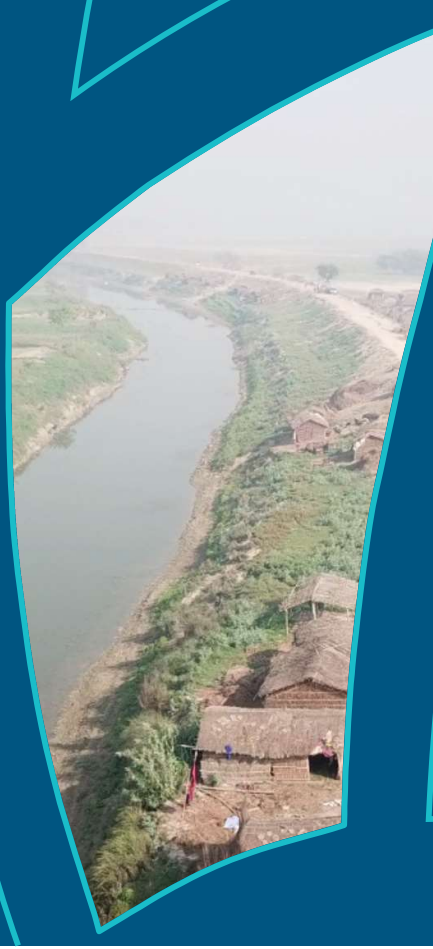
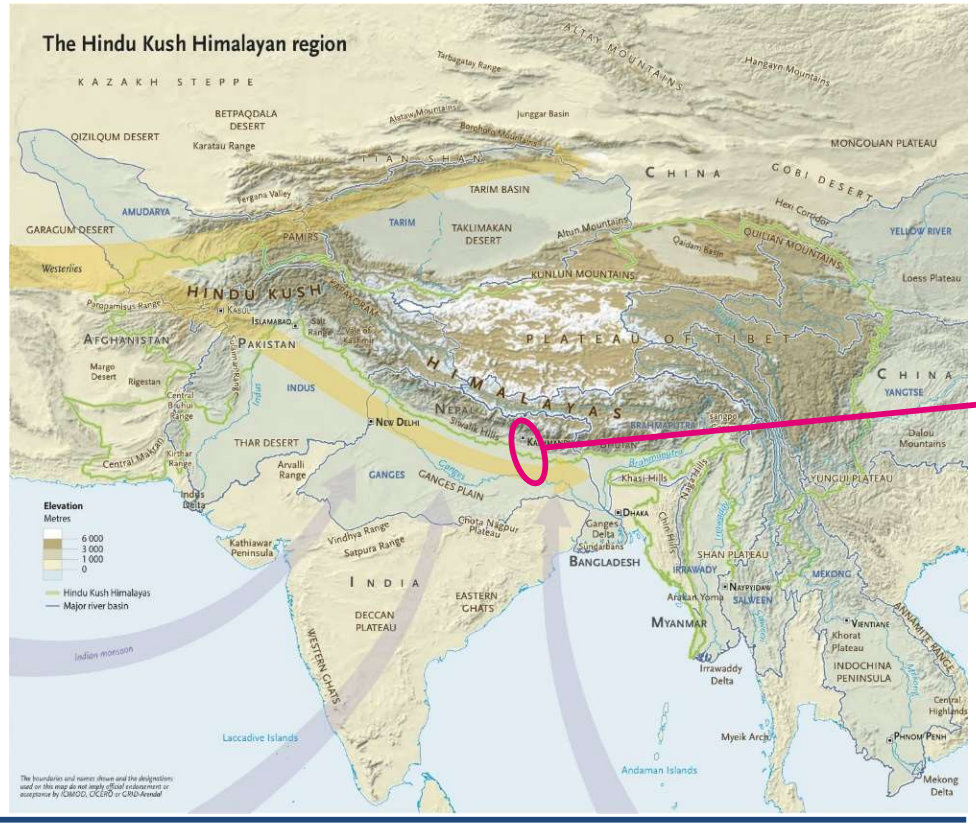
Bagmati-Adhwara River Basin Flood Forecasting System India

