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Hydrodynamic Modeling and Flood Inundation Analysis of the Beas River Basin in Northern Himalayas

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Outline of the Presentation

- Introduction
- Objective
- Study Area
- Methods used
- Results
- Conclusion

INTRODUCTION

- Himachal Pradesh has experienced recurring floods in recent years, particularly downstream of the Beas River during the rainy season. Flash floods have become frequent events in mountains.
- Cloudbursts, Landslides and GLOFs are expected during the rainy season because of
  - **Climate change**
  - **Population growth**
  - **Development of extensive infrastructure in close proximity to the river**
  - **Increased frequency of extreme rainfall events.**
- Floods are the most prevalent type of catastrophe, occurring when excess water submerges previously dry terrain.
- The extreme precipitation events are increasing in recent years and continue to increase in future due to global climate change. Thus, such extreme events must be considered in food modeling studies for exact mapping of inundation and risk involved

Damage Photograph Due to Monsoon Session-2022

- 39 incidents of cloud bursts in HP between June and September 2022. Out of these, 2 incidents occurred in June before the onset of the southwest monsoon, and the remaining 37 occurred during the monsoon season.
- District-wise, maximum cloud burst incidents have occurred in Chamba (13), followed by Kullu (10). Thus, 23 of such incidents occurred in just two districts.

Village Neuli Tehsil Sainj District Kullu

Village Bhang Tehsil Manali District Kullu

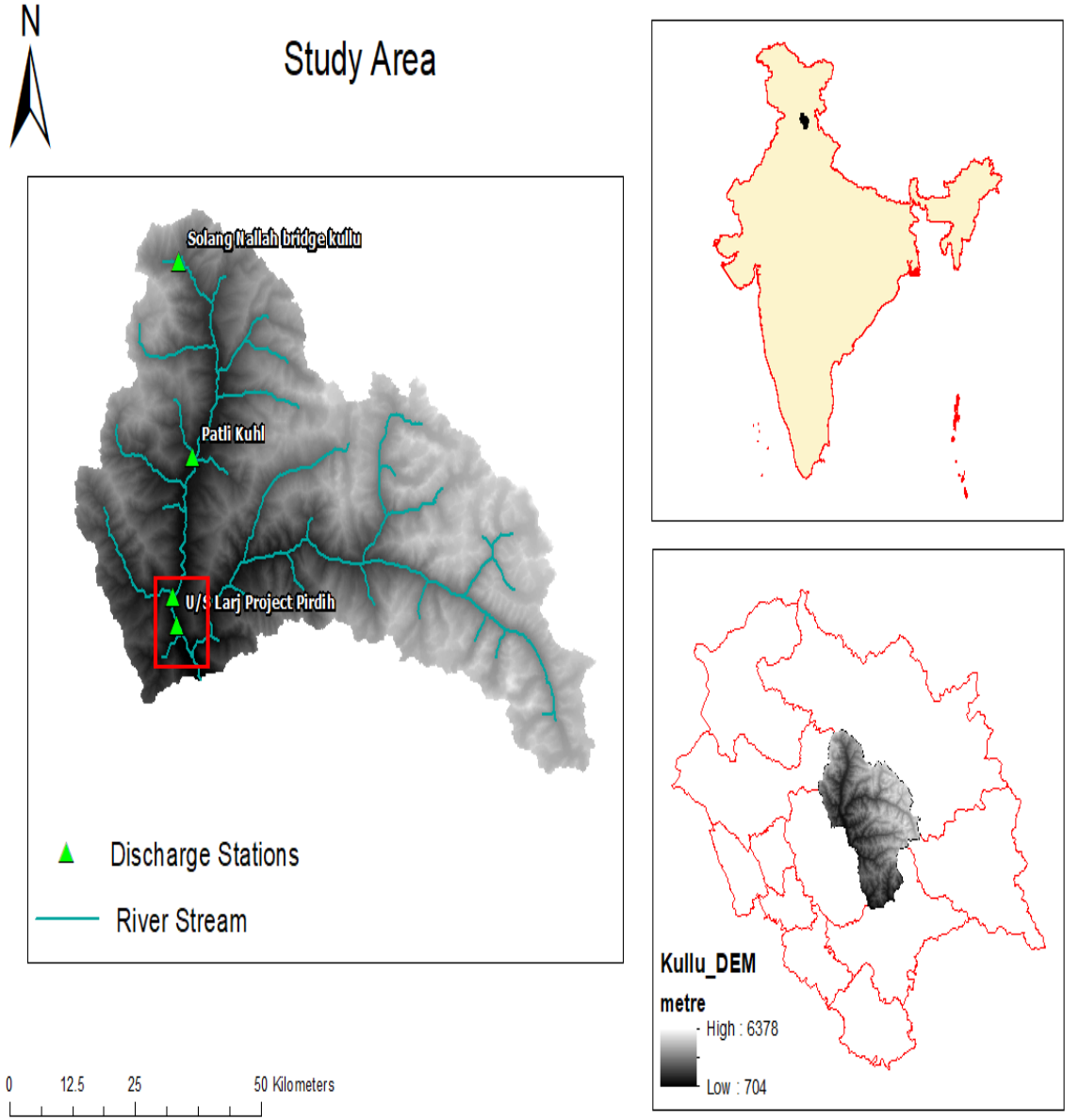
Research Objective

- Development of model for selected river stretch of Beas Sub basin.

- To identify critical stretches for flash flood hazards.

STUDY AREA

- The study area for this Hydrodynamic Modeling is in the Beas River Basin.
- The Beas River originates from Beas Kund located in the Kullu district of Himachal Pradesh at an elevation of around 4085 meters above mean sea level (AMSL), near the Rohtang Pass in the Central Himalayas.
- The basin spans from latitude 31º 43' 30" N to 32º 25' 0" N and from longitude 76º 58' 26.4" E to 77º 51' 44.399" E.
- The river travels approximately 470 kilometers before merging with the Sutlej River in the Indian state of Punjab and has a drainage area of 20303 km^2.
- The red rectangle shown in figure presents the stretch used for hydraulic simulation from Pirdi to Jard in Kullu district.



