Sustainable Water Resources Management in Urbanized Karst Areas. International Journal of Environmental Research and Public Health. 16. 2542. 10.3390/ijerph16142542.

Hydro Model

- Upper Mailung model testing
  - Tried adding weights to extra variables like temperature, soil moisture, humidity, and wind, but the performance did not improve.
  - Tested precipitation weighting, low-flow weighting, and transition weighting to give more importance to flow conditions.
  - Rechecked the base model (precipitation weighting only) for the 15-day forecast, and the model improved to an NSE of 0.80

Forecast ahead	R2
45 days	0.771
15 days	0.803
7 days	0.812


aki
Langtang
National Park
Bagmati
Kathmandu