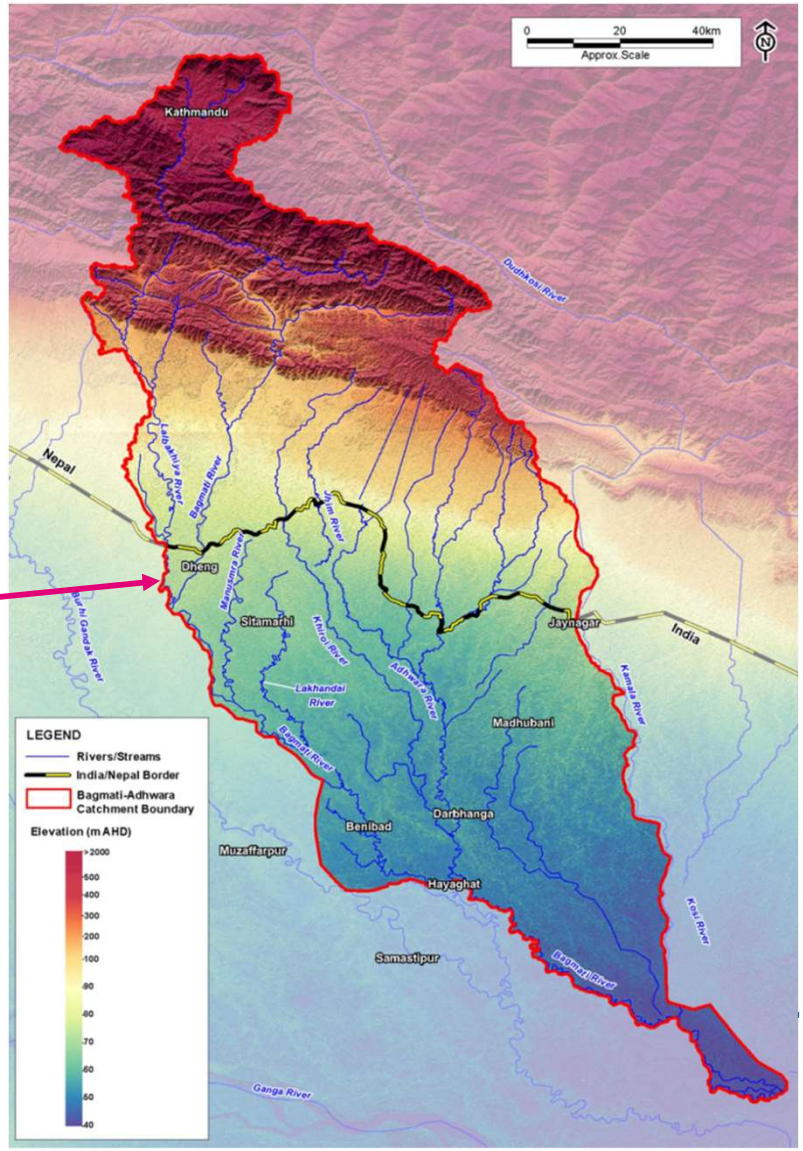
AWS Webinar | 22 November 2023

Ben Caddis



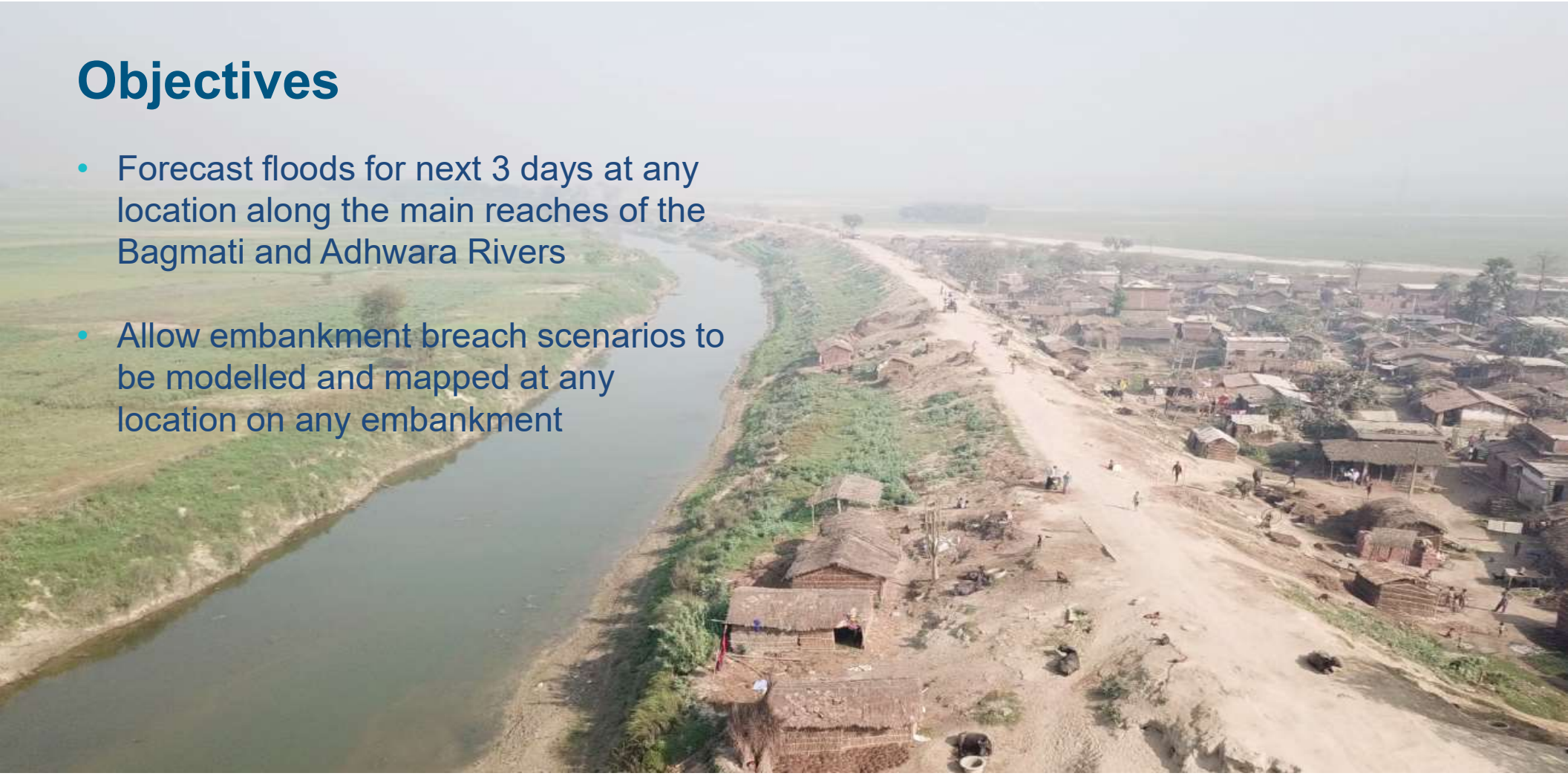
Project location





Objectives

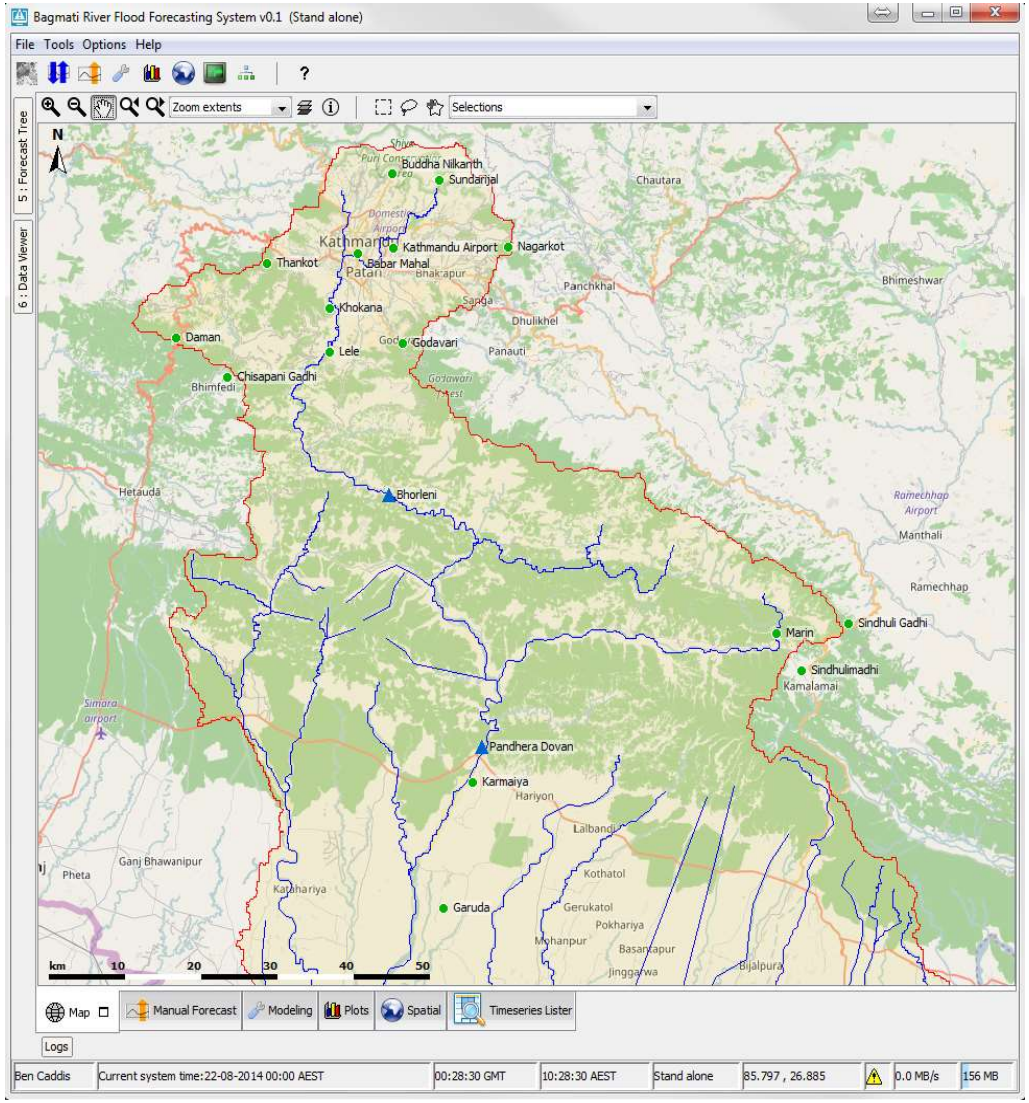
- Forecast floods for next 3 days at any location along the main reaches of the Bagmati and Adhwara Rivers
- Allow embankment breach scenarios to be modelled and mapped at any location on any embankment



BMT

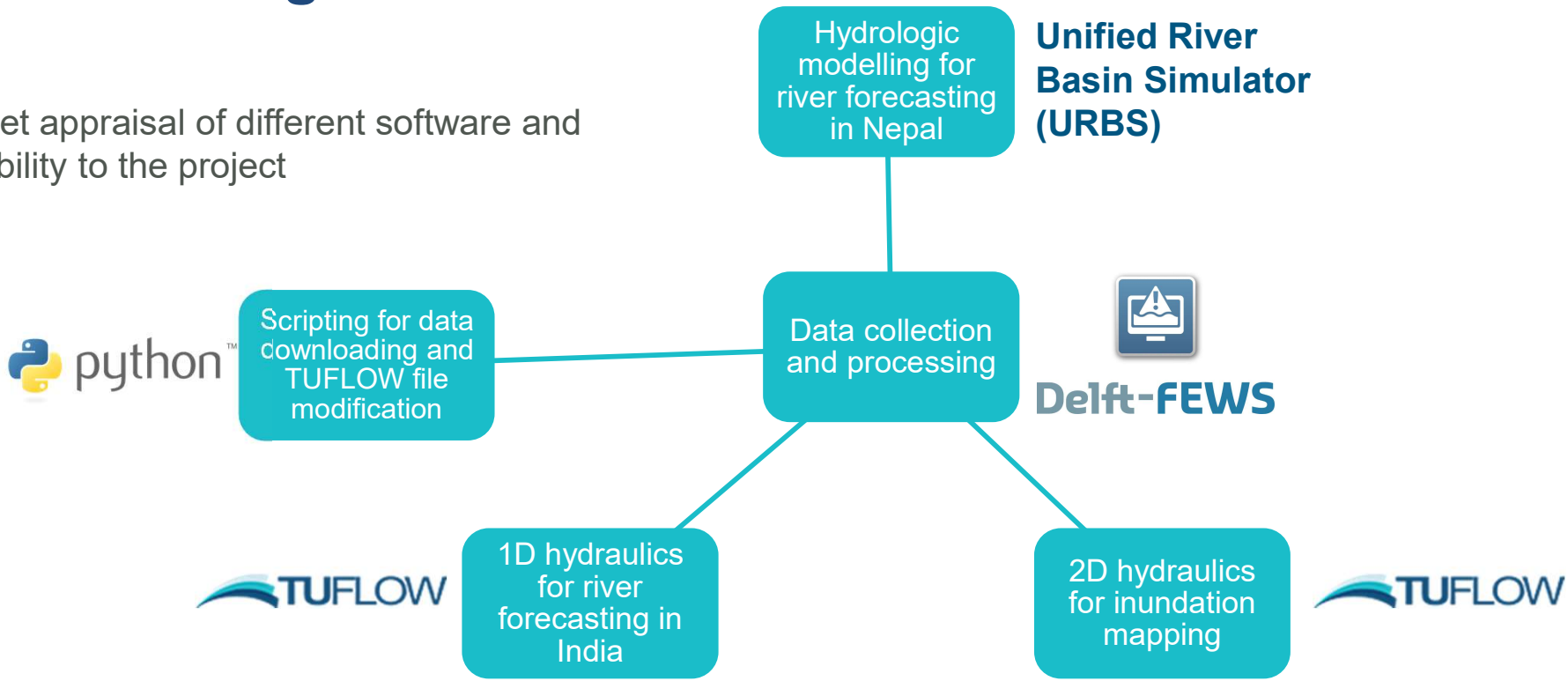
Challenges

- More than half of the catchment is located in Nepal
- Sparse network of rain gauges within Nepalese part of catchment for direct use in models, and verification of satellite observations
- One available river gauge in Nepal
- Large variability of rainfall across the catchment
- Data quality issues