- The Hydrodynamic Simulation model for the Beas river stretch was developed from 1st May 2022 to 30th October 2022.
- For the current Hydrodynamic Modelling the reach of 9535 Meter is Considered nearby the Kullu City in Himachal Pradesh, India
- The Gauge Station at Pirdhi is Located in the most upstream Point of the desired study reach.
- The Hydrolocial data like daily flow series data is an input for Unsteady flow Analysis.
- For this Study inflow data from State Data Centre Mandi was used. However the data available was only up to 2022 therefore one of the limitations of out study is that the field data after 2022, the field data was not available.

DATA COLLECTION PROCEDURE

S.No	Input Data	Description	Data Source
1.	Observed Discharge Data	Daily Discharge at two gauging stations data from 2021-2022 year	Hydrology Cell, State Data Centre Mandi, H.P
2.	Water level Data	Time Series	Hydrology Cell, State Data Centre Mandi, H.P
3.	Digital Elevation Model	12.5 m Resolution	Alaska Satellite Facility
4.	Land Use Land Cover Map	Sentinel-2 L2A 10-meters	ESRI
5.	Precipitation	Station Based	Indian Meteorological Department (IMD), Pune

Software Used

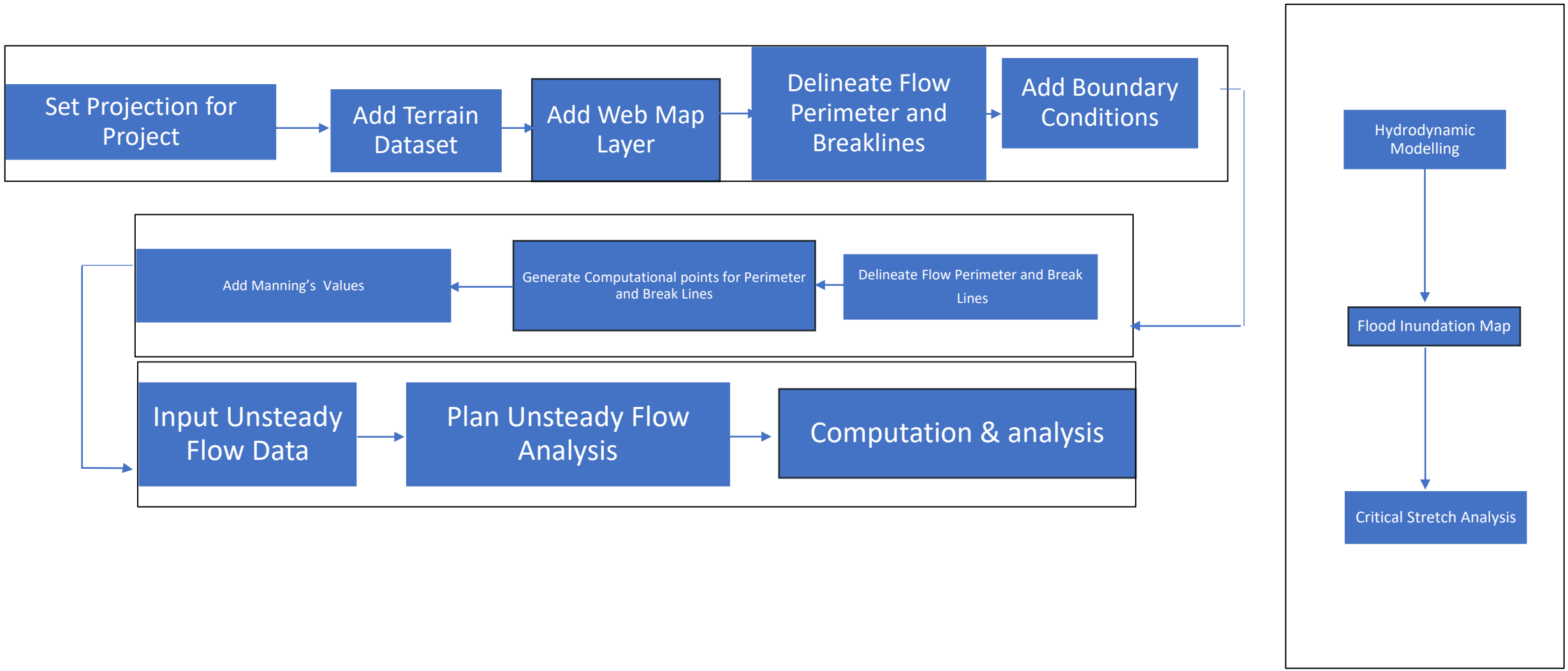
- **HEC-RAS (v6.1)**

  Stands for (Hydrological Engineering Centre - River Analysis System), Used for analysing the flood inundation in Beas River using 2-D Hydrodynamic unsteady flow modeling approaches.

