Valuation of sediment retention service based on forest cover in a Himalayan watershed using InVEST model

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Abstract

Soil erosion is one of the most implicit risks that affect the Himalayan watershed, its ecology as well as economy. Soil and water quality in a watershed are affected by soil erosion due to sedimentation. However, forests play a major role in controlling soil erosion and supporting sediment retention services in the ecosystem. The study attempted to understand the role of forests in sediment retention and valuation of soil loss due to erosion in the Himalayan watershed. Satellite-based datasets were used in this study to assess soil erosion. The sediment retention service was estimated using InVEST Sediment Delivery Ratio (SDR) model. The basin was assessed for SDR under two scenarios i.e., with (F1) and without (F0) forest cover to understand the role of forests regarding sediment retention service. The replacement cost method was used to estimate the costs that would have to be incurred for the replacement of the eroded soil. The cost of soil loss occurred was estimated using the price for dredging and disposing of 1m^3 un-eroded soil which is equal to 8.00 US$ (Chatrsimab Z. et al. 2018), hence, with the replacement cost method the economical benefit of forest cover in soil loss control were estimated. Furthermore, the results indicated that under the F1 scenario, the sediment export was lower resulting in a lower cost of soil replacement when compared to F0.

Method

Framework for Valuation of Sediment retention ecosystem service

Estimation of Sediment Delivery Ratio (with (F1) and without (F0) forest cover)

Parameter

- Rainfall Erosivity
- Soil Erodibility
- Digital Elevation Model
- Land use Land cover map
- Crop cover management factor (C) & Conservation practice factor (P)
- Flow accumulation

Data Source

- ERA 5 (Precipitation data 1986-2020)
- ISRIC soil data (SoilGrids version 2.0)
- NASA Earthdata (ASTER GDEM)
- ESA World Cover
- Literature Review
- ASTER GDEM

Method

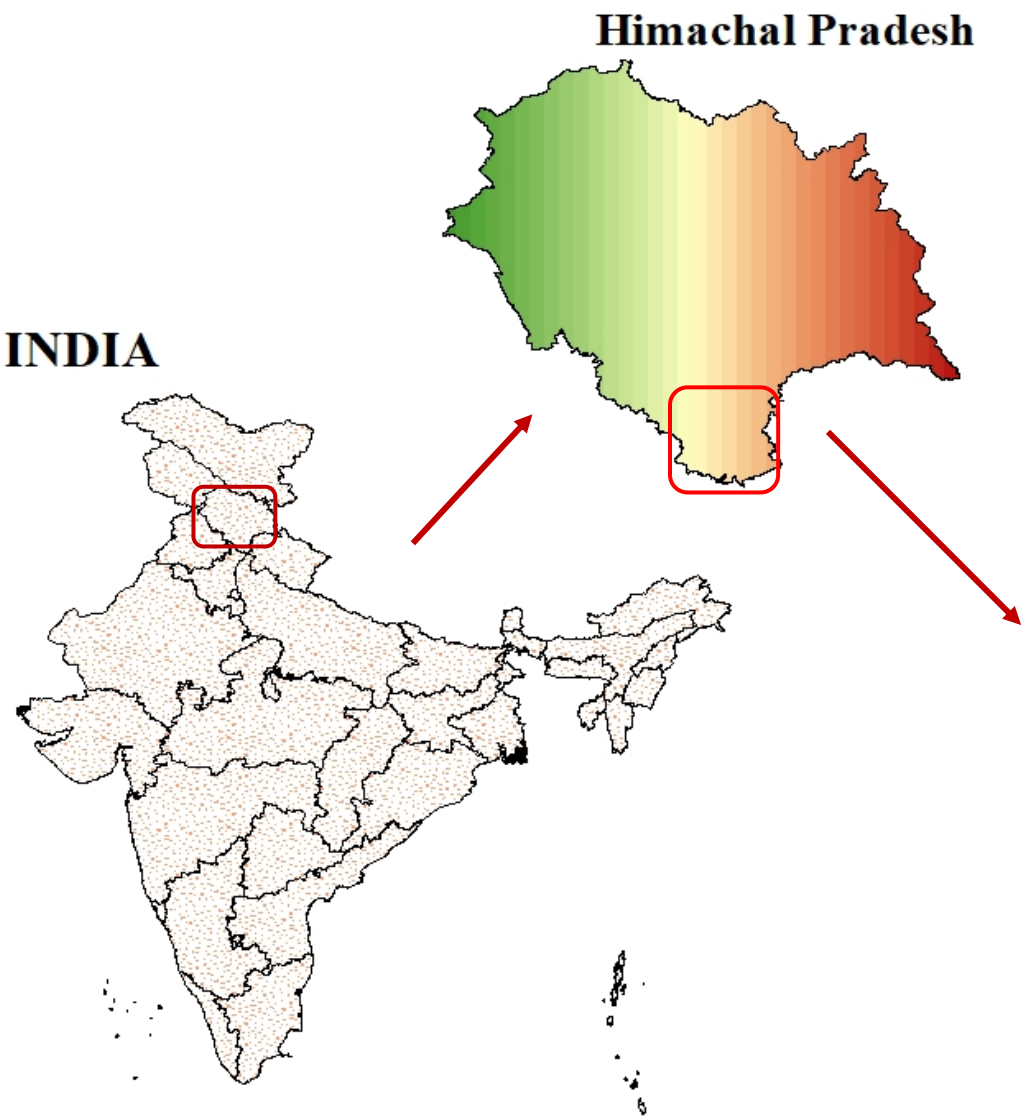
- InVEST (Integrated Valuation of Ecosystem Services and Trade-offs) model
- InVEST tools (DelineateIt and RouteDEM)

