Land & Water Management in Cold Deserts: a challenge of HIMALAYAN proportions

HIMALAYAN COLD DESERTS

A Unique Ecosystem

Elevation of >8,000 ft., inhabited upto 16,400 ft.

Extreme climate with winters of up to -40^{o}C; high annual temperature variation

Extremely arid conditions and major form of precipitation is snowfall

1 of 34 Global Biodiversity Hotspots

High species endemism with several rare species of flora and fauna;

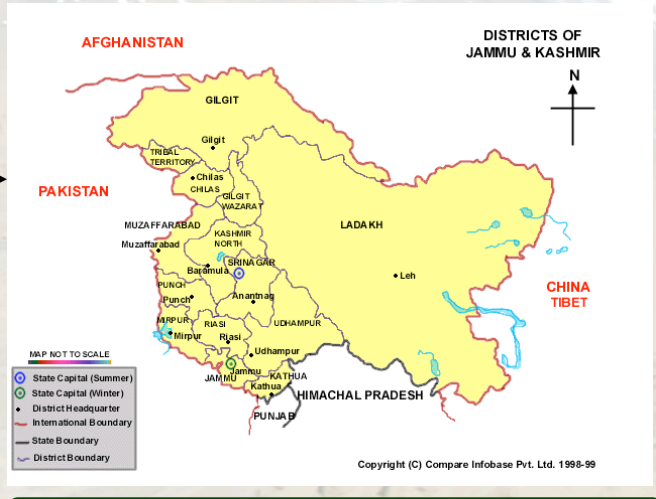
Sparse vegetation and fragile ecosystem

Strong People-NR Connect

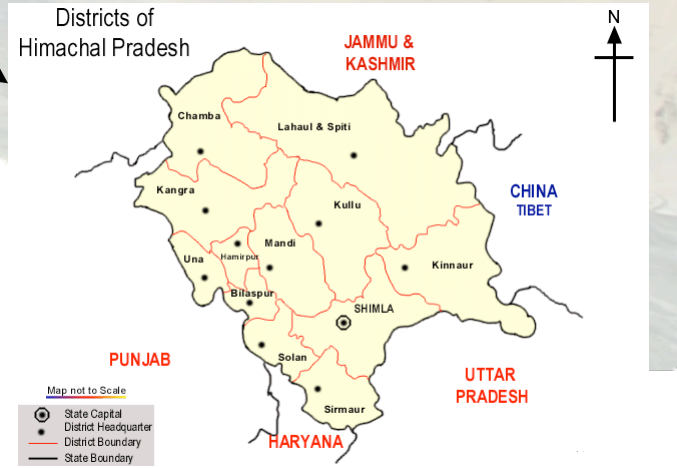
Scattered, remote habitations; agro-pastoral economy

Completely NR-dependent economy

Target Area



J&K -Leh, Kargil



HIMACHAL- L&S, Kinnaur, Chamba

Western Himalayas

J&K: *Leh, Kargil*

HP: *Lahaul & Spiti*
Kinnaur, Chamba

Characteristic Features

Anthropogenic features

Population density	2/sq km I.e. 89.7% rural population
literacy	25-35% (Female-male)
Land use pattern	65% of the land is barren & uncultivated 20% of the area sown 9.75% - cultivable wasteland 2.47% of total land under trees, shrubs & pastures
Socio-economic status	75% of the population are cultivators 4.5% are into livestock rearing 1.5% are into transport & communication

Land: *predominantly acidic soils, loamy to sandy texture*

- Low soil fertility and low crop productivity. Shallow soils with low water retention capacity.
- Steep gradients and limited arable land. 65% barren wastelands.
- Very high wind & water erosion.
- Increasing desertification. Increasing conversion for economic and development reasons.
- Increasing pressure on land and use of commercial crops with negative effects on soils.

Water: *sources- glaciers, springs, lakes, streams*

- Glacier dependent irrigation: receding glaciers, drying up of streams and rivers
- River systems under-utilized and difficult to harness with high silt content and high diurnal/seasonal fluctuations
- High evaporation & seepage losses
- Frequent droughts and shortage of water for irrigation

INCREASING THREAT LEVELS!

Climate Change

1. Impact of climate change 3-5% more pronounced in high altitudes.
2. 67% of Himalayan Glaciers have retreated in last decade, most will vanish within next 40 years.
3. Rise in 3^0C is equivalent to an ecological shift of about 500 m resulting in extinction of species. A loss of 1/10th of the world's biodiversity of high altitudes is expected in the Himalayas alone.
4. Grassland and rangeland productivity will decrease by 40-90% with increase in temperatures combined with low precipitation.