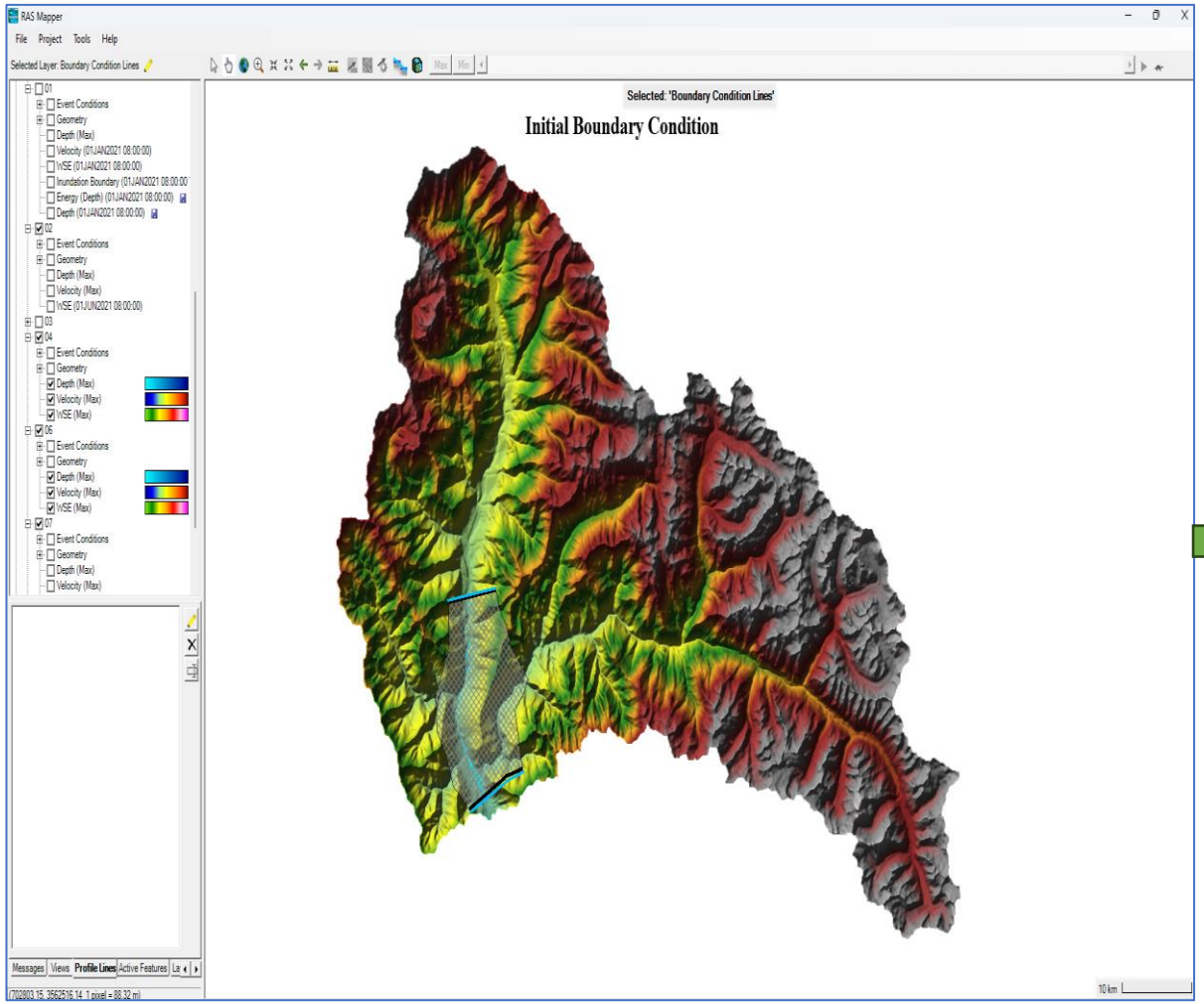
- **Arc-GIS (Ver. 10.2.2)**

  Used for the Watershed development through DEM, which includes information about the river and catchment.

