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Evaluating Flood Adaptation Effectiveness through Economic Analysis: A Case Study of Surat, India

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MIR LAB

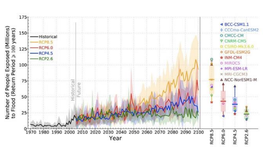
1. Introduction

- Socioeconomic changes, combined with extreme weather events, intensify floods' frequency and severity globally, leading to substantial loss of life and infrastructure damage.
- Effective flood adaptation strategies are essential, yet assessing their impact and cost-effectiveness, often overlooked before implementation, poses a significant decision-making challenge.
- Hydrodynamic studies provide insights into how floods interact with adaptation strategies, while decision-based matrices and cost-benefit analyses elucidate choices and effectiveness, considering regret costs associated with both under-preparedness and over-preparedness.
- Understanding the insights from this study will aid decision-makers in implementing flood adaptation strategies that are both hydrodynamically and economically viable.

2. Research Overview

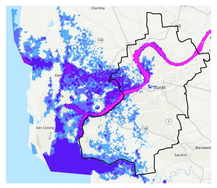
Climate-Related Impacts

Exposure in Changing Climate

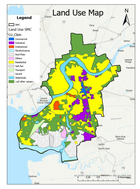


Economic Losses and

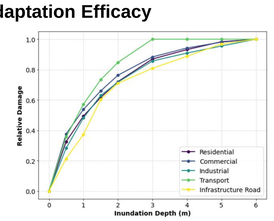
Assessment of Flood Adaptation Efficacy



Hydrodynamic Model



Land Use

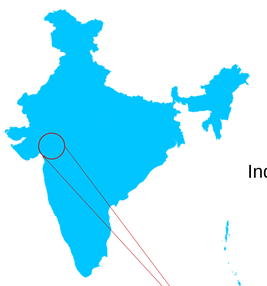


Damage Curve

3. Objective

- The objective of this study is to evaluate the effectiveness of flood adaptation strategies in terms of reducing inundation and mitigating damage, leveraging a 1D-2D coupled hydrodynamic flood model in the MIKE+ platform.

4. Study area and data used

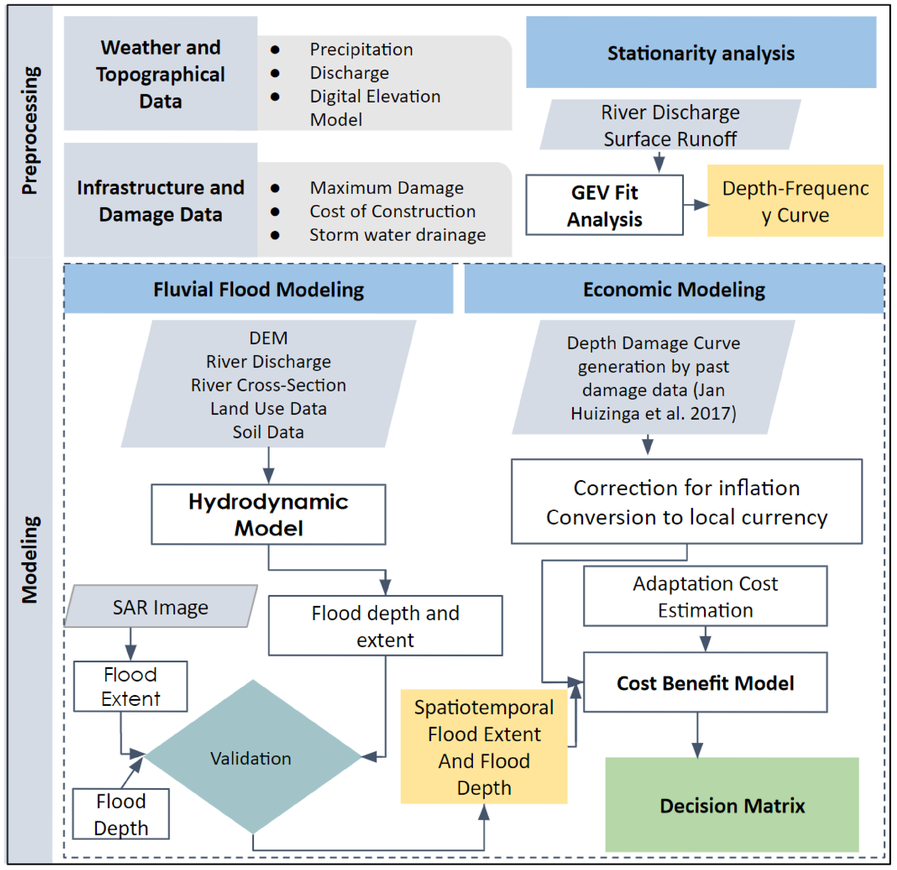


India

Surat Municipal Corporation (SMC)

Data	Sources
Stream flow	Hourly data, Ukai reservoir outflow (Surat Irrigation Circle)
Tide Level	Hourly data, INCOIS
Water Level (Stage)	Surat Irrigation Circle, Surat Municipal Corporation (SMC), and Central Water Commission India
River Bathymetry Data	SMC at 200 m
Digital Elevation Model	SRTM (30 m resolution)

