Watershed Restoration for Flood Resilience:

Hydrology, EbA Selection & Economics in the Mohana–Khutiya Basin Far-Western Nepal

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1 Introduction

The Mohana–Khutiya River Basin covers 725 km² across Kailali and Kanchanpur districts in Nepal's far-western Sudurpashchim Province, extending from the Chure (Siwalik) Hills at 1,962 m to the Terai plains at 164 m. The basin supports six rural and urban municipalities, including Dhangadhi, and depends on monsoon-driven, rain-fed hydrology, receiving about 2,048 mm of annual rainfall, nearly 80% of which occurs between June and September. Ministry of Forests and Environment classifies both districts as Flood Hazard Hotspots. Between 1991 and 2015 alone, the river experienced 390 flood events. Of these, 35 led to economic losses exceeding NPR 1 million, 37 resulted in 440 deaths, and 79 caused the destruction of more than 10 homes each.

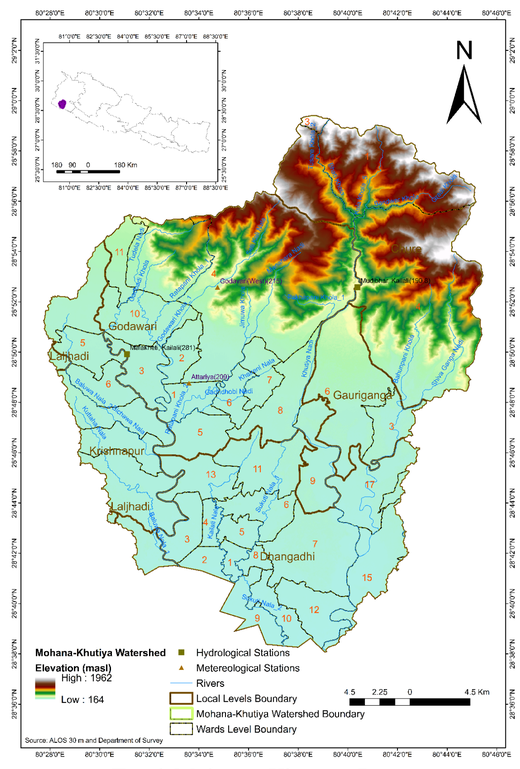

Fig.1 Mohana Khutiya Basin

(Source :(ADB, 2020) Priority River Basins Flood Risk Management Project: Mohana Khutiya.)

2 Objectives

- To quantify flood risk reduction from Ecosystem-based Adaptation (EbA) measures across the 725 km² Mohana–Khutiya Basin under historical and CMIP6 climate scenarios (SSP2-4.5, SSP5-8.5).
- To develop and validate a coupled Hydrological and Hydrodynamic model (donor-basin regionalisation from East Rapti) to simulate hydrology, peak flows, and inundation for 2–1000-year events.
- To prioritise EbA and soft-structural interventions using flood frequency analysis, hydraulic performance, and participatory vulnerability capacity assessment (VCA) across six municipalities.
- To evaluate economic viability of EbA portfolios (NPV, BCR, IRR; 5% and 9% discount rates) for 2026–2050.