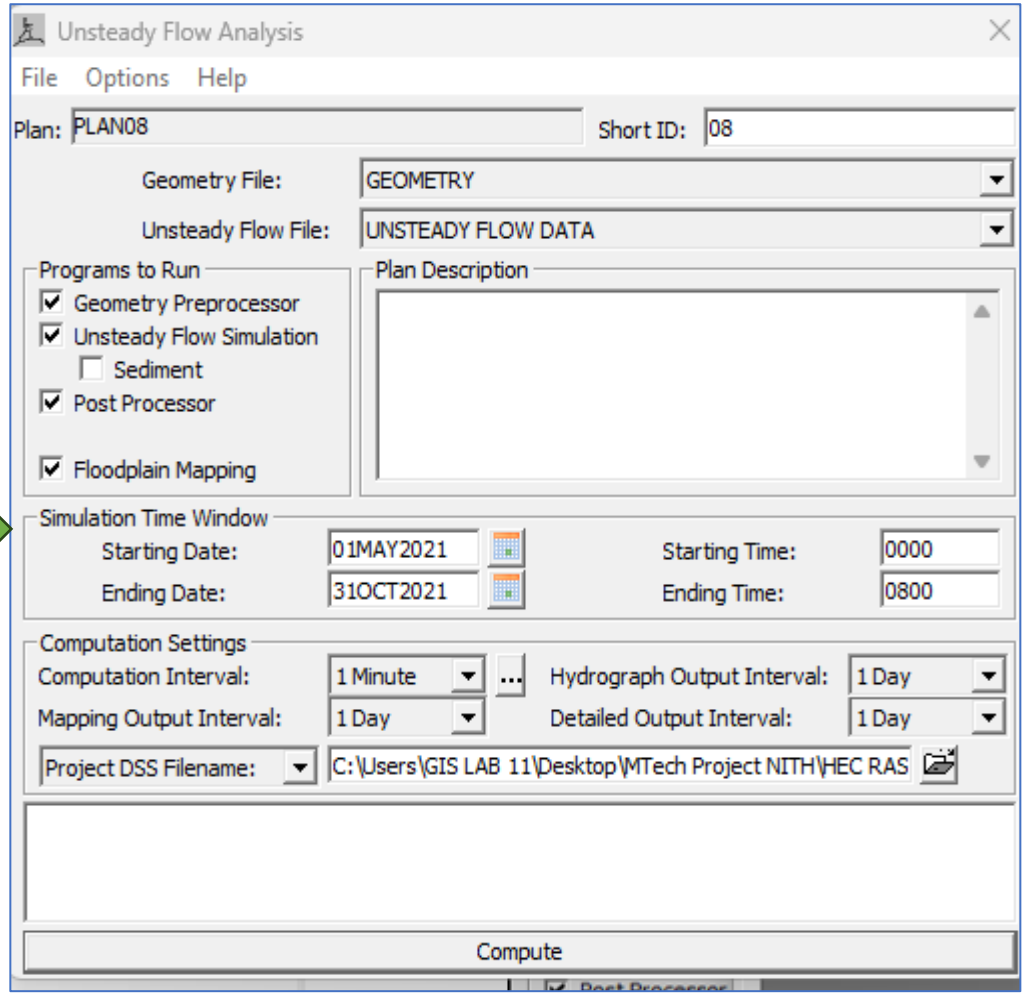
METHODOLOGY



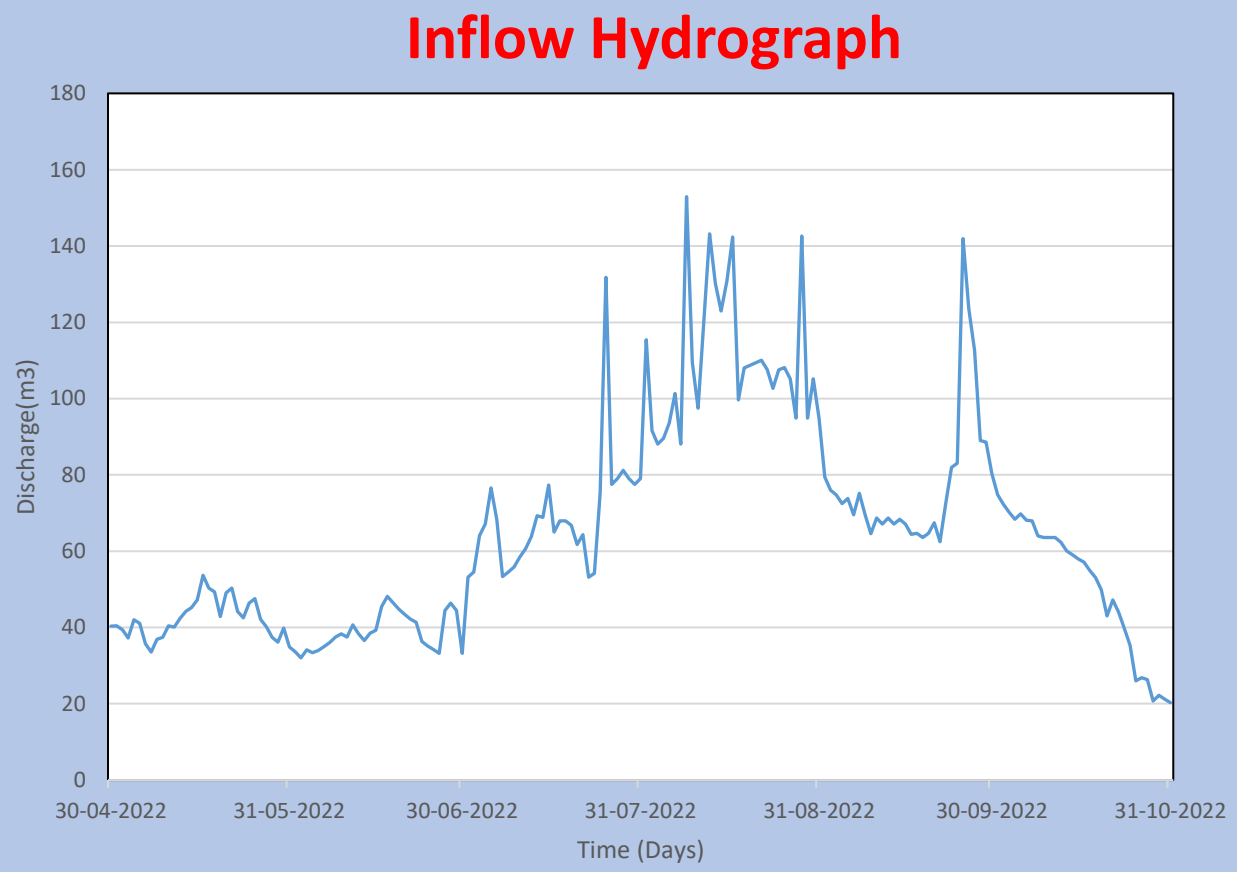
Initial Boundary Condition



Unsteady Flow Data Analysis



INFLOW HYDROGRAPH



Flow Hydrograph at Upstream Boundary
Station Name: U/S at Pirdi

Critical Stretch Analysis

Stretch Point	Lat/Long	Destination	Damage Infrastructure
i.	31°53’54.31"N 77°08’52.27"E	Near Confluence of Beas and Parvati river	Jia Arch Bridge
ii.	31°53’15.23"N 77°08’54.79"E	Bhuntar Bridge over Parvati Beas Sangam	Roadways near the bridge
iii.	31°53’28"N 77°08’37"E	HP Forest Department office	Infrastructure near Meandering
iv.	31°57’32.76"N 77°06’52.38"E	Sewage treatment Plant Kullu	Infrastructure near Meandering
v.	31°57’41"N 77°06’54"E	Chandramouli Mahadev Temple	Roadways and shops nearby
vi.	31°57’02"N 77°06’38"E	Playground Lanka, Dhalpur	Roadways and Nearby Infrastructure
vii.	31°59’06.88"N 77°07’43.00"E	Beach Camp	Roadways and Nearby Infrastructure

