Building Effective Water Governance in the Asian Highlands

IDRC Project Number 107085.002
Climatic / Hydrological Modelling

Downscaled climate models/scenarios - 2050
1. Use IPCC AR5 / RCM from China Climate Center
2. Delta Method – R. Hijmans (UC Davis)

Modeling CC impacts on terrestrial ecosystems / ecoregions
1. Bioclimatic stratification
2. Model CC impacts on ecosystems (spatial distribution)

Wetlands delineation
1. MODIS / Analyze impact of CC on wetlands

Hydrological/water balances
1. Model impacts of CC on study site/regional hydrological balances
2. Local – SWAT - Lijiang Study Site
3. Regional – Simple water balance approach

Drought Analysis
1. SPI _ Yunnan Province – 2000 – 2010
Asian Highlands Project Area
CC Impacts on Ecosystems – Regional Environmental Stratification

* Bioclimatic Stratification of the Asian Highlands region

* Use Global Environmental Stratification (GEnS) –

* Spatial analysis of climate change impacts on Ecosystems

* Reconstruct GEnS based on future climate conditions

* Analysis of CC impacts on hydrology by bioclimatic strata
Global Environment Stratification (GEnS)

- Statistically based
- 30 arc sec (~1 km²) resolution
- 125 Strata / 18 Zones
- GEO-BoN Framework
- Comparative Analysis
- Use for CC modelling

A globally consistent bio-climatic stratification based upon a statistical quantitative approach using spatially distributed climate data (WorldClim – 1 km²) developed within the framework of the GEOSS Biodiversity Observation Network (GeoBON) (Metzger et al. 2013)

GEnS – Global Stratification

Yunnan Province: Environmental Stratification

[Map of Yunnan Province showing different environmental zones labeled with codes A to R and their descriptions: F. Extremely Cold and Mesic, G. Cold and Mesic, H. Cool Temperate and Moist, J. Cool Temperate and Mesic, K. Warm Temperate and Mesic, L. Warm Temperate and Moist, M. Extremely hot and Mesic, N. Hot and Mesic, R. Extremely Hot and Moist.]

Xishuangbanna Prefecture

100 200 300 400 500 Kilometers
Climate Change: 2000 – 2050
China

Generally hotter and wetter

Annual average temperature: increases 2.3 – 3.3 °C by 2050

Annual average temperature: increases 3.9 – 6.0°C by 2100

Increase in precipitation of 11-17%

Lin et al. (2007)
Weng and Zhou (2006)

Yunnan Province

Annual temperature: increases 2.1°C by 2050
Climate Change 2000 - 2050

WorldClim / Hadley GCM = SERS A2A (IPCC AR4)

Kailash Sacred Landscape – China, India, Nepal
Modelling Change (2050)

- Reconstruct the Asian Highlands-EnS based upon GCM future conditions
  - Statistical profiles for each stratum
    - Multivariate Analysis – Other techniques...
  - Reconstruct AH-EnS – Based on original statistical profiles
GEnS Significant Bioclimatic Variables

- **a1**: Tmean * days > 0 C
  - 0 - 100
  - 100 - 200
  - 200 - 400
  - 400 - 600
  - > 600

- **b1**: Aridity Index
  - 0.6 - 0.8
  - 0.8 - 1.0
  - 1.0 - 1.2
  - 1.2 - 1.4
  - > 1.4

- **c1**: Monthly Mean Temp Seasonality (St Dev * 100)
  - 450 - 480
  - 480 - 520
  - 520 - 560
  - 560 - 600
  - > 600

- **d1**: PET Seasonality (St Dev * 100)
  - 1,500 - 2,500
  - 2,501 - 3,000
  - 3,001 - 3,500
  - 3,501 - 4,000
  - 4,001 - 5,000

- **a2**: Tmean * days > 0 C
  - 0 - 100
  - 100 - 200
  - 200 - 400
  - 400 - 600
  - > 600

- **b2**: Aridity Index
  - 0.6 - 0.8
  - 0.8 - 1.0
  - 1.0 - 1.2
  - 1.2 - 1.4
  - > 1.4

- **c2**: Monthly Mean Temp Seasonality (St Dev * 100)
  - 450 - 480
  - 480 - 520
  - 520 - 560
  - 560 - 600
  - > 600

- **d2**: PET Seasonality (St Dev * 100)
  - 1,500 - 2,500
  - 2,501 - 3,000
  - 3,001 - 3,500
  - 3,501 - 4,000
  - 4,001 - 5,000
Yunnan Province:
Bioclimatic zones and predicted change in distribution by the year 2050