3 Modeling Methodology

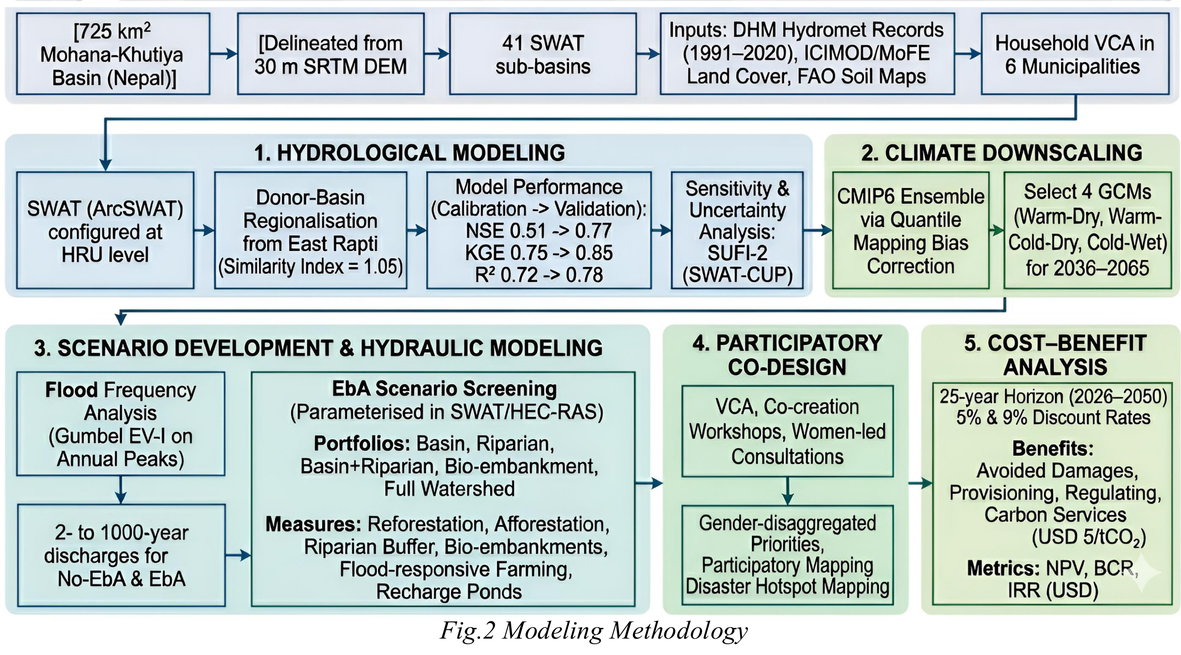

Fig.2 Modeling Methodology

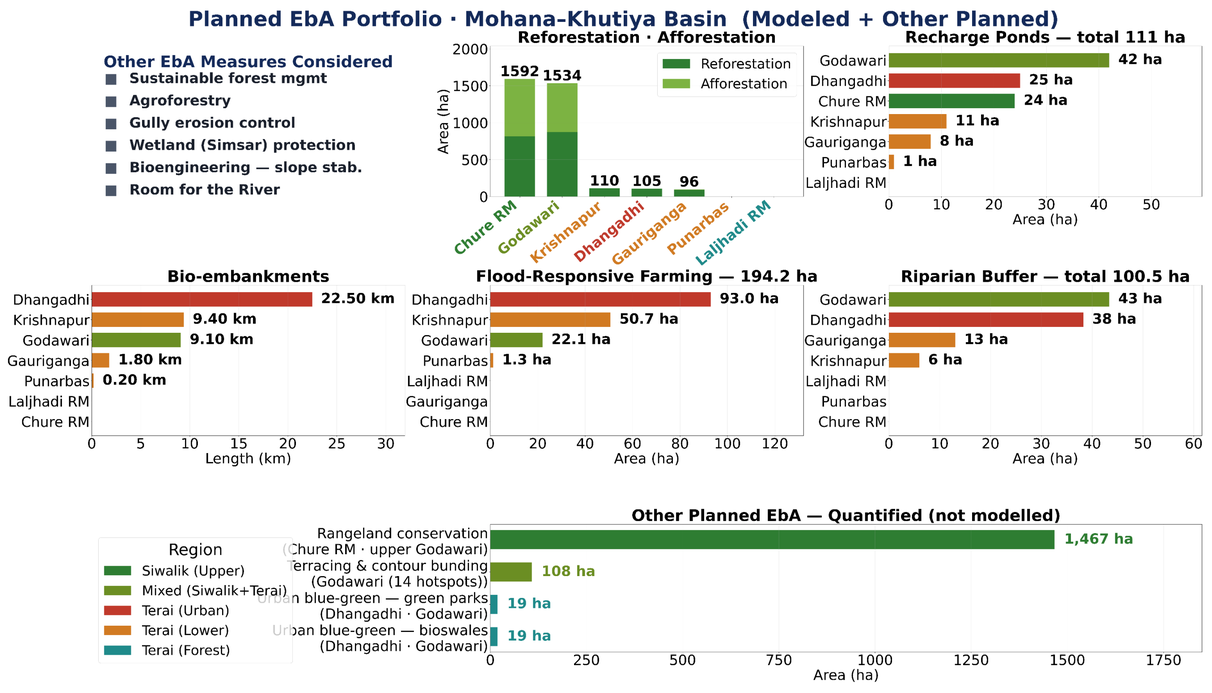

Fig.3 Modelled and Planned EbA intervention in the Basin