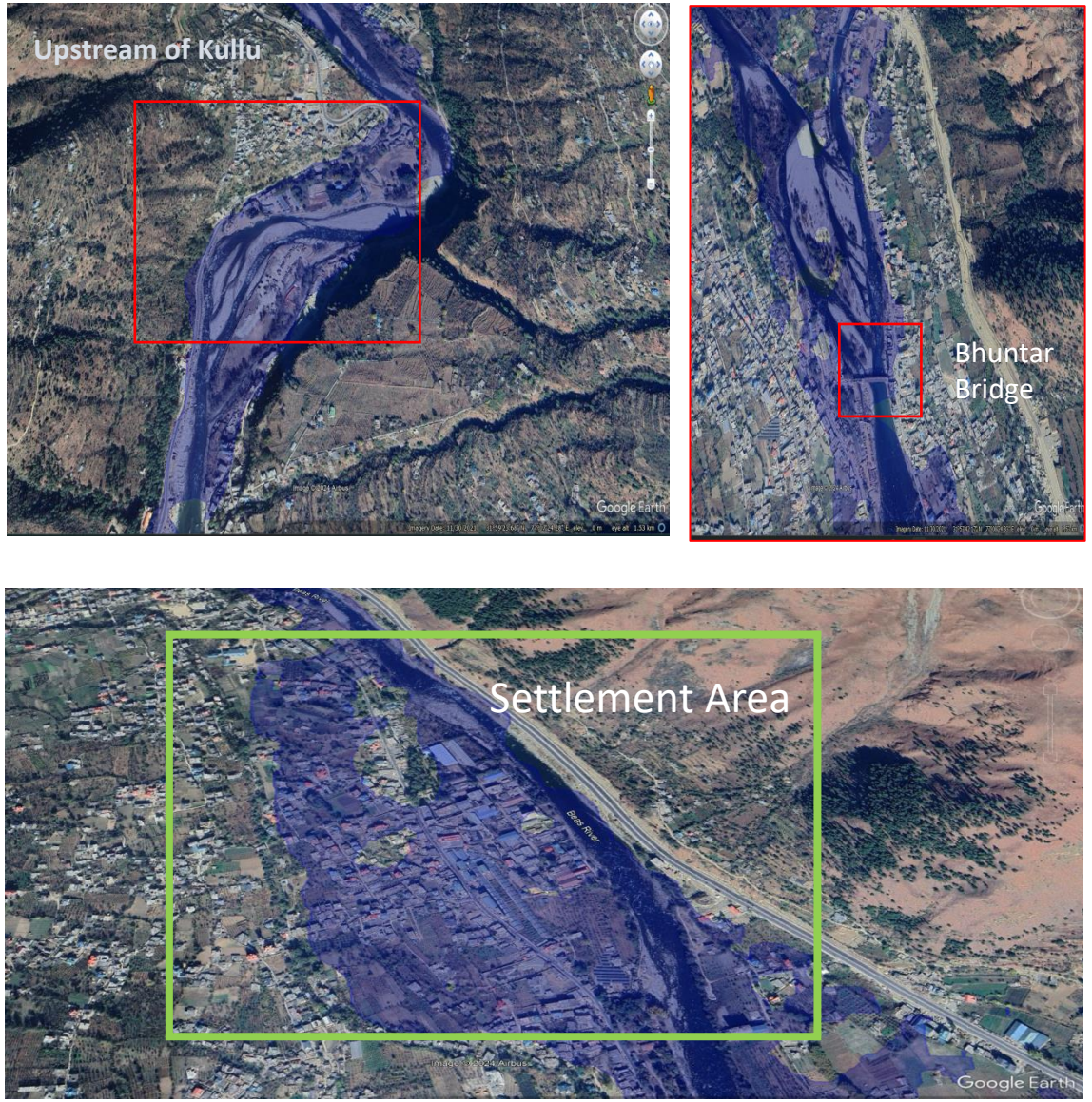
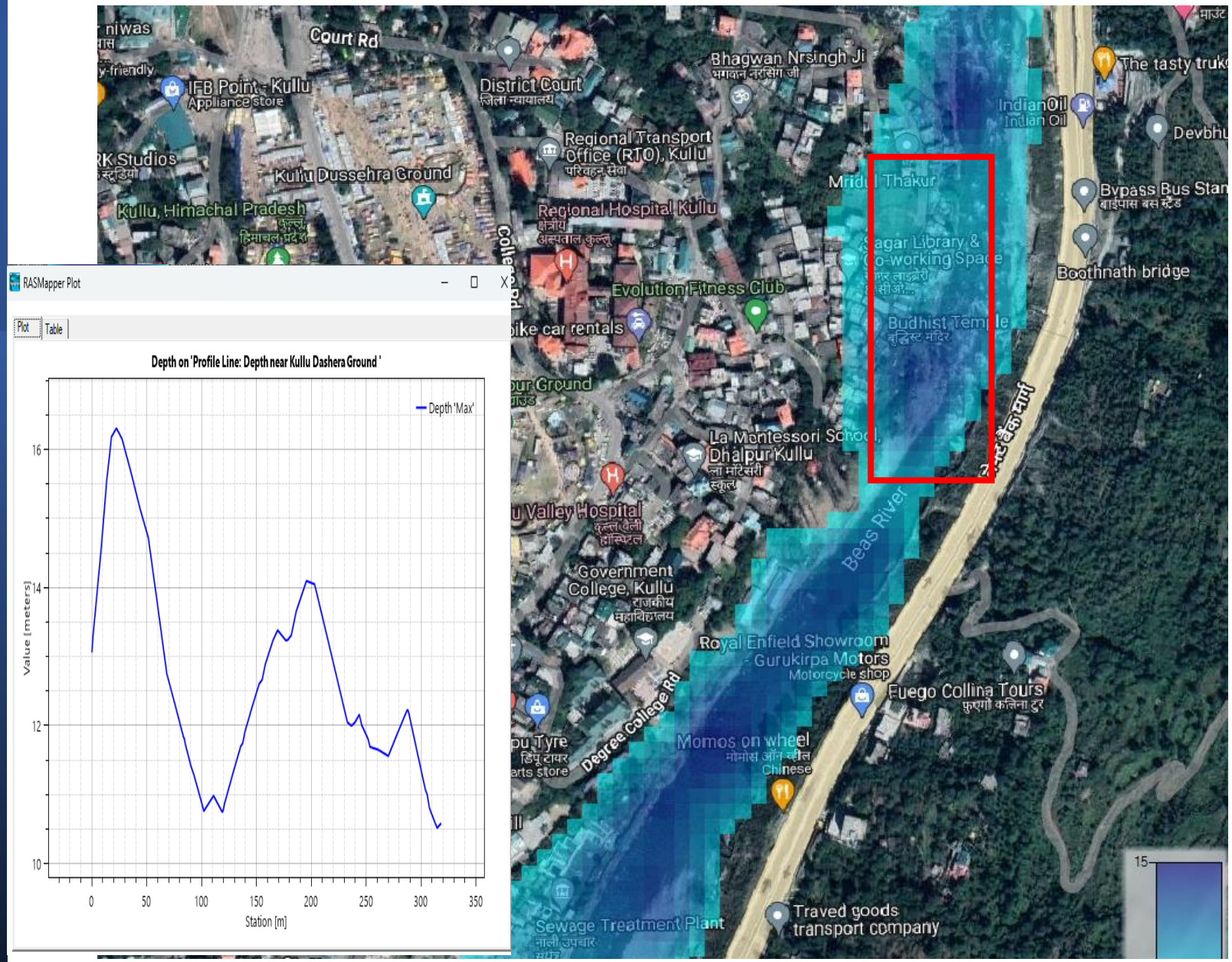