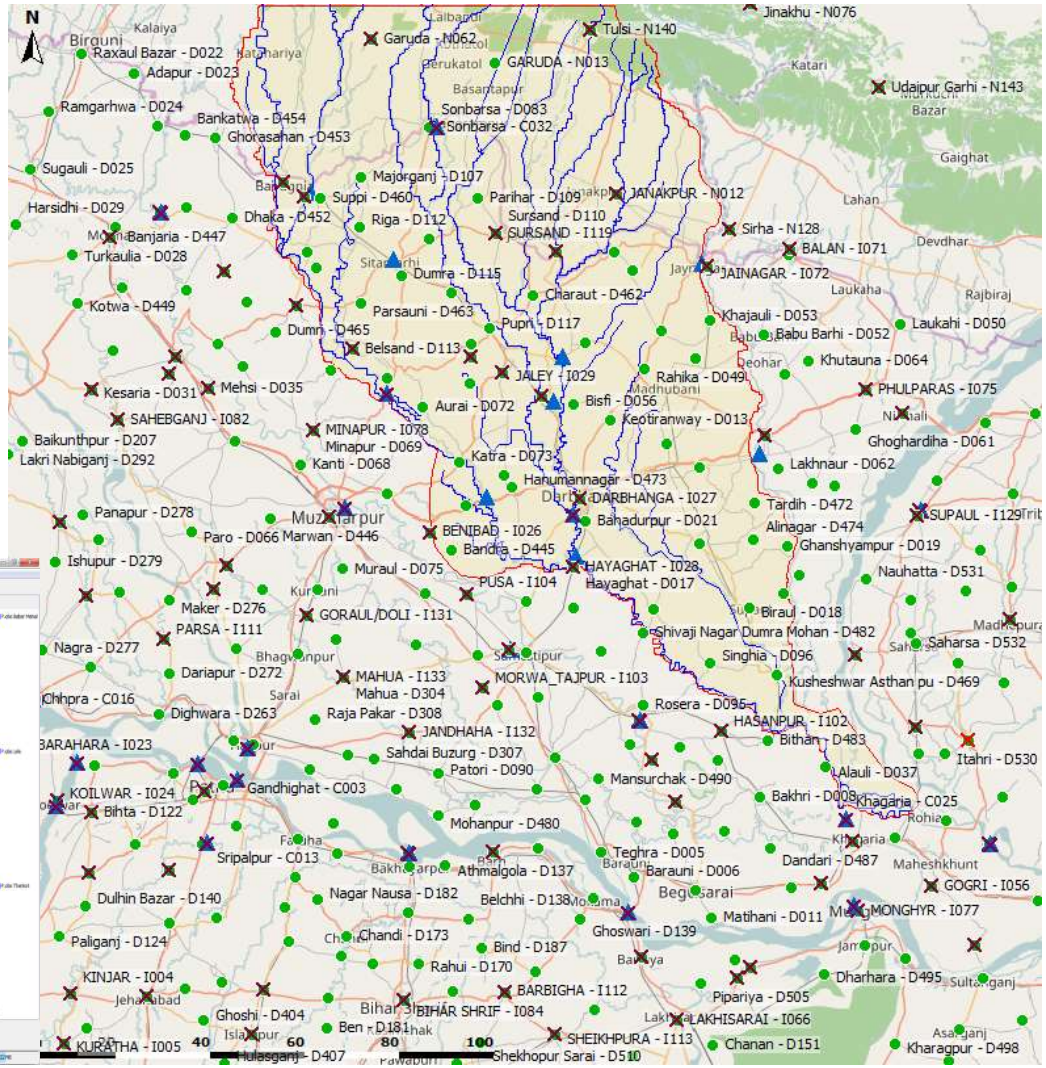
Software design

- Market appraisal of different software and suitability to the project



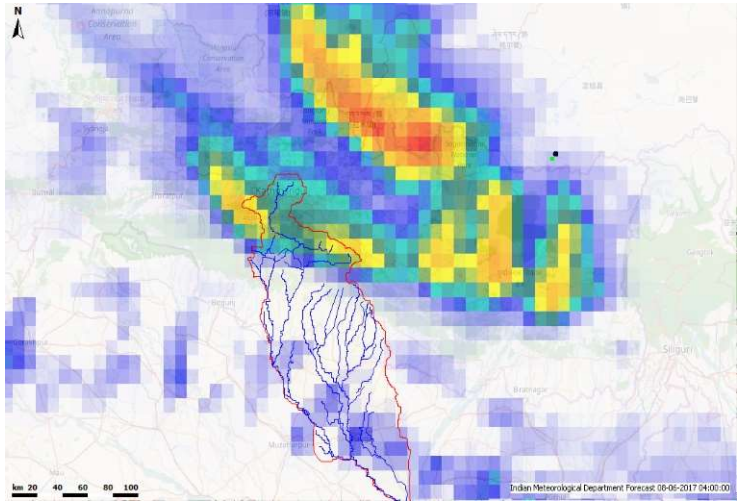
Data input - rainfall

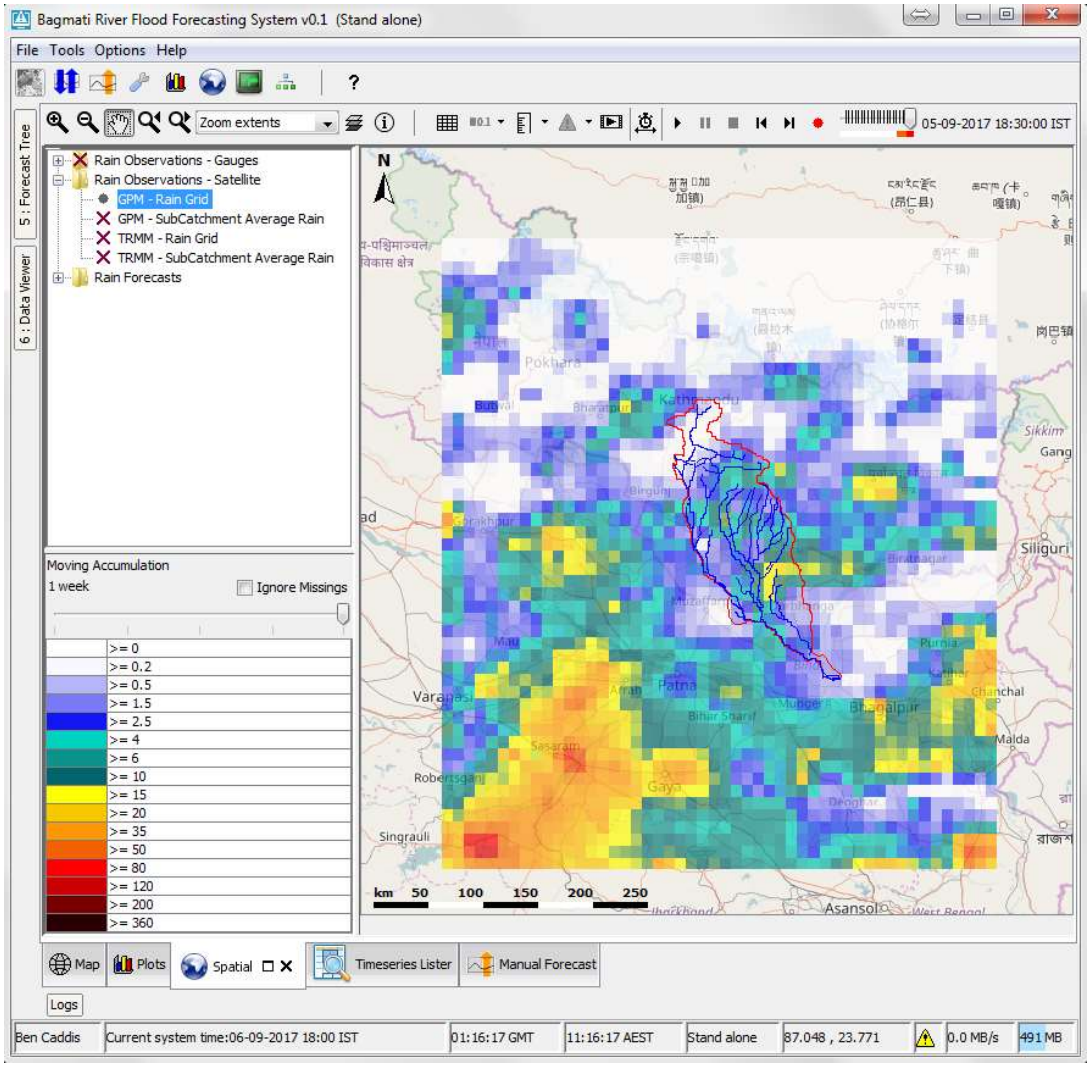
- Data accessed from international agencies (NASA, JAXA, NOAA, UCAR)
- Feeds from Indian Meteorological Department, Central Water Commission and other national agencies
- Data from Nepalese sites from DHM website



Data input

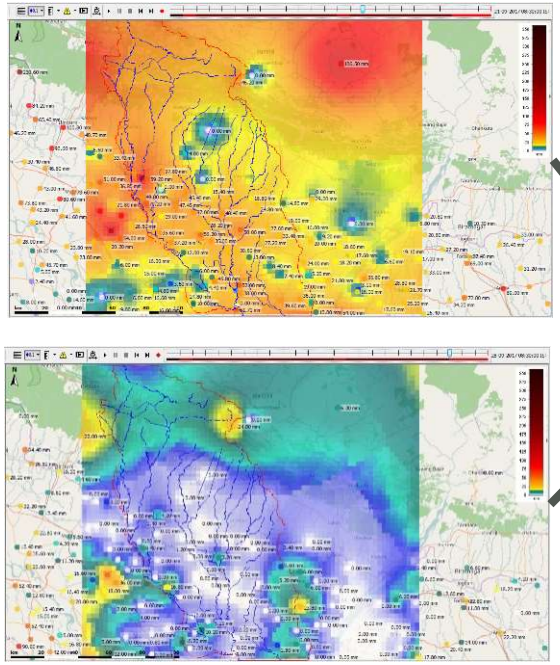
- Gridded rainfall estimates (GPM) updated every 30 minutes
- Gridded rainfall forecasts (IMD, GFS) updated every 12 hours



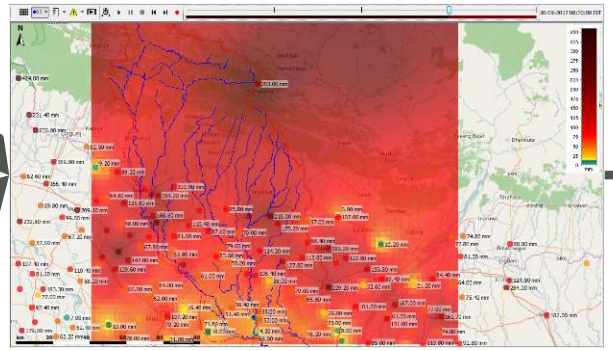


Rainfall processing - observations

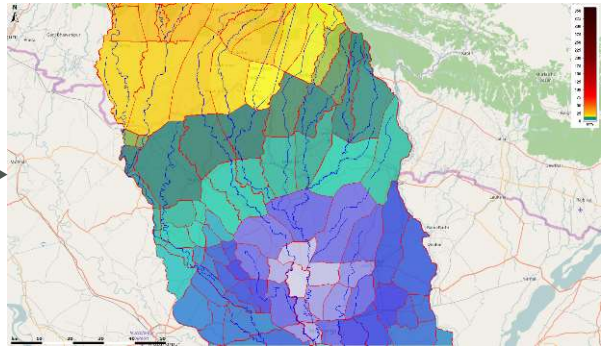
Original:



Missing gauges removed:

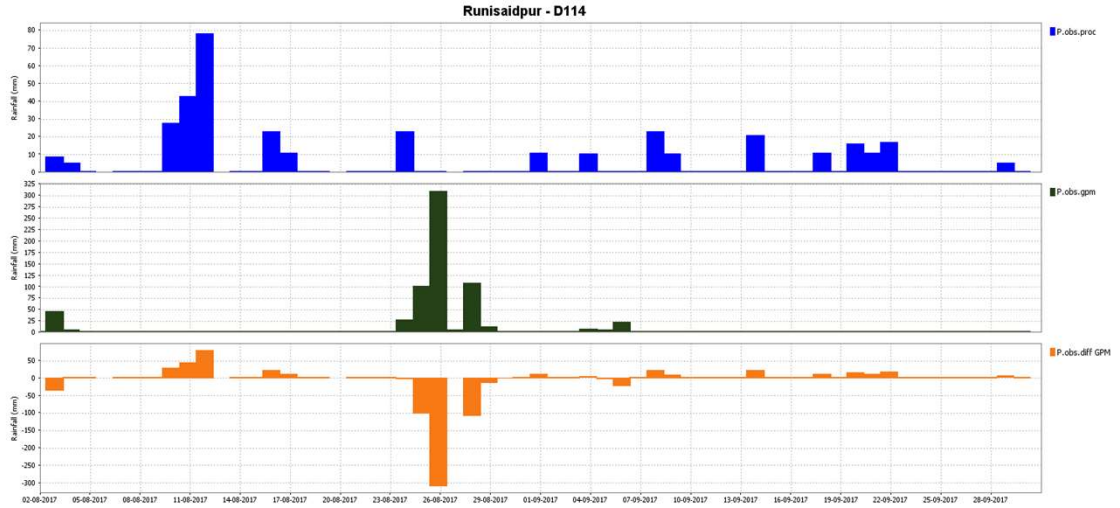


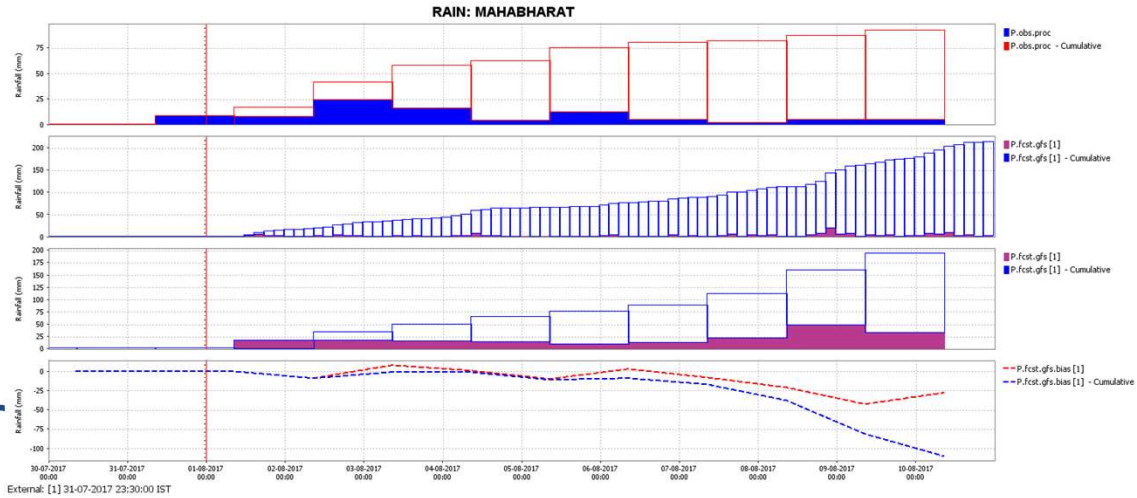
Sub-catchment average:



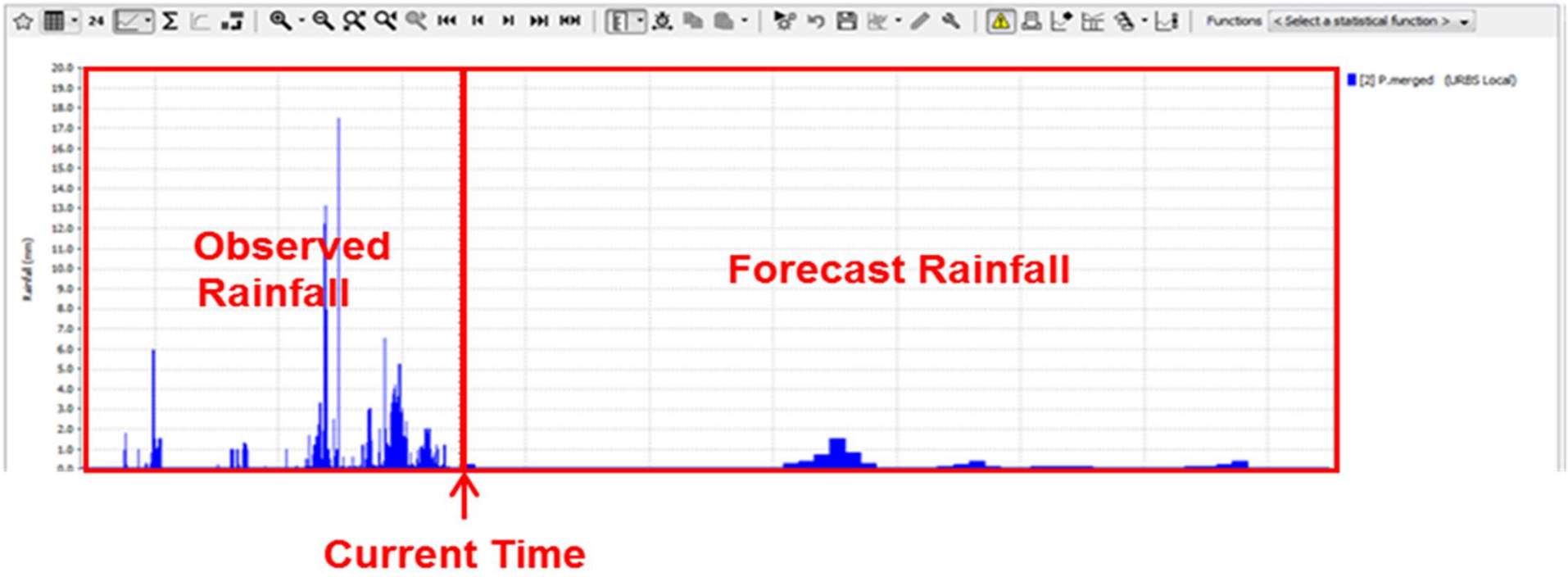
Bias correction

- Two methods for assessment of bias:
  - Rainfall estimates compared against rain gauge locations
  - Catchment average rainfall compared
- Bagmati-FEWS configured for operational bias assessment and correction
- Bias assessment of forecast rainfall only possible in hindcast mode due to need for observed rainfall
- Bias correction can be applied to rainfall estimates (satellite) and rainfall forecasts



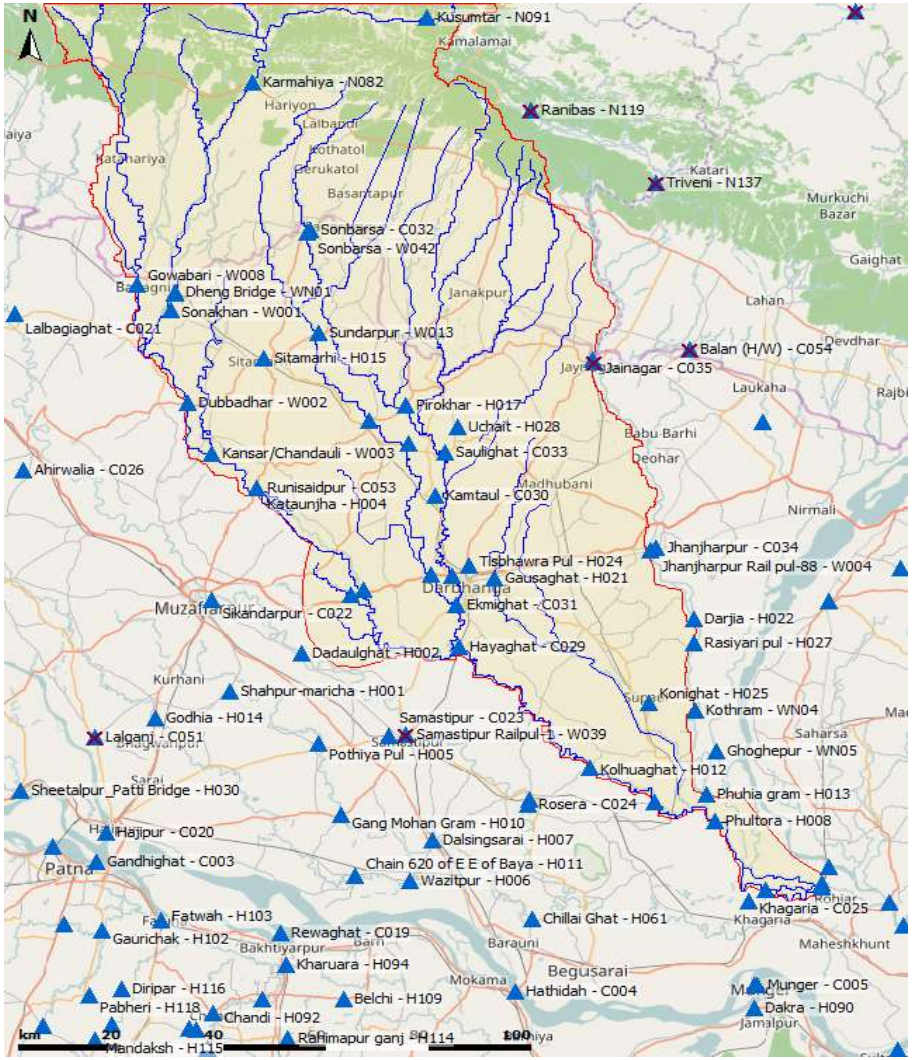


Rainfall processing for forecast modelling



Data input – water levels

- Water levels observed daily
- Data is processed to fill gaps and convert levels to flows using rating curves

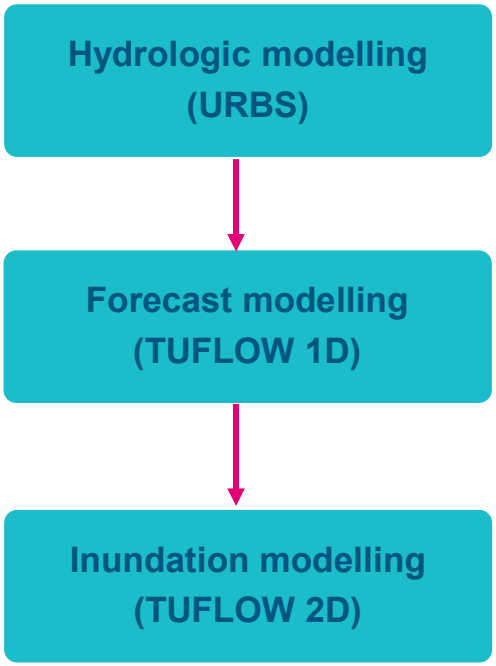


Rating curves

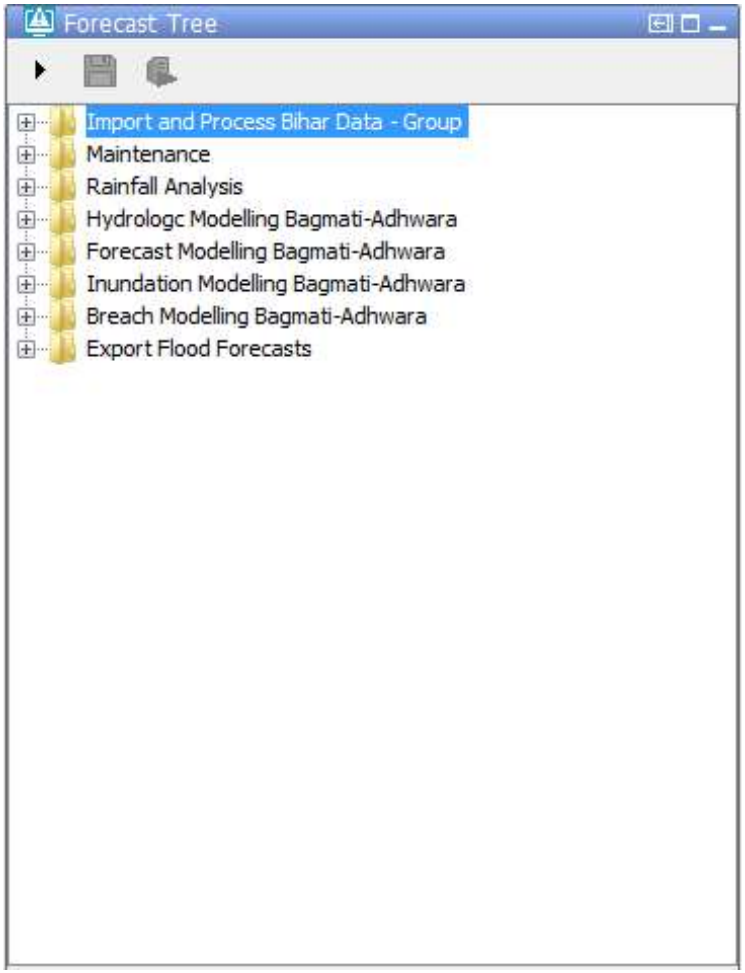
- Rating curves are available for some river gauge sites
- River profile changes on annual basis