4 Findings - Hydrology

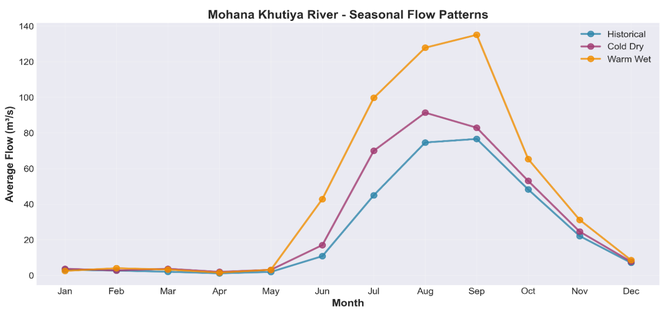

Fig.4 Basin hydrological flow

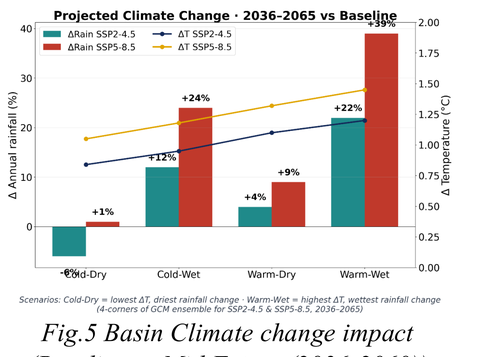

Fig.5 Basin Climate change impact (Baseline vs Mid Future (2036-2060))