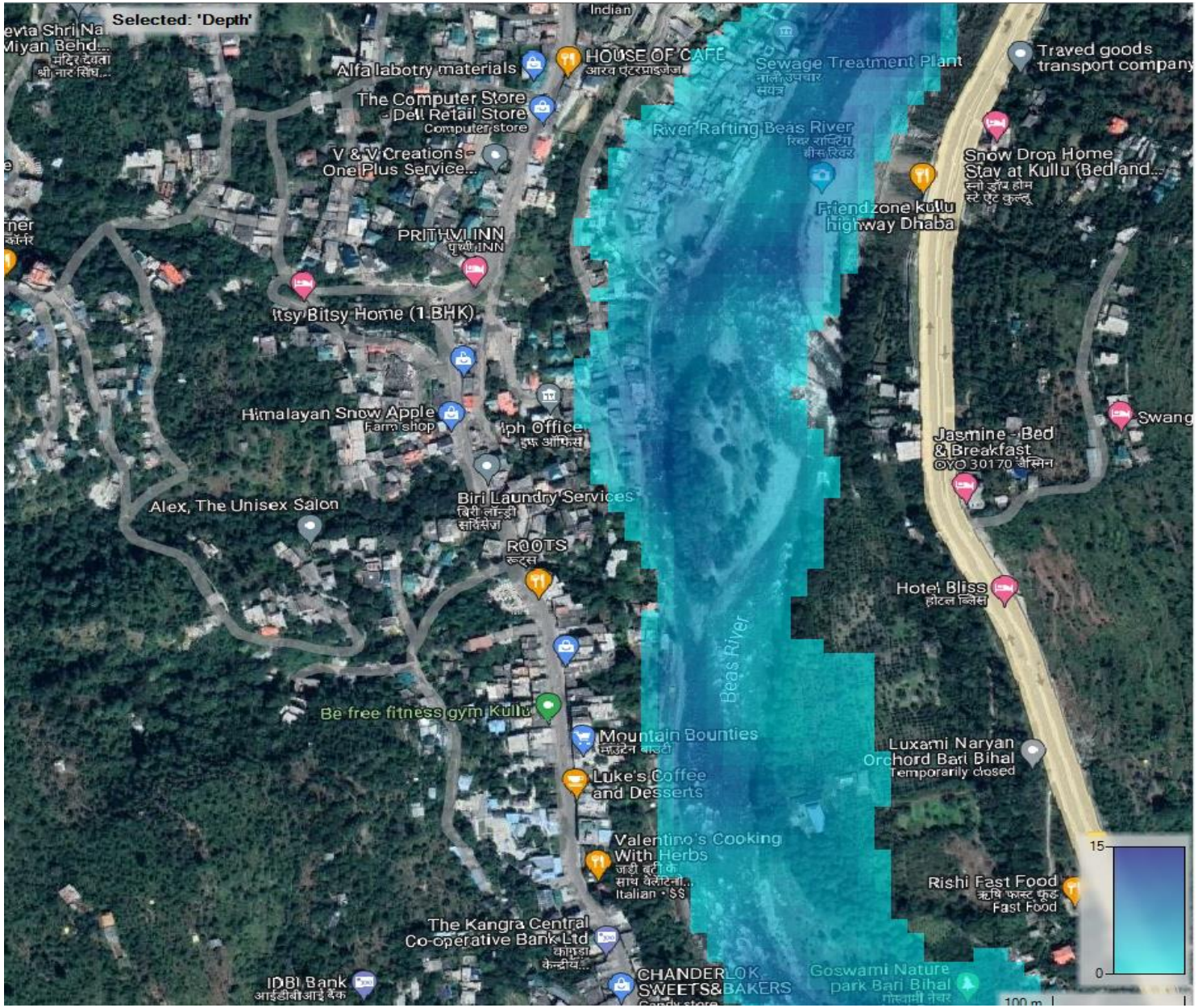