5. Methodology



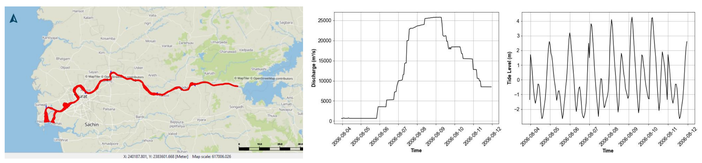
6. Hydrodynamic Model

1. Governing Equation, Computational Domain, and Boundary Conditions

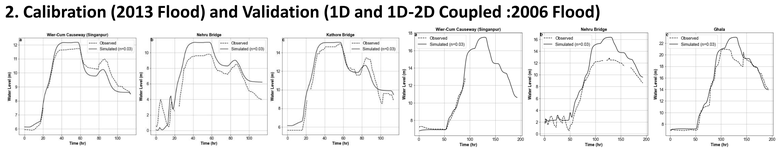
$$\frac{\partial h}{\partial t}+\frac{\partial (hu)}{\partial x}+\frac{\partial (hv)}{\partial y}=0 \quad \text{continuity eq.}$$

$$\frac{\partial (hu)}{\partial t}+\frac{\partial (hu^2)}{\partial x}+\frac{\partial (huv)}{\partial y}+gh\frac{\partial h}{\partial x}=-gh\frac{\partial z_b}{\partial x}-gn^2u\frac{\sqrt{u^2+v^2}}{h^{\frac{1}{3}}} \quad x\ \text{momentum eq}$$

$$\frac{\partial (hv)}{\partial t}+\frac{\partial (huv)}{\partial x}+\frac{\partial (hv^2)}{\partial y}+gh\frac{\partial h}{\partial y}=-gh\frac{\partial z_b}{\partial y}-gn^2v\frac{\sqrt{u^2+v^2}}{h^{\frac{1}{3}}} \quad y\ \text{momentum eq}$$



2. Calibration (2013 Flood) and Validation (1D and 1D-2D Coupled :2006 Flood)



1D-2D Flood Model Validation for water level at Ghala, Nehru Bridge, and Singanpur

3. Generalized Extreme Value (GEV) Distribution Fit

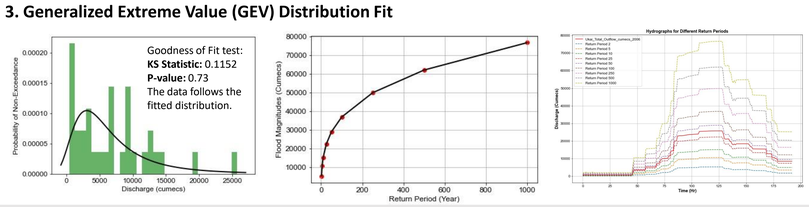
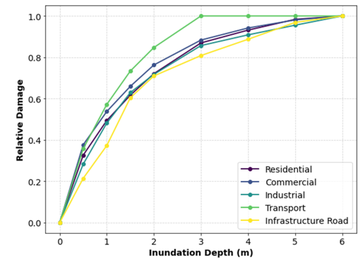


Fig. Hydrographs for different return periods

7. Results



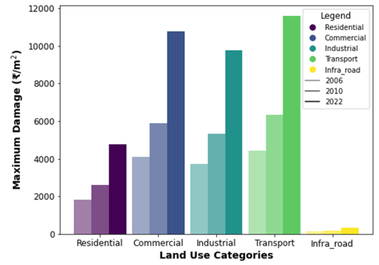


Fig. (left): Relative depth damage curve (Huizinga et. al, 2017) ; (right) maximum depth at 2010 and inflated value at 2006 and 2022.

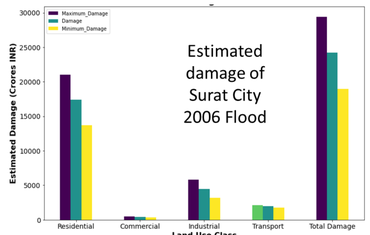
Correction for Inflation

$(\text{Max. Damage})_{2022} = (\text{Max. Damage})_{2010} * (CPI_{2022}/CPI_{2010})$

Estimation of total damage

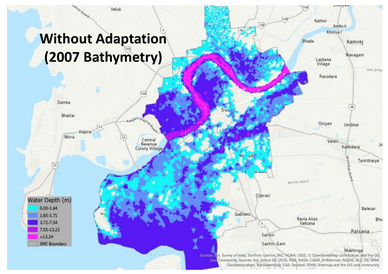
$$C=\sum_{i=1}^{n} D_{x(i)} \times f(d_i) \times A_i$$

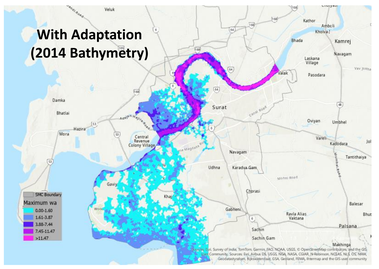
C: Total estimated damage
$D_{x(i)}$: max. monetary damage of i-th element
d_i : inundation depth
f: proportion of the element destroyed
Ai: affected area of I element



In August 2006, a massive flood in the city of Surat caused property damage estimated at **Rs 22,000 crore.** (IIM Ahmedabad, Dileep Mavalankar, Amit Kumar Srivastava, 2008).

Comparison of Inundation map with and without levee





8. Conclusions and Future Work

- The embankment construction along the Tapi River significantly reduced the inundated area during the 2006 major flood.
- The economic model indicates damage reduced from Rs. 27,000 to Rs. 19,000 crores due to the 2006 flood, including the actual estimated damage worth Rs. 22,000 crores, demonstrating the applicability of the depth damage curve for Surat city.
- A frequency damage curve will be estimated for annual damage estimation for both scenarios, with and without adaptation.
- A cost-benefit analysis based on various discounting rates and adaptation scenarios will be conducted to create a decision matrix.

References

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Acknowledgement

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