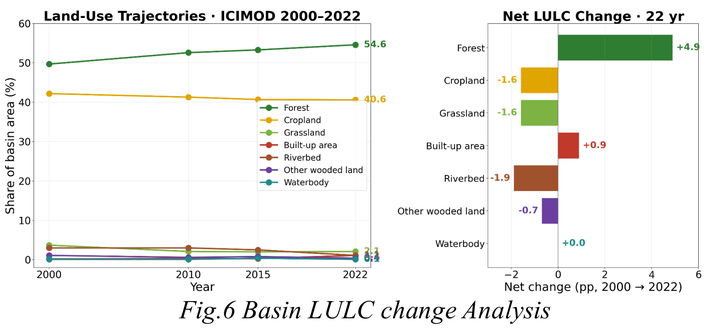

Fig.6 Basin LULC change Analysis

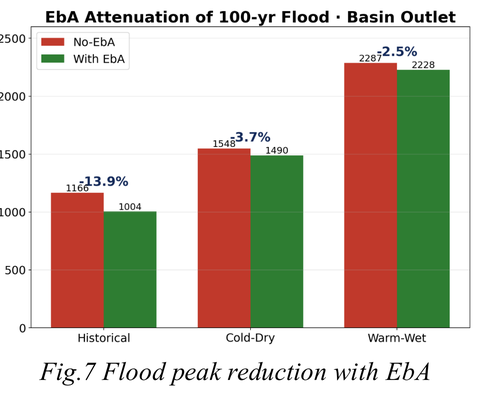

Fig.7 Flood peak reduction with EbA

5 Findings – Hydrodynamic/ VCA

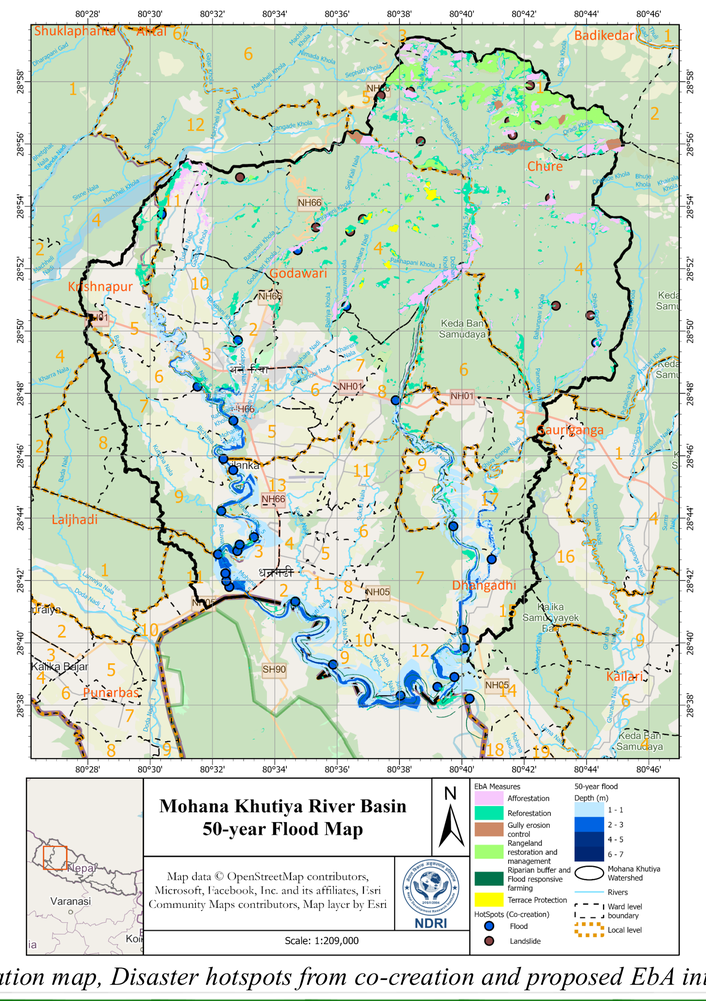

Fig.8 Inundation map, Disaster hotspots from co-creation and proposed EbA intervention