Figure 2. (a) Location of Upstream of Kullu; (b) Location of Bhuntar Bridge (c) Location of Kullu City

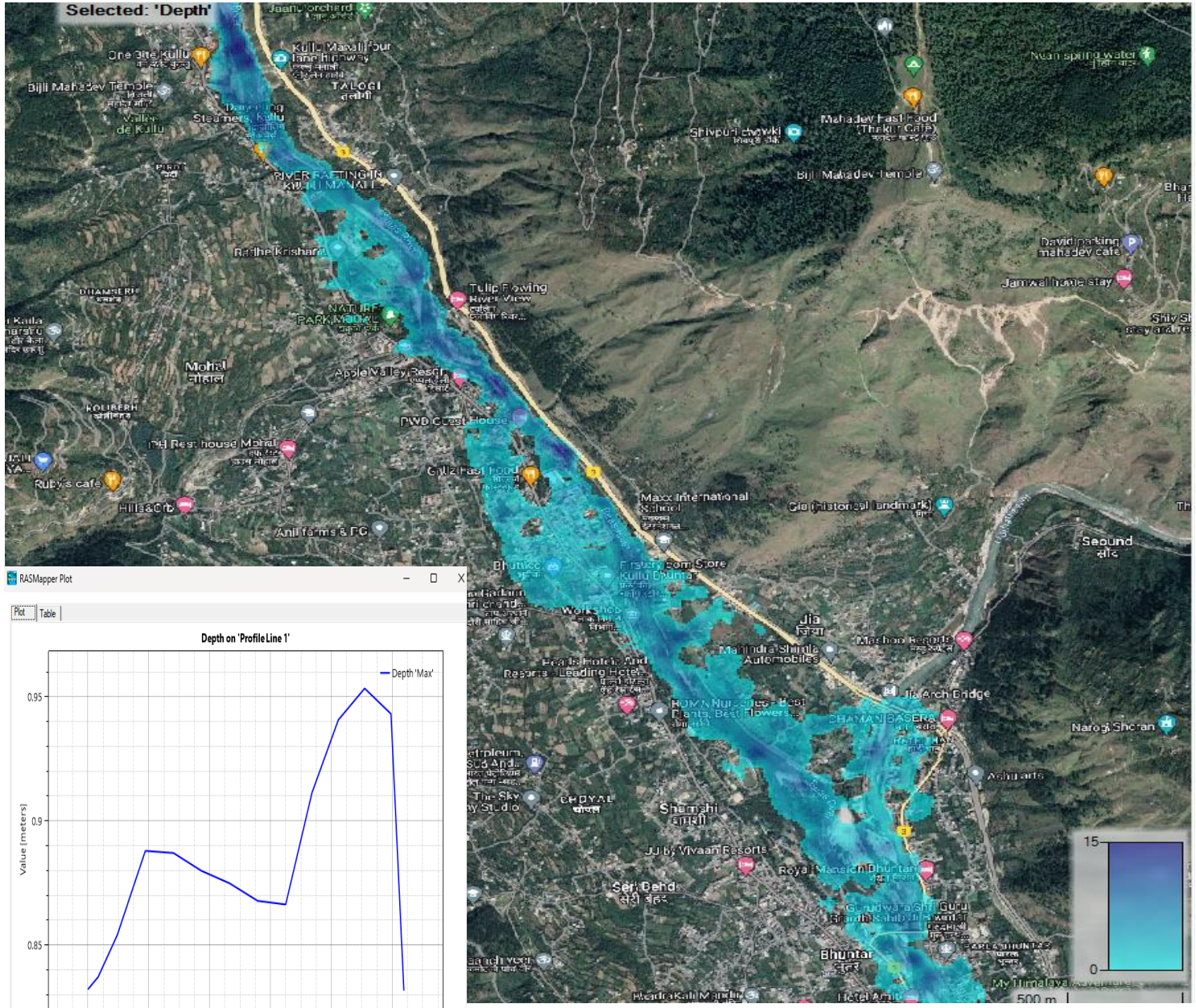
CRITICAL STRETCH 1



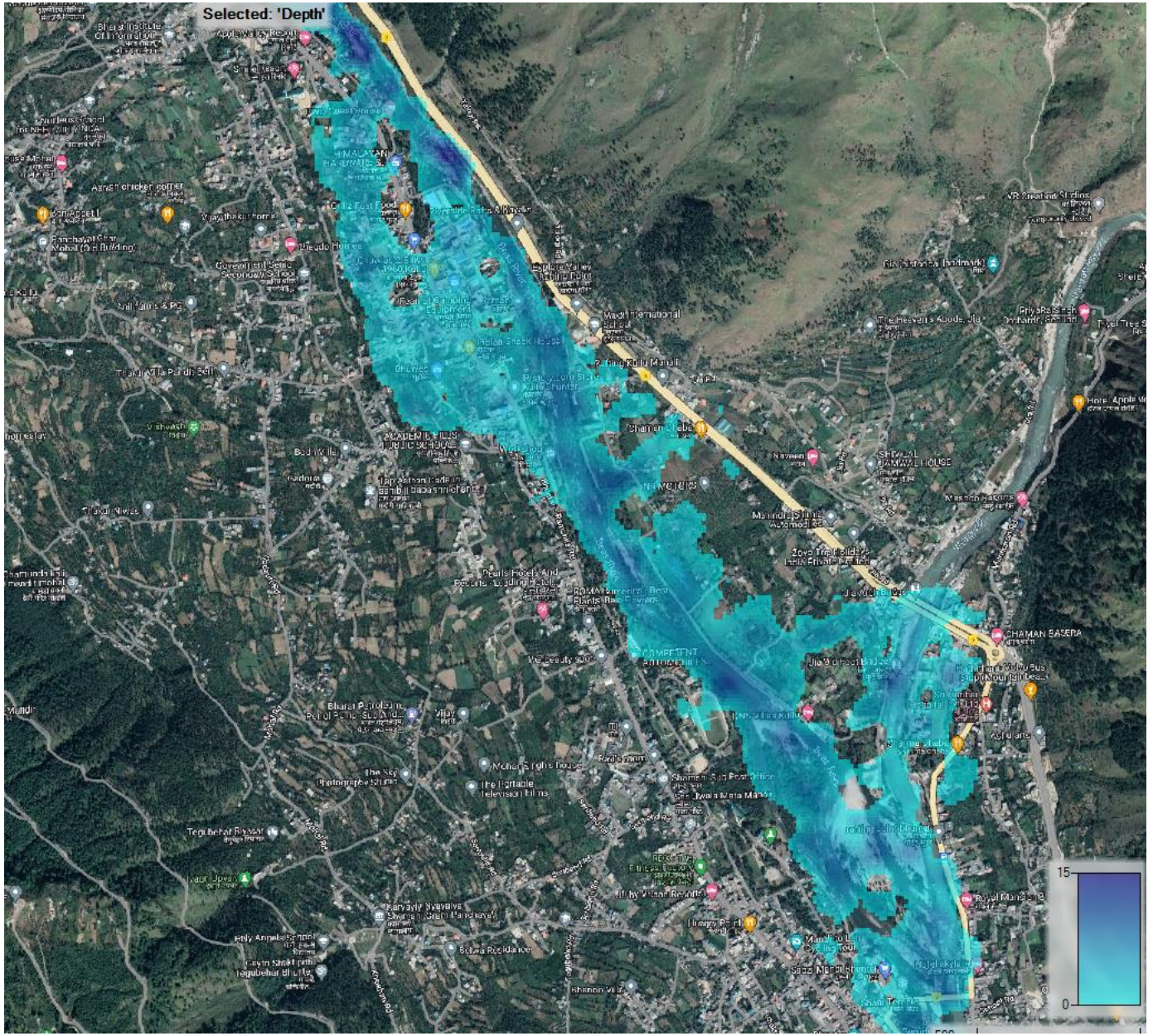
CRITICAL STRETCH 2



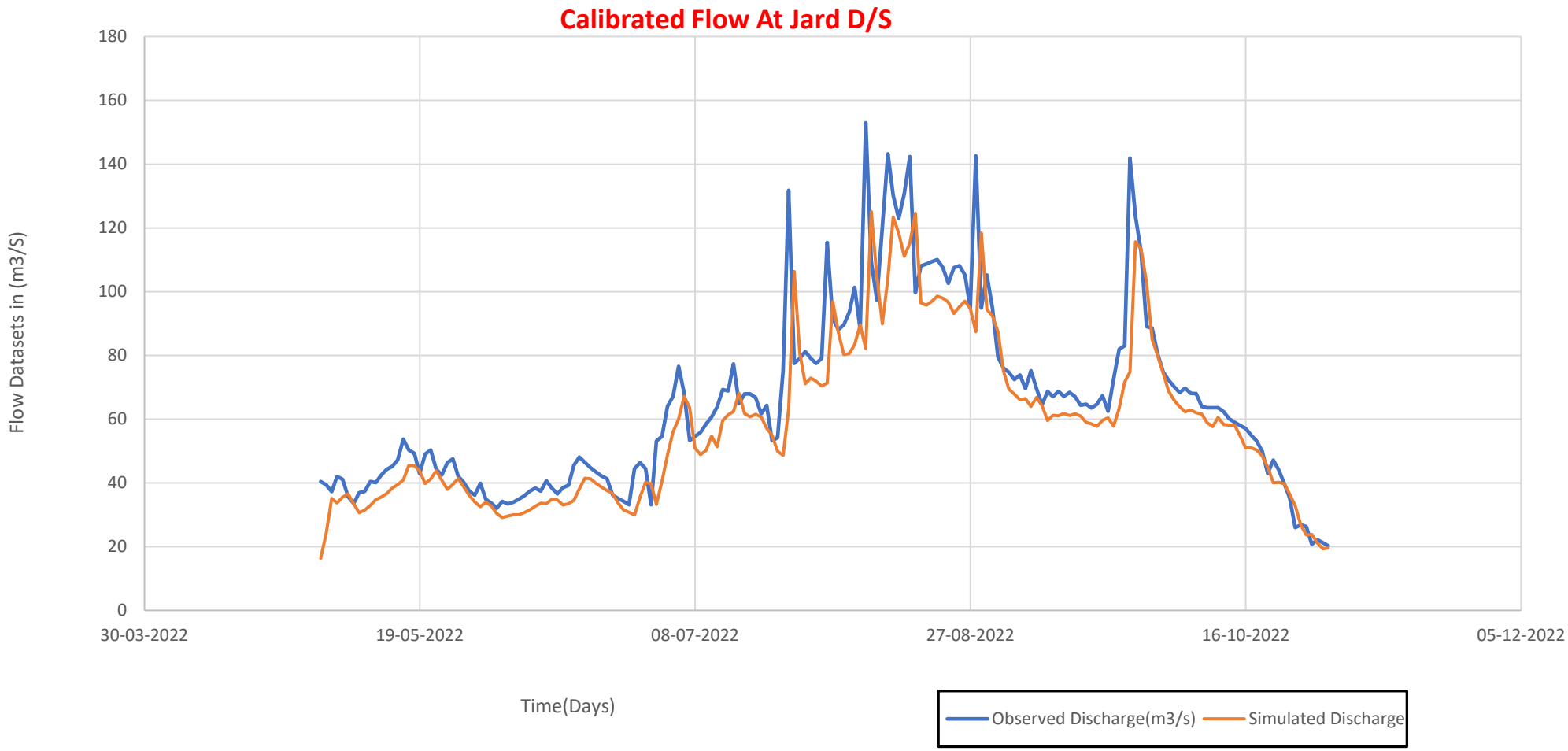
CRITICAL STRETCH 3



CRITICAL STRETCH 4



CALIBRATION



Results & Discussion

- Peak discharge of 120 m^3/s achieved its peak time in 1 hr 7 min, and flow reached the Kullu city, 10 km downstream after 2 hr 10 min at a rate of 112 m^3/s. Inundation mapping shows that outbursts flood inundates buildings situated near the bank of Beas river.
- In the worst-case scenario, maximum flow depth 12 m and maximum flow velocity of 5.8 m/s is achieved near the Bhuntar bridge.
- The unsteady flow modeling tells that average water depth will remain in between 4-7 m and velocity in between 2-6 m/s.
- The Cloudburst Scenario indicated that rainfall of more than 100 mm/hr in the catchment, can cause severe disaster in the downstream region. .

Results & Discussion

- The hydrodynamic model HEC-RAS 2D simulated the River stretch from Pirdi to Jard. Comparison of different mesh sizes (25, 50) for the event simulation from 2022 demonstrated no significant difference in model performance.
- However, substantial differences in simulation time have been observed. In addition, the inclusion of break lines, though it did not result in consistent performance improvement, demonstrated the shortening of simulation duration.
- Sensitivity analysis and subsequent manual calibration using different manning's N Value N=0.03,resulted in a slight improvement in the model's performance.

CONCLUSION

- The main objective of this study is to develop a model and inundated area identification.
- Flood study is crucial for sustaining the livelihood of a community. In the present study, the HEC-RAS 2D hydrodynamic model was set up and evaluated for flood inundation mapping in the Beas River catchment in Kullu, Himachal Pradesh.
- The local authorities should use the inundation areas identified in the settlements for the adoption of structural and non-structural measures.

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THANK YOU