BMT

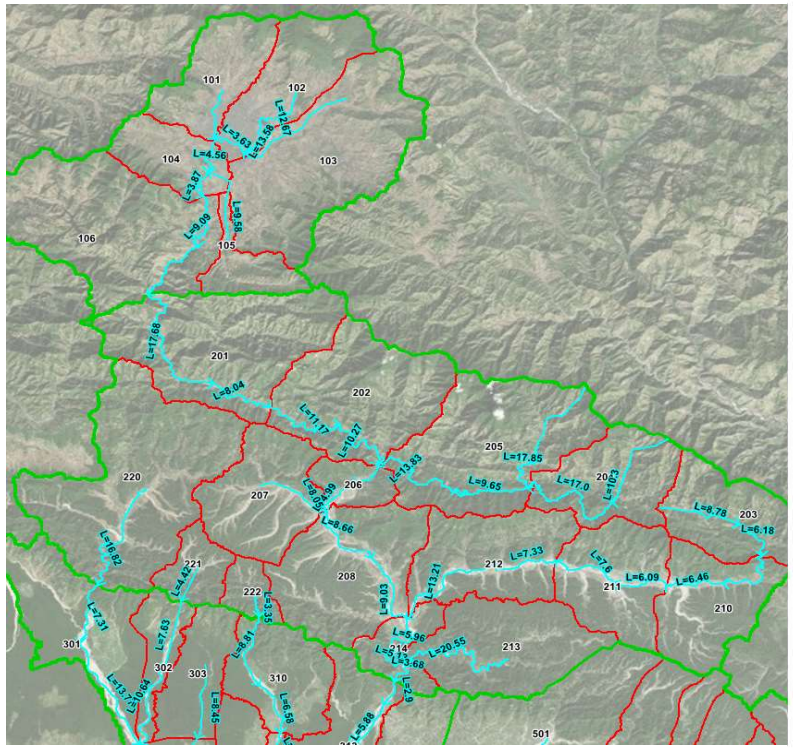
Modelling sequence

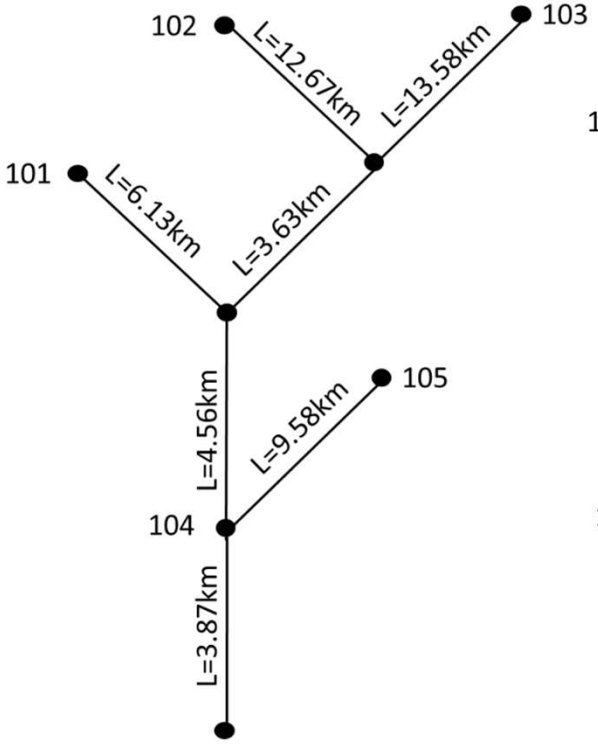


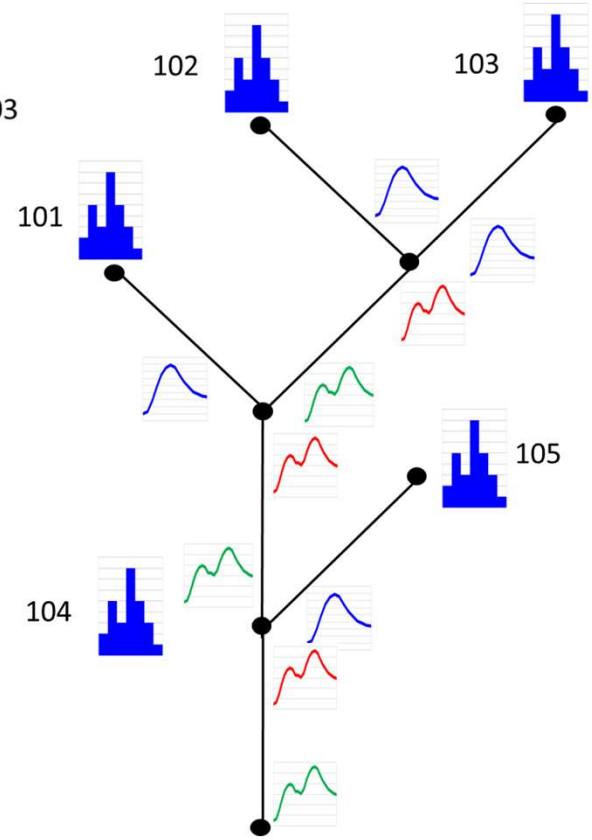
Sequence defined by Forecast Tree to guide the user through the process



Hydrologic modelling

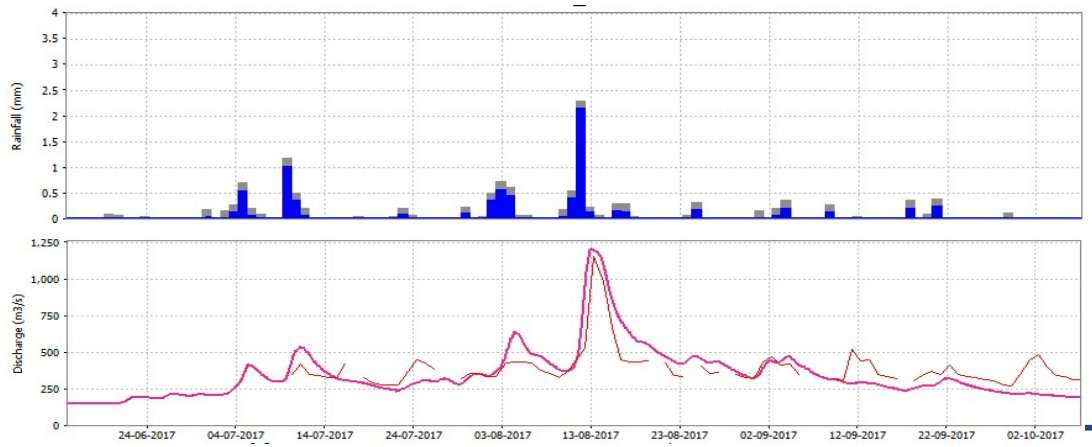




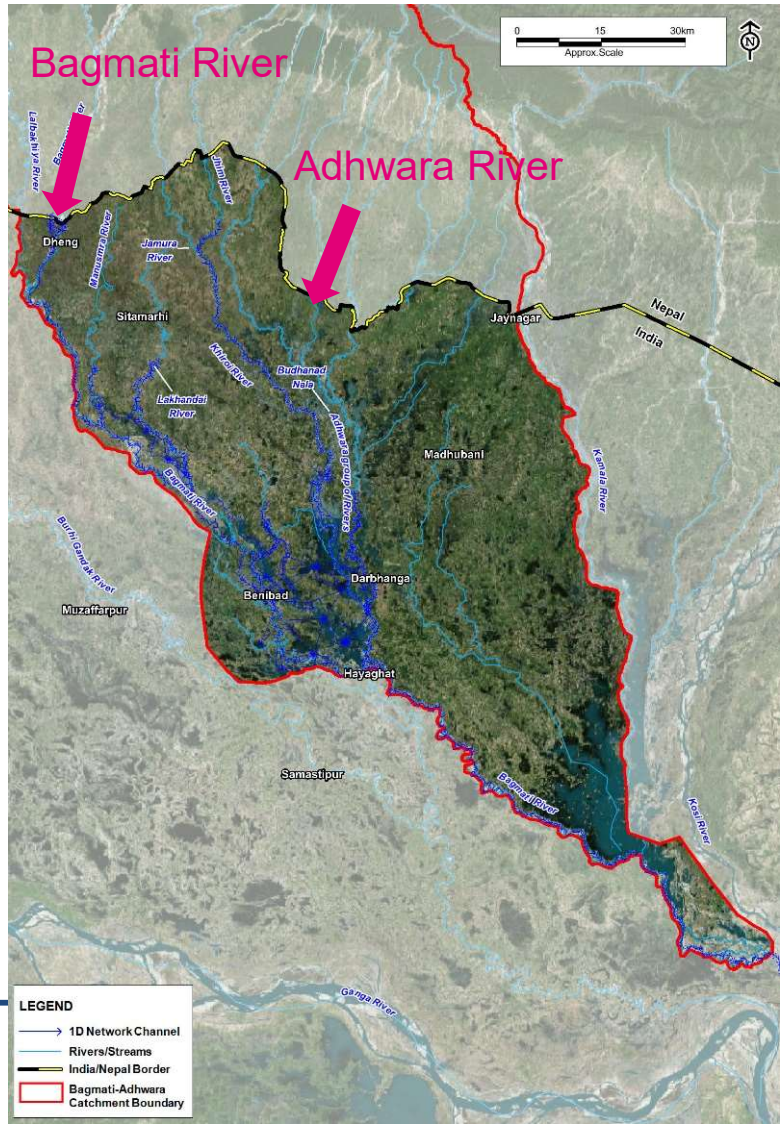


Hydrologic modelling

- Due to limited rain gauge data from Nepal, hydrologic model is run in ensemble mode based on:
  - 7 rainfall depth variations for Bagmati River
  - 7 rainfall depth variations for Adhwara River
- Matrix of 49 inflow scenarios into Indian part of river basin