<table>
<thead>
<tr>
<th>Ecosystem Type</th>
<th>Mean Precip (mm/yr)</th>
<th>Mean Temp (°C)</th>
<th>Area (km²)</th>
<th>Area (km²)</th>
<th>Avg Elev (m asl)</th>
<th>Avg Elev (m asl)</th>
<th>Elev Change (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>F. Extremely cold and mesic</td>
<td>740</td>
<td>1.57</td>
<td>6260</td>
<td>5008</td>
<td>4312</td>
<td>5068</td>
<td>756</td>
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<tr>
<td>G. Cold and mesic</td>
<td>872</td>
<td>6.18</td>
<td>18855</td>
<td>15084</td>
<td>3534</td>
<td>4318</td>
<td>784</td>
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<tr>
<td>H. Cool temperate and dry</td>
<td>690</td>
<td>8.79</td>
<td>882</td>
<td>-</td>
<td>3127</td>
<td>-</td>
<td>-</td>
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<tr>
<td>J. Cool temperate and moist</td>
<td>1026</td>
<td>9.91</td>
<td>20949</td>
<td>705</td>
<td>2862</td>
<td>3279</td>
<td>418</td>
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<tr>
<td>K. Warm temperate and mesic</td>
<td>1127</td>
<td>14.45</td>
<td>181886</td>
<td>16759</td>
<td>2016</td>
<td>2297</td>
<td>281</td>
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<td>L. Warm temperate and xeric</td>
<td>957</td>
<td>16.75</td>
<td>30198</td>
<td>-</td>
<td>1790</td>
<td>-</td>
<td>-</td>
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<tr>
<td>N. Hot and dry</td>
<td>1342</td>
<td>21.84</td>
<td>17504</td>
<td>145508</td>
<td>783</td>
<td>1195</td>
<td>412</td>
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<td>M. Extremely hot and mesic</td>
<td>1258</td>
<td>18.88</td>
<td>117149</td>
<td>24159</td>
<td>1318</td>
<td>1831</td>
<td>513</td>
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<tr>
<td>R. Extremely hot and moist</td>
<td>979</td>
<td>23.79</td>
<td>1039</td>
<td>14003</td>
<td>552</td>
<td>770</td>
<td>219</td>
</tr>
</tbody>
</table>
Bioclimatic zones can be matched to Ecoregions, Veg Types, Forest Classes, and Etc.
Impact of Climate Changes and Landuse – Xishuangbanna, SW China
Hydrological impacts of climate change

We looked for a method that could be easily applied with available datasets, both at regional scale and as a support tool for pilot studies.

A monthly Thornthwaite-Mather Soil-Water Budget is calculated as:

\[ SWC = EPr ec \cdot AET \cdot R \]

- SWC is the soil water content
- EPr ec is the effective precipitation
- AET is the Actual Evapotranspiration
- R is the Excess Water (Runoff)
Overview of Analysis

* Geospatial analysis - based on global datasets:
  * Calculation of AET / SWC / Runoff
    * Year 2000 (avg 1960-2000) - WorldClim
  * Calculation of AET / SWC / Runoff with climate change
    * Year 2050 (avg 2040-2059) – IPCC AR5 – CCC RCM
  * Calculation of change AET / SWC / Runoff
  * Identify, analyze and map change in Water Cycle
    * Identify impacts and implications
      * Geographically / Basins

Spatial Resolution = 30 arc sec = approx. 1 km sq. at the equator
CDM-AR Project

Project Area CDM-AR Area Precip
(ha) (ha) (mm/yr)
32,142 9,873 900
40,604 11,077 3000
15,104 13,327 700
41,878 26,564 1300

Aridity Index Vapor Flow Increase Runoff Decrease SWC Decrease
(Mean Al) (%) (%) (%)
0.8 7.1 27.7 7.3
1.8 15.1 12.4 1.1
0.6 4.7 54.0 32.0
0.9 23.4 47.4 13.4

Local Scale / Pilot Sites
Global Circulation Model (GCM) outputs downscaled (~1km) and calibrated (bias corrected) WorldClim 1.4 used as baseline 'current' climate (average 1960-2000)

Time period: 2050 (average for 2041-2060)

Variables:
- tn - monthly average minimum temperature (degrees C)
- tx - monthly average maximum temperature (degrees C)
- pr - monthly total precipitation (mm)
- bc - 'bioclimatic' variables

Total # of Model / RCP Combination = 63

Provided by: Robert Hijmans – UC Davis

Regional Climate Model (RCM)
China Climate Center – Downscaled to ~1km
WorldClim 1960-2000

Mean: 481 mm
Asian Highlands Project Area