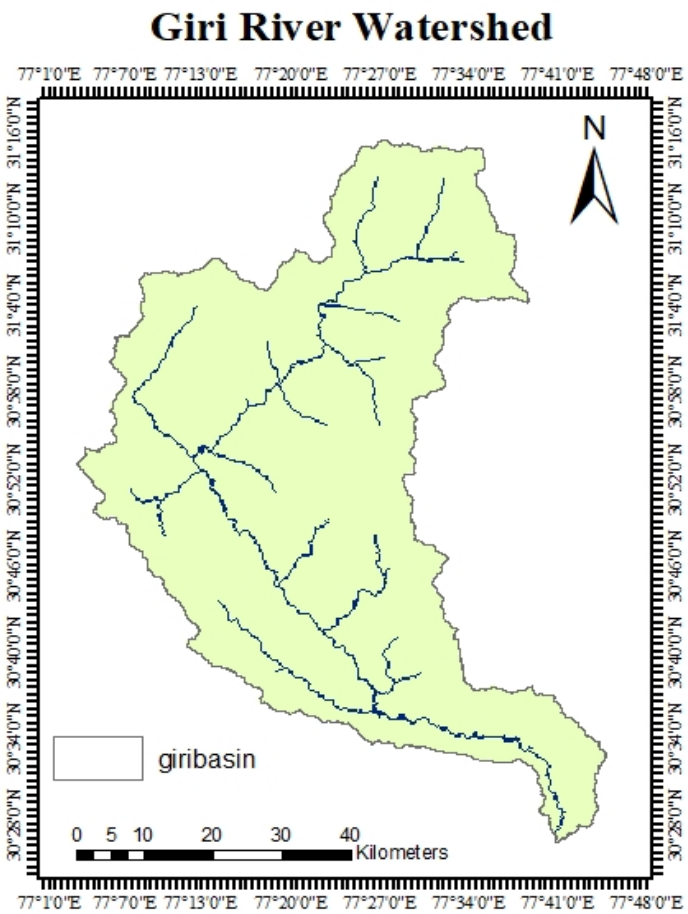
Output

- USLE potential soil loss
- Sediment Retention
- Sediment Export
- Sediment Deposited