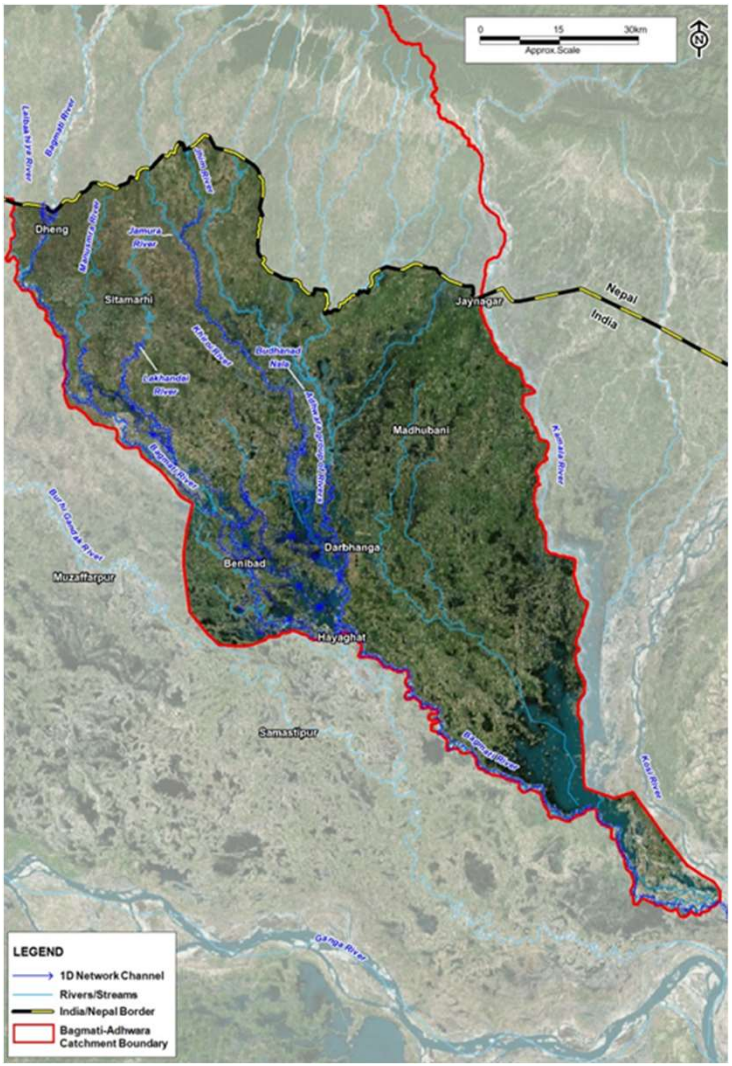


Model calibration only possible on Bagmati River



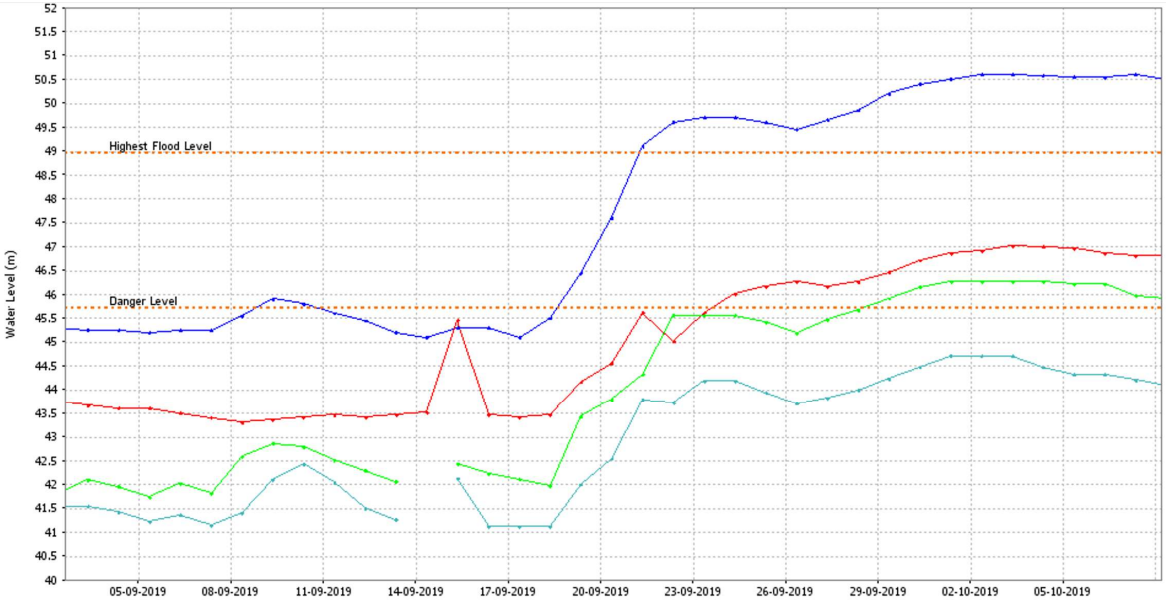
Hydraulic modelling for forecasting

- 1D hydrodynamic model of Bagmati and Khiroi/Adhwara Rivers (based on availability of cross sections)
- Modelling options for:
  - Historical runs
  - Ensemble rainfall scenarios
  - Forecast runs
- Ensemble of 49 rainfall scenarios



Hot-start modelling for forecasting

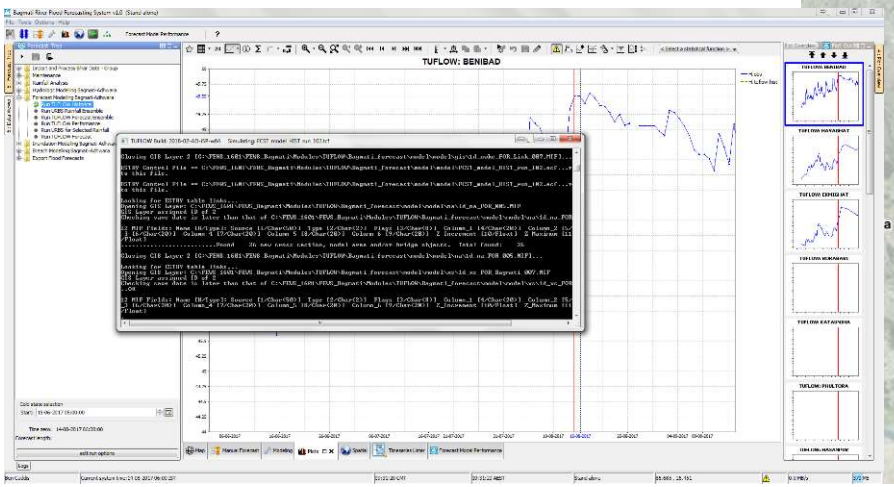
- Annual floods are driven by the monsoon rainfall
- Water levels usually build over several weeks and can remain high for over a month
- Hydraulic modelling generates re-start files to use as initial conditions for next day's simulations
- Restart files can be adjusted / or fully synthetic based on gauged levels
- Allows active tracking of volume of water in the river system

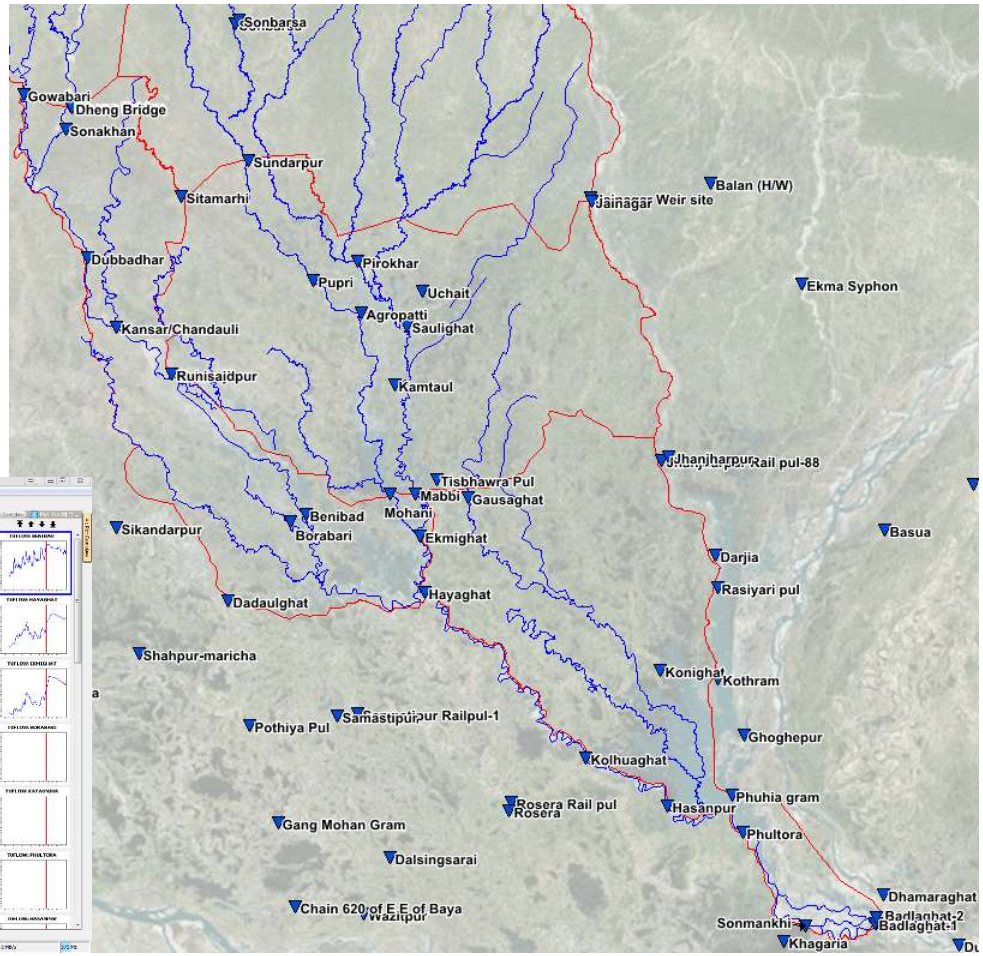


BMT

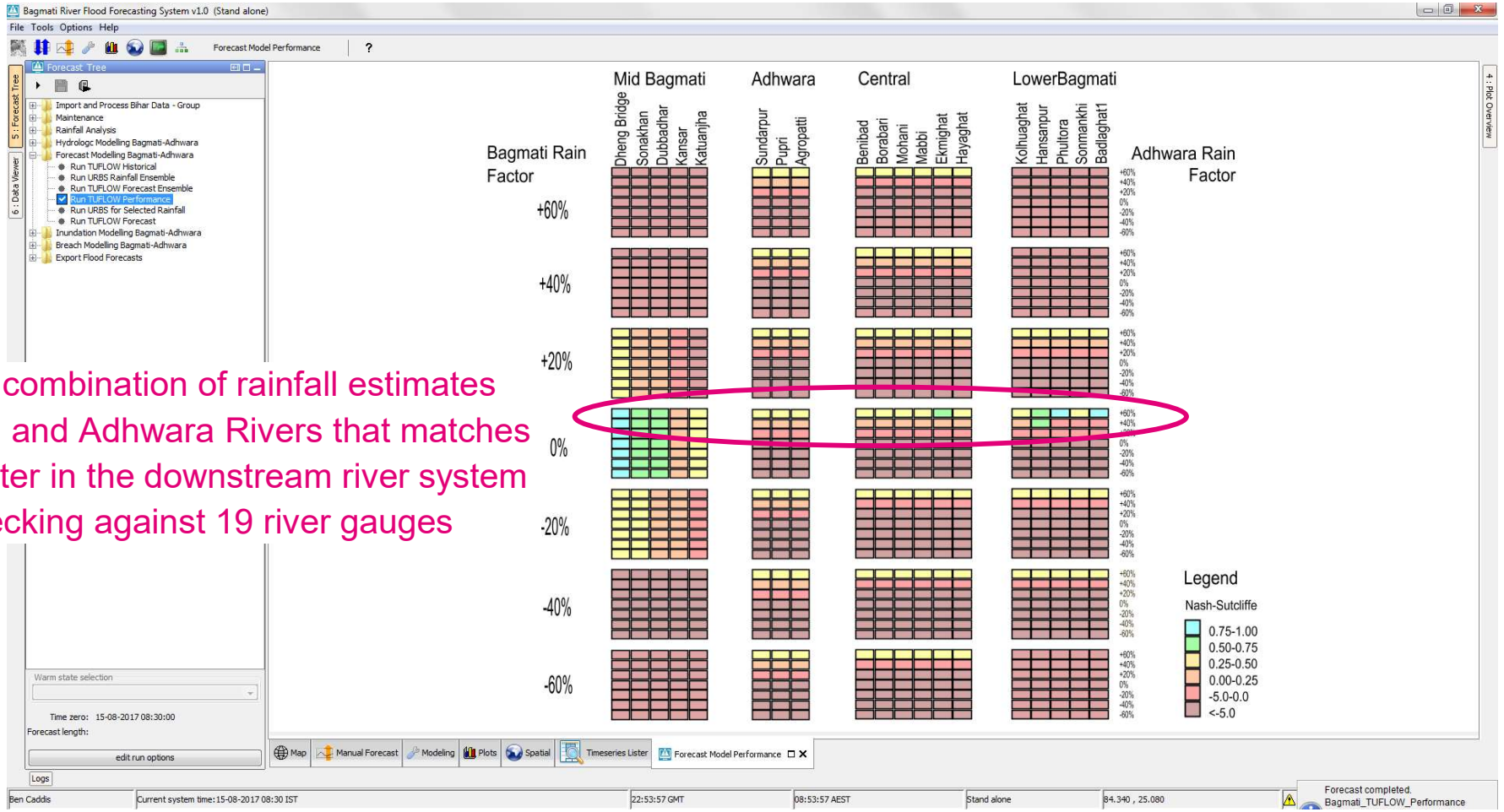
Hydraulic modelling for forecasting

- In 2018 the 1D hydrodynamic model took:
  - approximately 90 seconds to run for a single forecast
  - approximately 40 minutes to complete the 49 member ensemble
- Model results assessed using the Nash-Sutcliffe performance indicator at 19 river gauge sites