7 Findings – Economic Analysis

Fig.9 Scenario development for Economic analysis

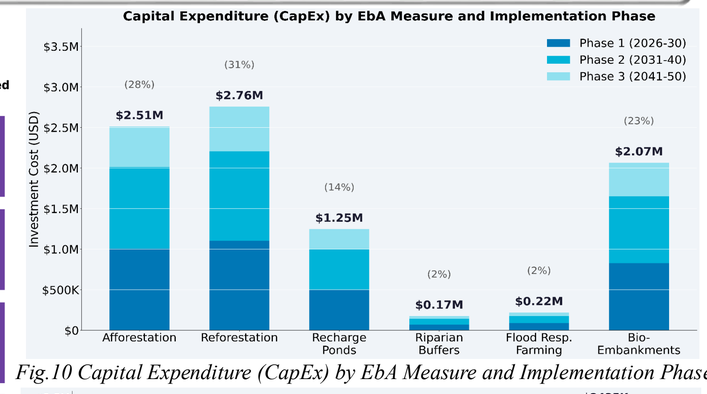

Fig.10 Capital Expenditure (CapEx) by EbA Measure and Implementation Phase

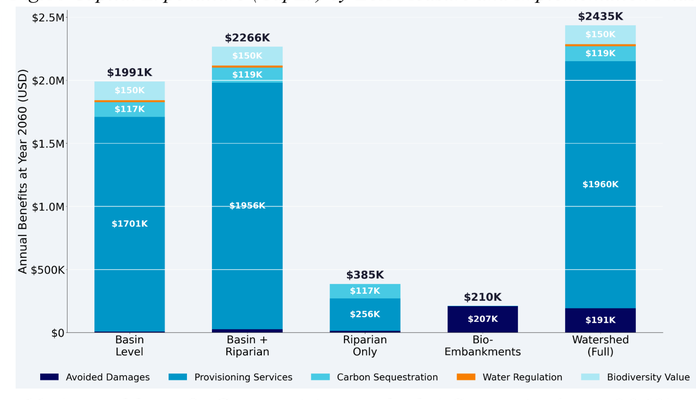

Fig.11 Annual benefit Composition and EbA Scenario (Year 2060)

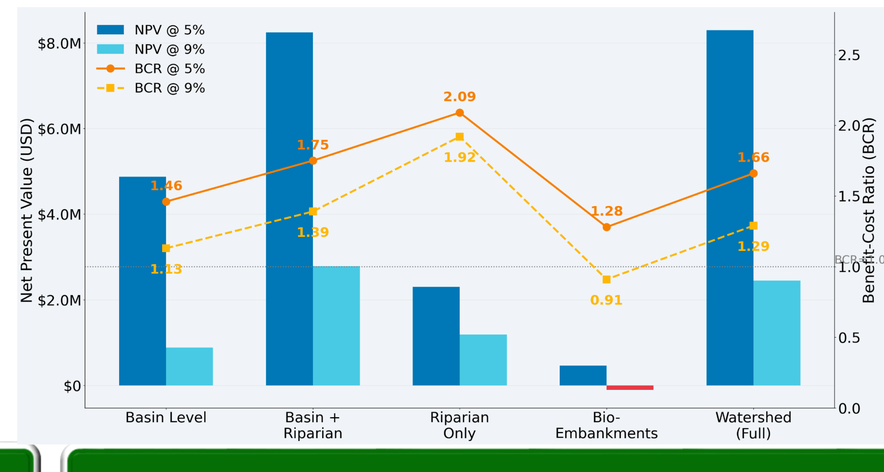

Fig.12 Economic Performance by EbA Scenario (NPV and BCR at 5% and 9% Discount Rates)

6 Key Observations and Findings

- Basin + Riparian interventions deliver the strongest absolute returns, generating NPV of USD 8.25 M (5% discount) and USD 2.78 M (9%), with Benefit Cost Ratios (BCR) of 1.75 and 1.39.
- Riparian-only measures show the highest efficiency, achieving the peak BCR of 2.09 (5%) and 1.92 (9%), effectively doubling invested capital through low-cost, high-impact flood protection benefits.
- Full watershed intervention provides balanced long-term gains, with NPV of USD 8.30 M (5%) and USD 2.45 M (9%), BCR of 1.66 (1.29), and IRR of 13%, yielding USD 20.88 M in benefits against USD 12.58 M in costs.
- Bio-embankments remain economically sensitive but locally critical, becoming viable at discount rates below 8% (NPV USD 0.47 M, BCR 1.28 at 5%), supporting their use as targeted hotspot interventions. Projected annual benefits by 2060 range from USD 0.21–2.44 M.
- We use of conservative USD 5/tCO₂ compared to international benchmarks (~USD 25/tCO₂). Higher social carbon pricing would significantly improve forest-based EbA returns, subject to enabling benefit-sharing mechanisms.

7 Strategic Implications / Actions

- Economic results underscore the importance of integrating direct benefits (avoided flood damages estimated through the hydrological modeling) and significant indirect ecosystem services benefits when evaluating the EbA measures at the watershed level.
- Results confirm that catchment-level investments generate substantial ecosystem benefits to upstream communities and flood reduction benefits primarily to downstream communities, justifying basin-level cost and benefit sharing mechanisms.
- Municipality level LAPAs and DRMPs are good entry points to implement the Watershed Restoration Plan (WRP).







Acknowledgement:

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