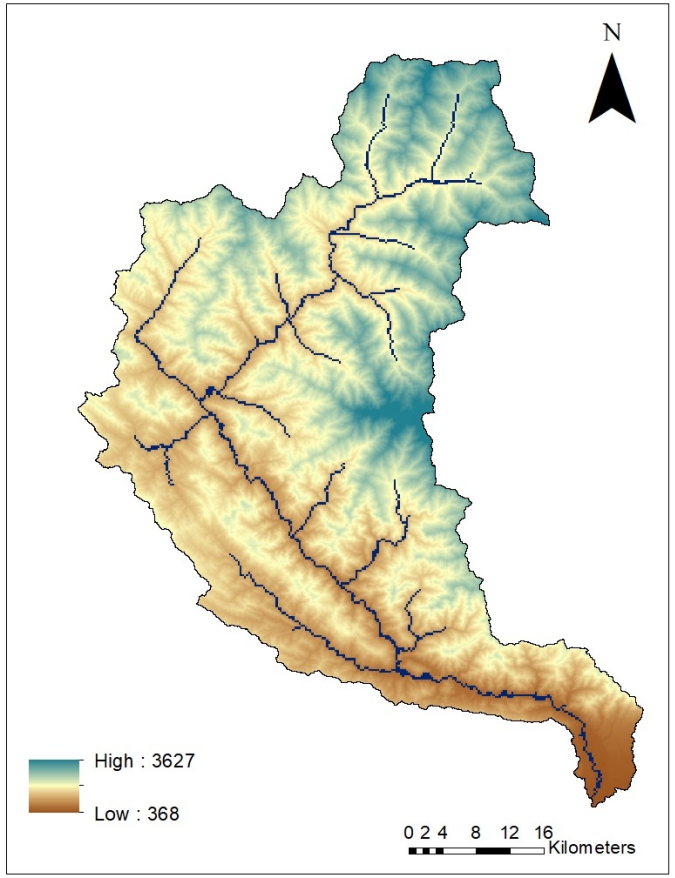
Valuation → Total Sediment export with (F1) and without (F0) forest cover → Replacement Cost for soil dredging (in US $) → Valuation of Sediment retention service