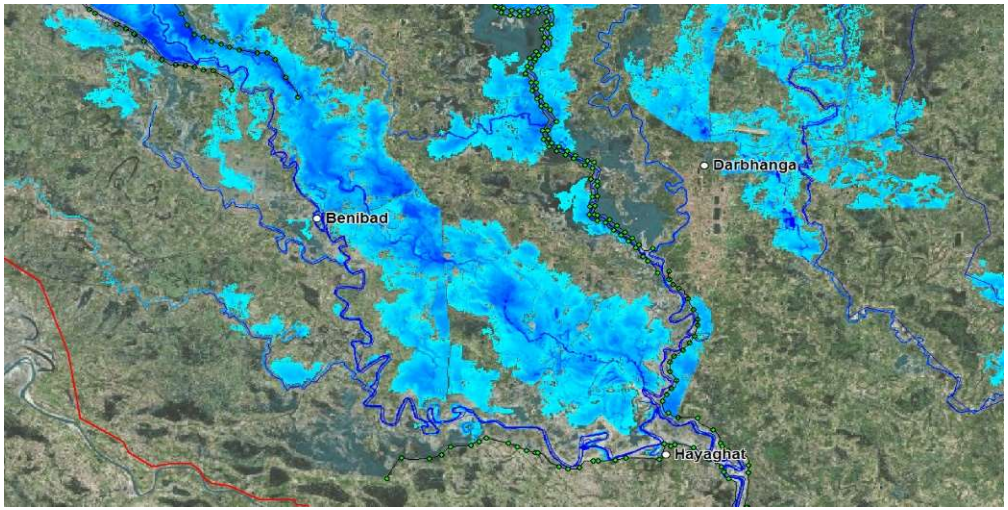
Hydraulic modelling for forecasting – performance module

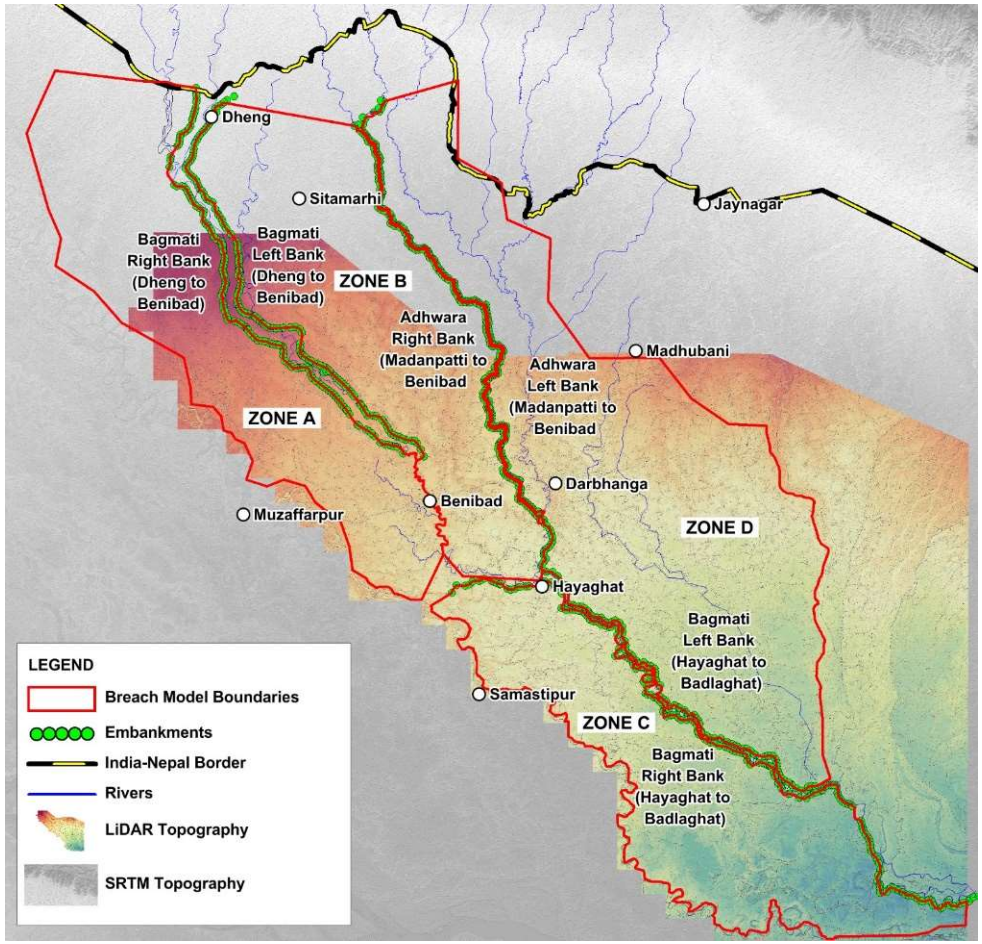


Indicates the combination of rainfall estimates from Bagmati and Adhwara Rivers that matches volume of water in the downstream river system based on checking against 19 river gauges

Hydraulic modelling for inundation mapping

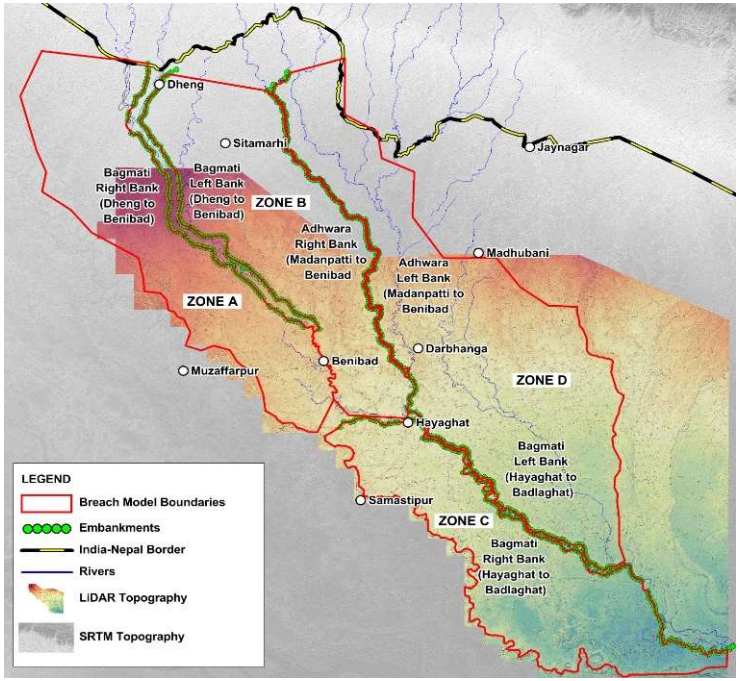
- 2D hydrodynamic model of Bagmati-Adhwara floodplain
- High resolution topography available for most of the project area
- Modelling options for:
  - Historical runs
  - Breach scenarios

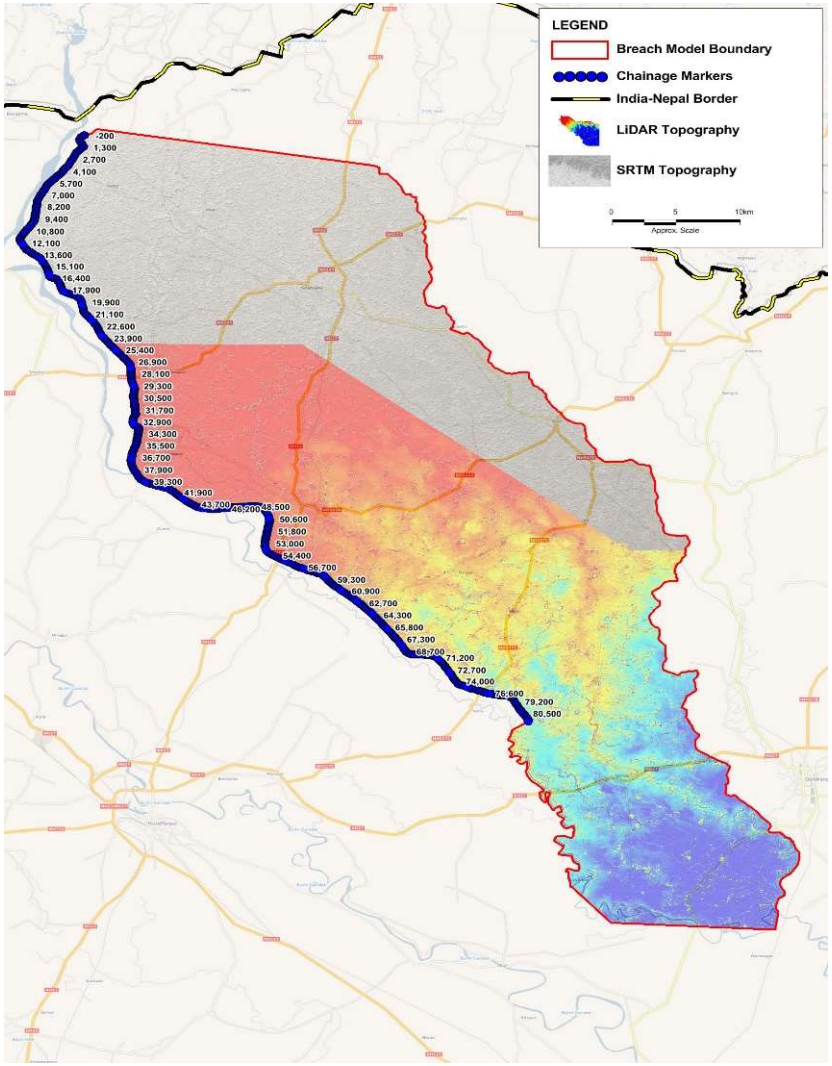




Hydraulic modelling for embankment breach

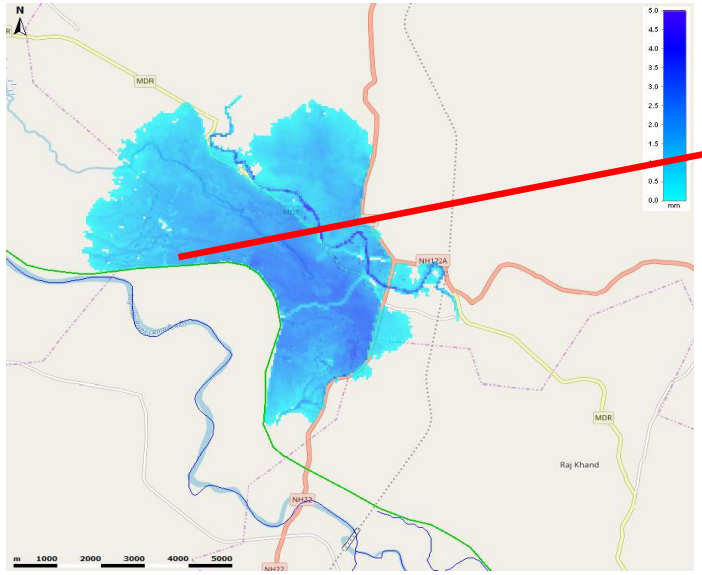
- 2D model for whole floodplain used to generate initial conditions for breach models
- 4 breach models, applied to specific embankments





