Assessing Climate-change Impacts on Nepal’s Forests for Landscape-Scale Spatial Planning

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The Eastern Himalayas are a region of global importance for biodiversity.

- Three Global 200 ecoregions
  - Eastern Himalayan Alpine Meadows,
  - Eastern Himalayan Broadleaf and Conifer Forests,
  - Terai Duar Savannas and Grasslands
- Biodiversity Hotspot
- Endemic/Important Bird Areas
IPCC 2007 predicts the Himalaya’s temperature will increase by 3 °C by 2050 and 5 °C by 2100.

- But more recent assessments predict greater increases

- Precipitation is expected to be greater, but erratic, and unpredictable


Climate Change

- Projected and predicted impacts of increased temperature and precipitation:
  - shifts, changes, and loss of forest type, quality, and community
  - species extinctions
  - changes to ecosystem service delivery
  - increased vulnerability to livelihoods, lives, agriculture, infrastructure
  - cascading, downstream impacts

- Important to understand consequences to develop comprehensive, long-term conservation plans and strategies

Climate Change Impacts in Nepal

- Global climate change expected to cause warmer, wetter conditions

- Considerable local variation across the country
  - higher temperatures in western and central Nepal
  - Monsoon (summer) precipitation increase by about 15-20%
  - decrease in rainfall in the mid-hills (NAPA).

- Unpredictable, extreme weather events (floods, droughts)
Climate Change Impacts in Nepal

- These changes have to be considered in landscape-scale conservation strategies.
Climate Change-Integrated Conservation Strategies

- Climate envelopes widely used to predict future distribution of habitats and species
- But, complex mountain terrain of Nepal Himalaya adds a layer of complexity from meso- and micro-climates that are de-coupled from regional effects of climate change.
- These can be overlooked in coarse-scale climate envelope models
Climate Change-Integrated Conservation Strategies

- Used a ‘hybrid’ approach:
  - combined regional bioclimatic data–based climate envelope model with terrain-based analyses.
  - Identified macro- and microrefugia for landscape-scale climate change-integrated conservation planning in two conservation landscapes in Nepal
Conservation Landscapes

Legend
- Terai Arc Landscape (TAL)
- Chitwan Annapurna Landscape (CHAL)
- Major Rivers

0 30 70 140 Km

North  East
26°00'N 27°00'N 28°00'N 29°00'N 30°00'N 31°00'N
80°00'E 81°00'E 82°00'E 83°00'E 84°00'E 85°00'E 86°00'E 87°00'E 88°00'E

Conservation Landscapes

Terai Arc Landscape

Chitwan Annapurna Landscape
Chitwan Annapurna Landscape

- Snow leopard, Himalayan wolf, Brown bear, Blue sheep, Himalayan Thar in alpine regions

- Red panda, clouded leopards, wild dogs, golden cats, musk deer in upper and mid-hill temperate forests

- North-south corridor for migratory birds

- Endemic plants in alpine areas

- Water
• East-West connectivity for metapopulation management of tigers, leopards, elephants, and other large species

• Conservation of Siwalik/Churia mountain range

• Livelihoods through sustainable forest and water management
Climate Change Integrated Conservation Planning

- Landscape conservation plans should consider climate vulnerabilities and develop adaptation strategies.

- Climate resilient areas (refugia) can occur along a continuum of scales, especially in complex terrain.

- These refugia should be integrated into conservation plans:
  - Macrorefugia essential for large, wide-ranging species, ecological processes
  - Microrefugia important for smaller, habitat specialist and endemic species
  - Strategic inclusion of refugia into climate corridors for ecological connectivity
• IPCC A2A GHG scenario

• Assessed change in distribution of 8 climate resilient forest vegetation types (2050 and 2080 time scales)

• Climate envelope analyses with 19 WorldClim bioclimatic variables in Maxent

• Used forest map of pre-conversion state of forest distribution (prepared by Government of Nepal)
Approach and Methods – Meso and Microrefugia

- Terrain-based analyses to select major terrain features that are decoupled from influences of regional climate change

- Applied ruggedness index to SRTM 90m Digital Elevation Model (DEM) in ArcGIS 10 to identify steep, deep areas

- Applied the Solar Radiation extension in ArcGIS 10 to the DEM to identify low insolation slopes

- Selected old growth forests clipping forest cover with above two outputs
Results: 2013 Forest Distribution

Current Distribution of Forest Vegetation Types

- Mid-hill forests and lowland forests highly fragmented
- Subalpine forests relatively more intact
2050 Scenario for Macrorefugia

- Temperate Broadleaf and Subalpine Conifer forests resilient, retain large patches
- Subtropical forests more fragmented
- Hill Sal forests, along the Siwalks/Churia highly fragmented with scattered patches
- Lowland Sal completely converted
- Chir Pine forests mostly converted
Results: 2050 scenario

2050 Scenario for Macrorefugia and Microrefugia

- Several patches of Subtropical Forests, Lowland Sal Forests, Hill Sal forests, and Chir Pine forests in microrefugia.
Results: 2050 scenario

2050 Scenario for Macrorefugia and Microrefugia

- Several patches of Subtropical Forests, Lowland Sal Forests, Hill Sal forests, and Chir Pine forests in microrefugia.
2080 Scenario for Macrorefugia and Microrefugia

- Macrorefugia in the mid-hills and lowhills will become more fragmented.
- Upper montane forests will be less fragmented.
- But microrefugia will persist and provide connectivity.
Results: Impact on forest ecosystems

- Temperate Broadleaf and Subalpine Conifer forests more resilient to CC even under A2A GHG scenarios

- Large patches of Eastern Himalayan Temperate Broadleaf and Conifer Forests Global 200 ecoregions will remain and are important for irreplaceable eastern Himalayan biodiversity

- Forests in mid- and lower-hill forests vulnerable. These forests important to maintain species migrations, ecosystem services/e-flows, and as climate corridors

- But the terrain-based analysis shows presence of micro- and meso- climate refugia, where vegetation will be resilient to change.
Recommendations

• Secure and conserve the climate resistant forests in the upper and mid-hills conserved as climate refugia and micro-refugia for the habitat specialist species

• Maintain north-south connectivity maintained for migrations and as climate corridors.

• Conserve riparian corridors and upper watersheds to sustain ecosystem services.

• Strategically restore and conserve areas vulnerable to natural disasters

• Develop climate-smart natural resource management strategies at landscape or basin scale, also address the proximate and current threats that exacerbate climate change related threats

• Train protected area staff and local community groups to assess and integrate climate change impacts into conservation planning and management
This presentation is made possible by the generous support of the American people through the United States Agency for International Development (USAID). The content is the responsibility of the authors and does not necessarily reflect the views of USAID or the United States Government.