Study Area

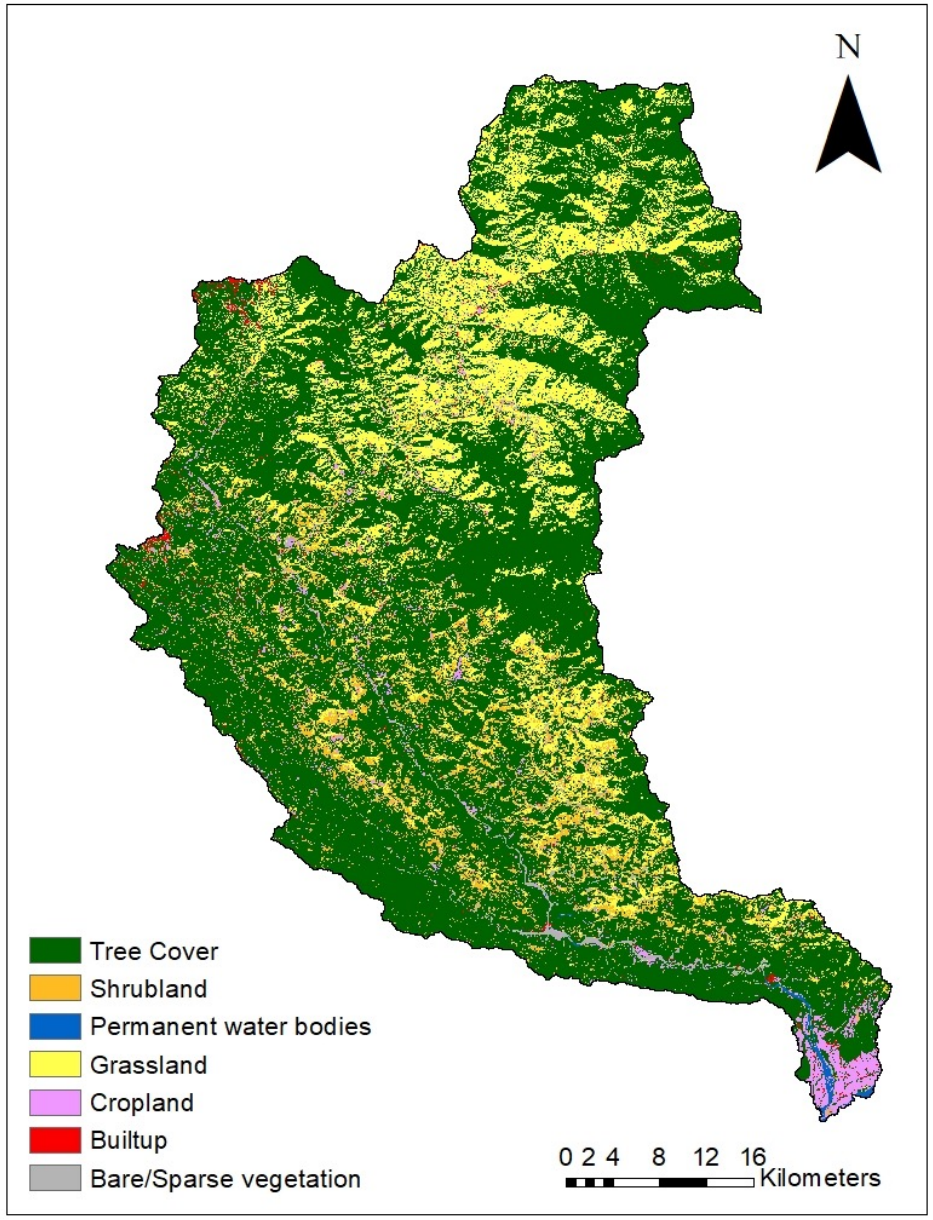




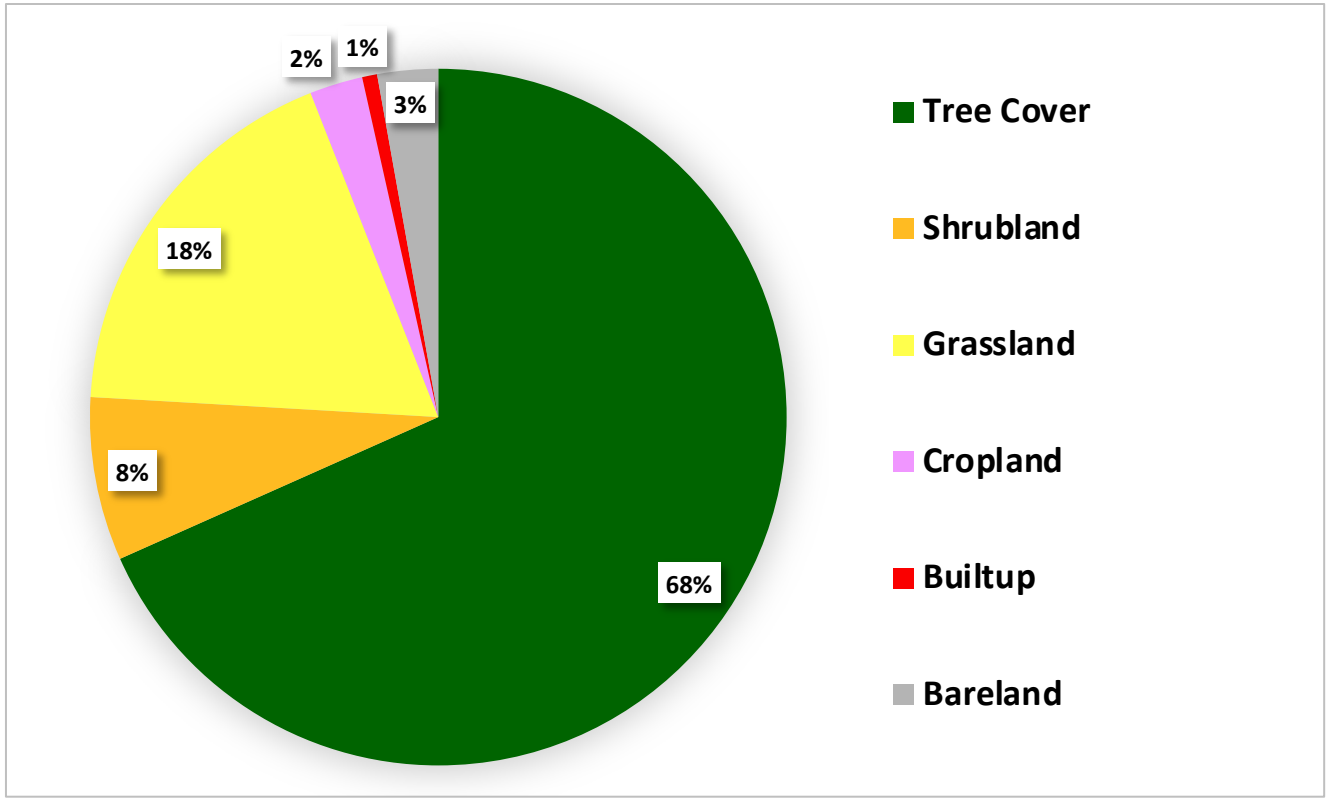
Elevation map for Giri River Watershed



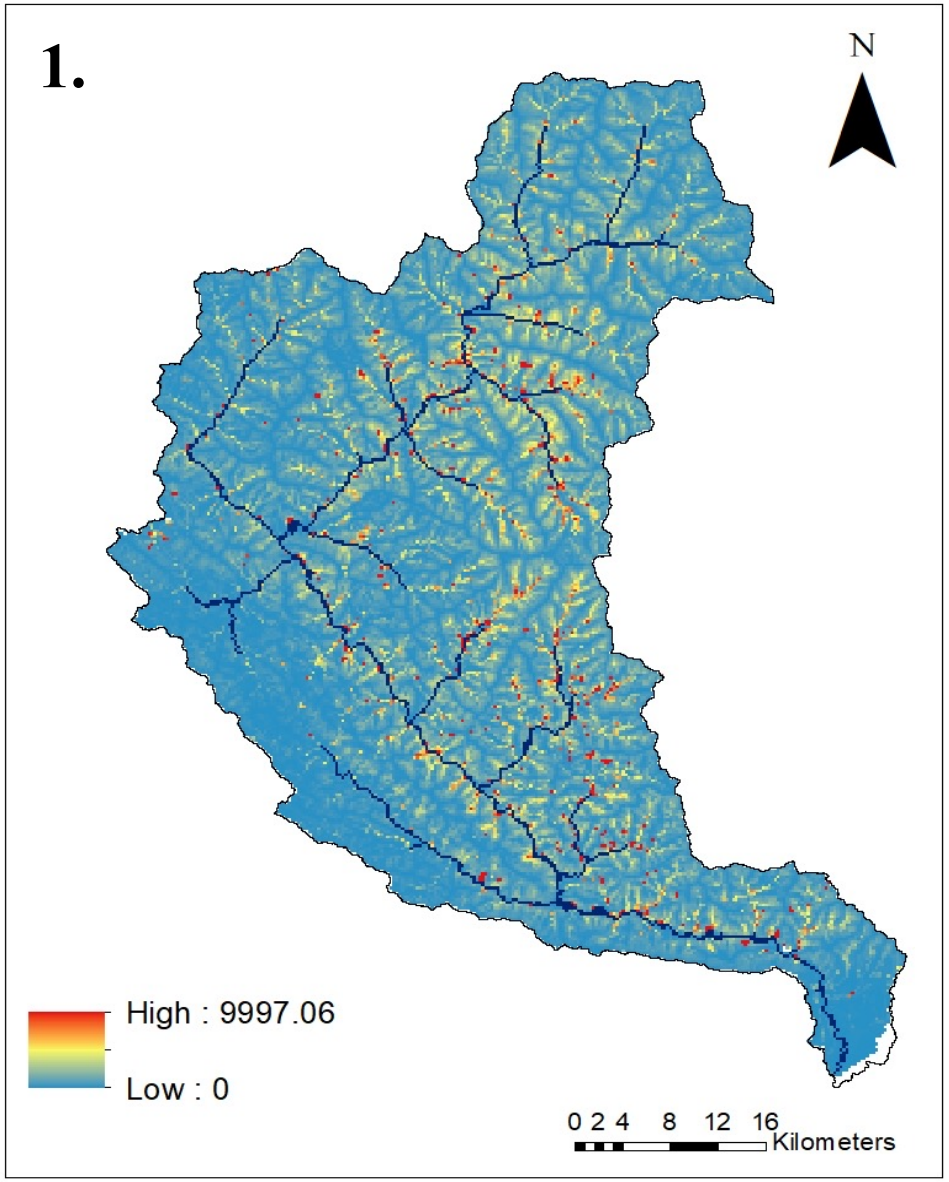
Results

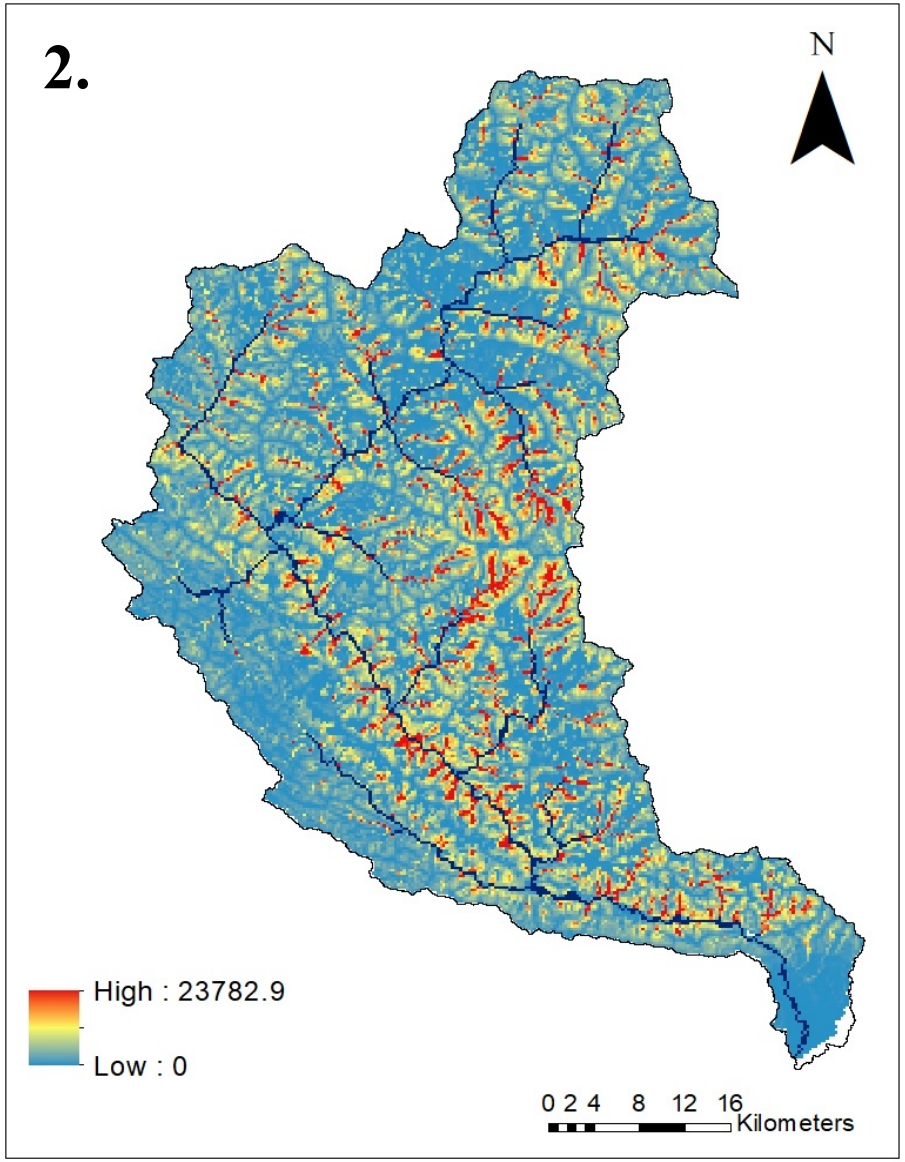


Land use and Land cover map and its distribution in the Giri river watershed

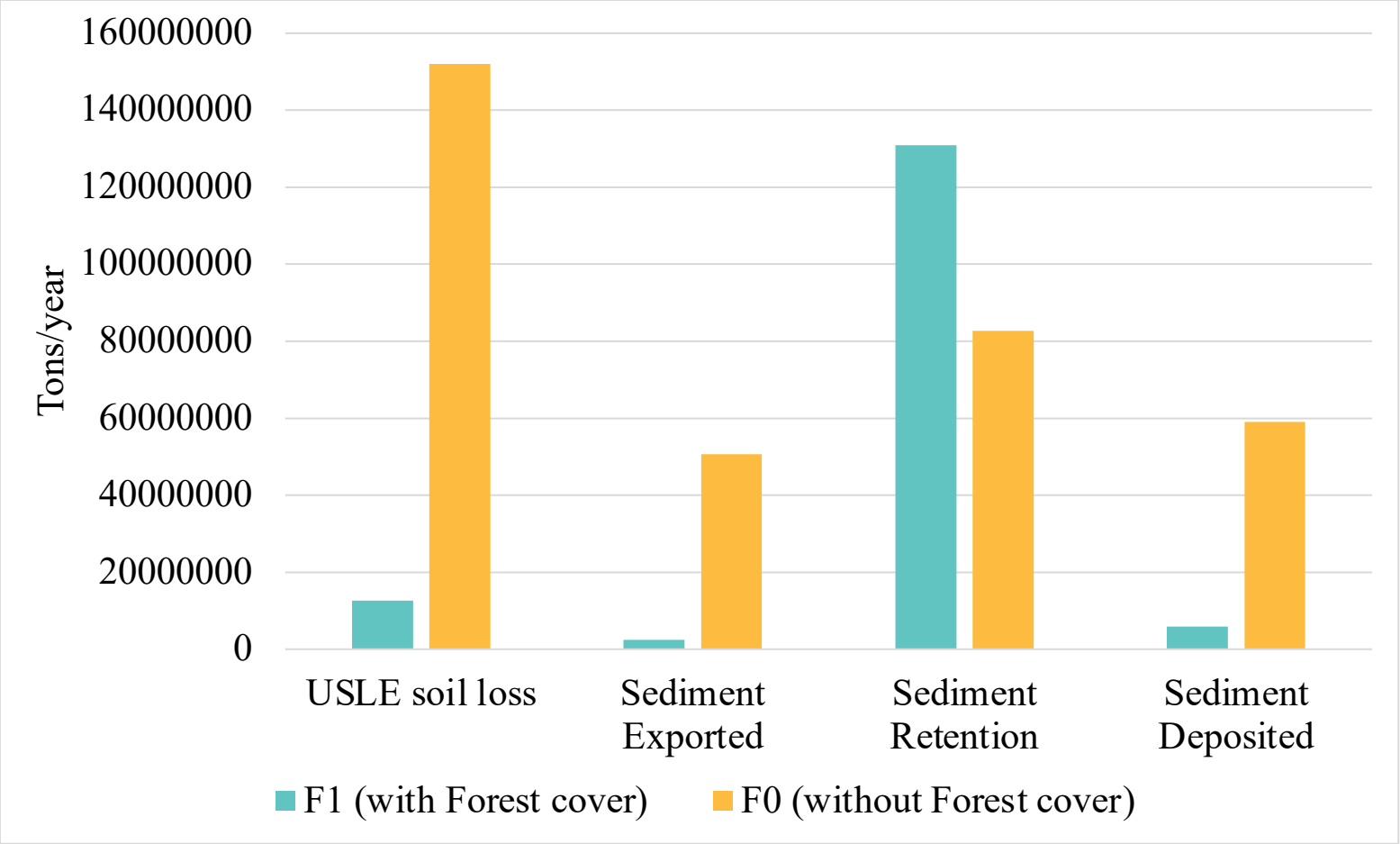


Estimated Sediment yield in the Giri river watershed in Himalayan region under two different scenario 1. with forest (F1) & 2. without forest (F0)