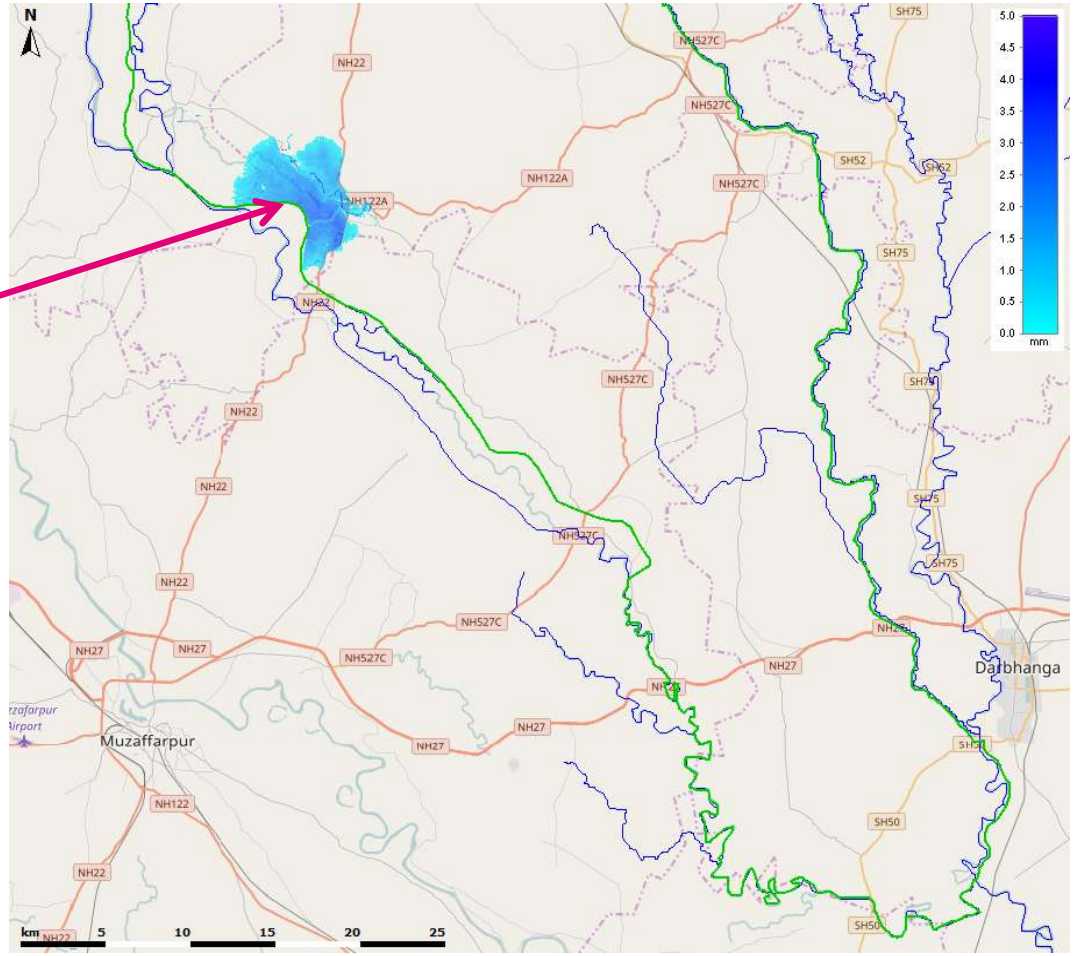
Hydraulic modelling for embankment breach

- Running the breach scenario starts a Python script which generates TUFLOW GIS input layers (MID/MIF):
  - Variable geometry (2d_VZShape)
  - 2D boundary condition (2d_bc)
  - Plot output (2d_po)
- Lookup table for ground levels and bcs

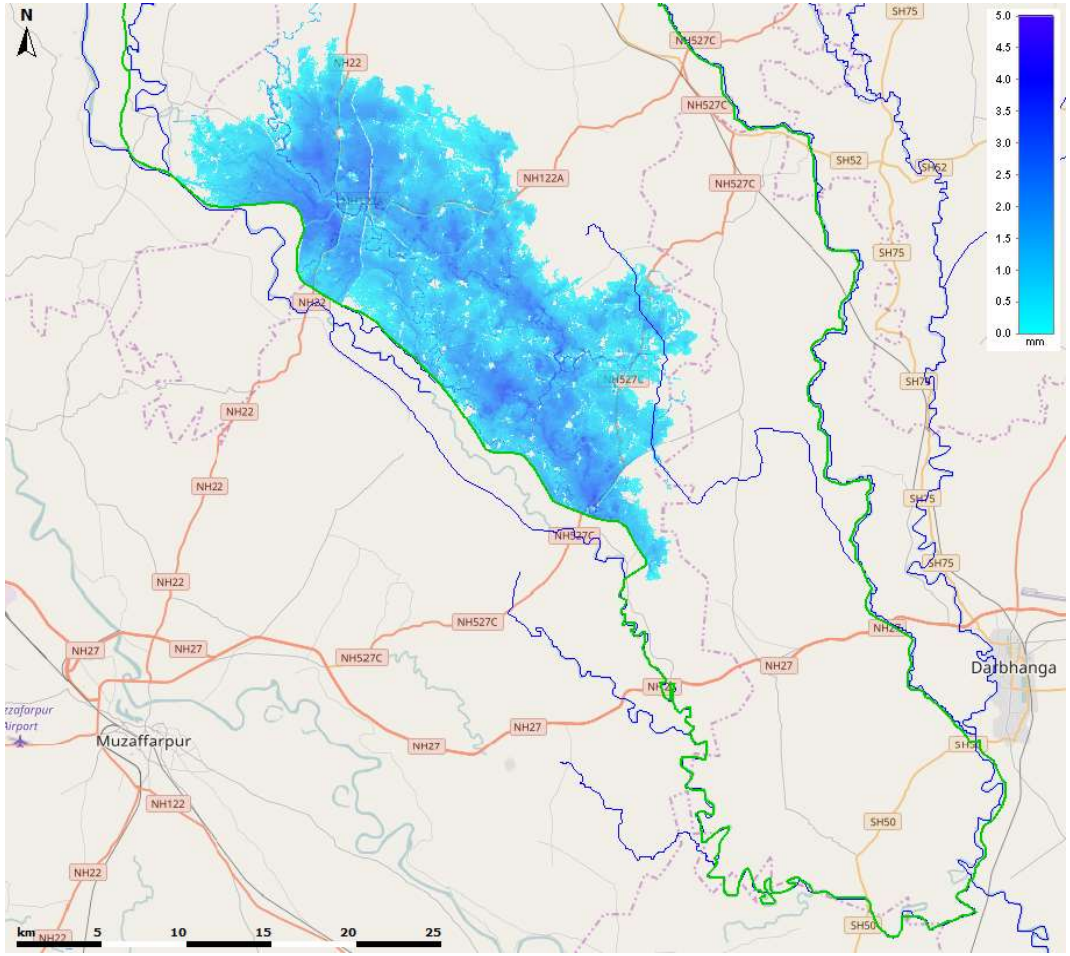


Hydraulic modelling for embankment breach

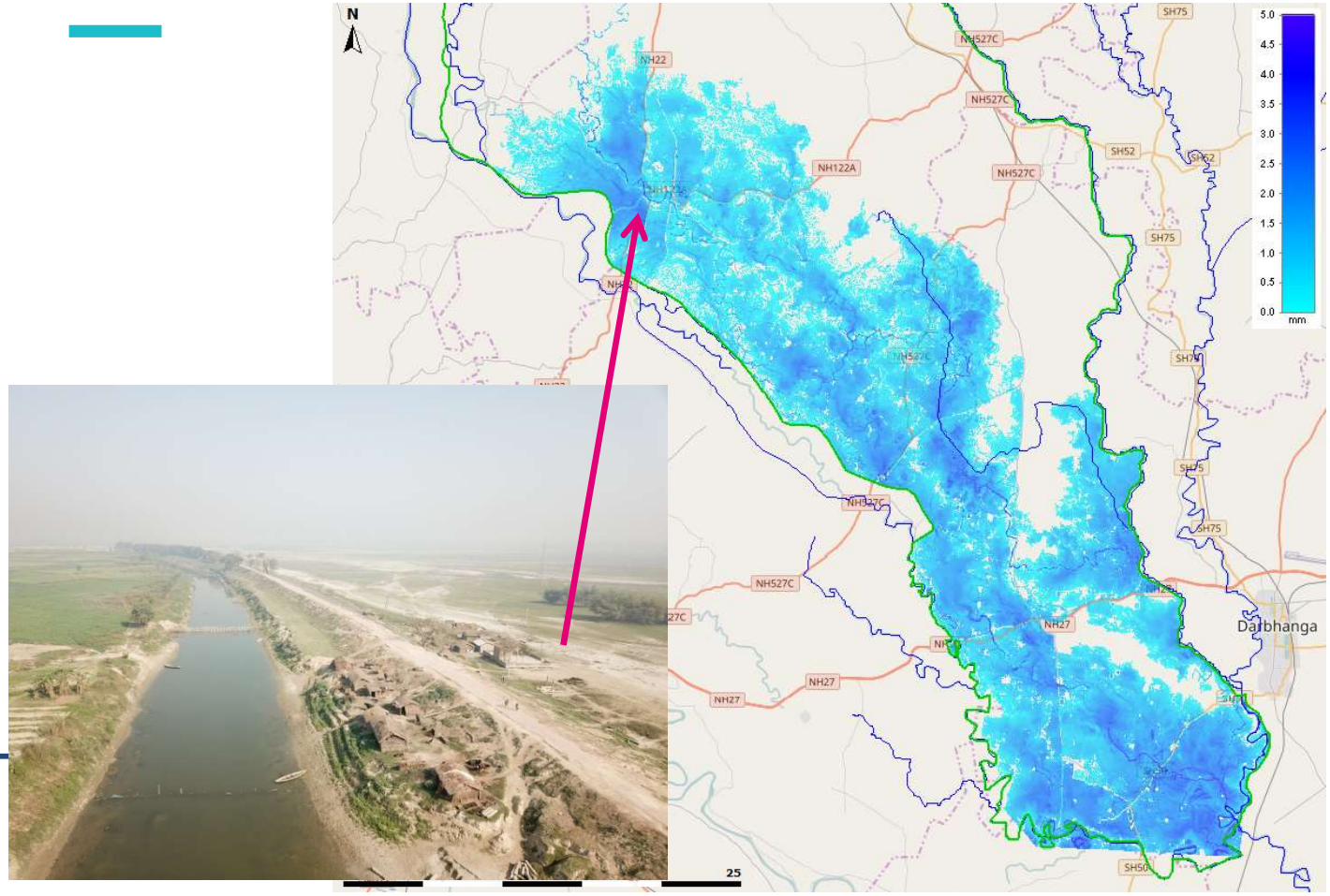
Breach occurs here on 14 August 2017



Hydraulic modelling for embankment breach



Hydraulic modelling for embankment breach



Concluding remarks

- Project objectives were met
- The project delivered a modelling framework and associated training for the client to continue to develop and calibrate models using new and verified data
- NetCDF data handling built into TUFLOW
- Project demonstrates flexibility and power of combining TUFLOW, Python and Delft-FEWS for operational flood forecasting and inundation mapping