Estimated Sediment Yield and Deposition in the Giri River Watershed under different scenarios



Valuation of the Sediment retention service by Replacement Cost Method in the Giri river watershed

Area (in sqkm)	**2651.53**
Sediment Yield (tons/year)	48256741.85
Sediment Yield (m^3/year)	30160463.66
Total Replacement Cost (in US$)	241283709.3
Total replacement cost × 10^8 (in US$)	2.4

Conclusion

- The estimated sediment yield in the Giri watershed was 2363260.41 tons/year with forest cover and 506200002.26 tons/year with absence of forest cover in the watershed.
- The forest cover had an influence on sediment yield in the watershed. The average soil loss was observed to be 12544155.28 tons/year and 152003094.4 tons/year with and without forest respectively.
- The total estimated cost for dredging and disposing of the accumulated sediment was 2.8×10^{8} US$. The estimated cost is direct indication of the loss occurred in case of the soil loss due to removal of forest/ tree cover in the watershed.
- Spatial distribution of soil loss and erosion cost could provide a basis for comprehensive and sustainable watershed management.
- The study concluded that the forests play a key role in supporting sediment retention service in Himalayan watersheds. Furthermore, valuation methods integrated with advanced system analysis are useful for sustainable management, decision making and restoration practices in the Himalayan watershed.

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