Environmental Threat

1. Increasing frequency of droughts and escalating desertification
2. Flashfloods, landslides, GLOFs: the Sutlej valley has had flashfloods almost every year in the last 6 years
3. Increased run-off with high hydraulic gradients and rapid stream responses destroying land; damage due to avalanches & landslides.

Anthropogenic Pressure & Resource Stress

1. Agro-pastoral economy with near total dependence of the population on NR. Population in the IHR has increased 2.7 times in the last 4 decades, and led to widespread clearing of land for cultivation/development.
2. Shift to commercial species has affected water table and soil quality.
3. About 70% of the pasturelands are facing degradation, affecting thousands of high altitude pastoralists.
4. There is severe burden on women and households dependent on NTFPs.

Technology and Development Gaps and Low Adaptation Capacity

1. Steep gradients with implications for management of land and water. Most technologies not suitable for extremes of climate and topography.
2. Poor infrastructure and services and few development interventions.
3. Low human resource capacity. Low occupational diversity. Less livelihood options and adaptation potential.

ENVIRONMENTAL VULNERABILITY
A Study on Environmental Threat & Adaptation in Cold Deserts

- ***A less-understood region***: Very little research interest and technology development focused on this region.
- ***People's distress and ecological degradation***: The ecology is under pressure and people's lives affected.
- ***What's the nature & severity of the problem***: A scientific understanding is required of the problem- nature, scale, magnitude, variations, …
- ***Appropriate and area-specific solutions***: Suitable strategies are needed for natural resource management (ie for land and water) around which the livelihoods of people revolves.

Objectives

- **Assess Degree and Nature of Environmental Threat for Cold Desert Watersheds**
- **Assess Development Status and Adaptation Capacity**
- **Determine Vulnerability Index for Cold Desert Watersheds and determine major causal and mediating factors.**
- **Evolve appropriate land & water management strategies for cold deserts to reduce vulnerability.**

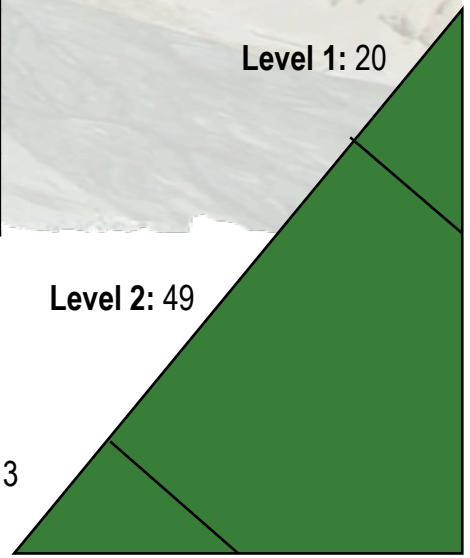
Key Approach

1. data by geographical range and watershed level
2. examine ecological aspects including climate and anthropogenic pressure; measure resource aspects, including stress
3. determine development status and its contribution to adaptation capacity

Stratification of Watersheds

Biogeographic Zone (4)	State (2)	Watershed level	Watersheds (82)
Trans Himalayas	*J&K*	1	8
		2	10
		3	7
	Himachal Pradesh-Lahaul & Spiti	1	6
		2	24
		3	4
Western Himalayas	*Himachal Pradesh-Kinnaur & Pangi*	1	6
		2	15
		3	2

Zonation of WS



Methodology

Sampling

- Bio-geographic zonation
- Detailed study of maps for delineation of Watershed Levels and included watersheds
  - first level WS
  - second level WS
  - third level WS
- Determination of key differentiators: aspect, distance from water source, distance from HQ
- Recce of area and selection of representative, stratified sample based on
  - zonation,
  - watershed levels
  - key differentiators

Data collection

Participatory approach melded with scientific observation

- Data collection
  - Village information (*PRAs*)
  - Ecological data:
    Hydrological data,
    Soil data,
    Vegetation related data
    (*scientific survey & measurement*)

Data Analysis

Principal Component Analysis: *survey instruments translated into several composite indices with weightage to each individual component variable*

Predictive Variables

Development:	
• Distance from development:	resource ownership; NR-dependence; road & transportation, other infrastructure
• Human development status	income, education, health, etc.; food security; occupational diversity; development interventions
Ecology:	
• Hydrology	stream flow & quantity; wetland area; precipitation; no. of water sources
• Vegetation	vegetation cover; integrity & status
• Soil	soil quality & moisture
Climate:	
• Climate (supportive)	precipitation & snow cover; temperature
• Climate Change	change in above and water resources
Disaster occurrence	freq of floods, droughts; perception of threat

Predictive Variables

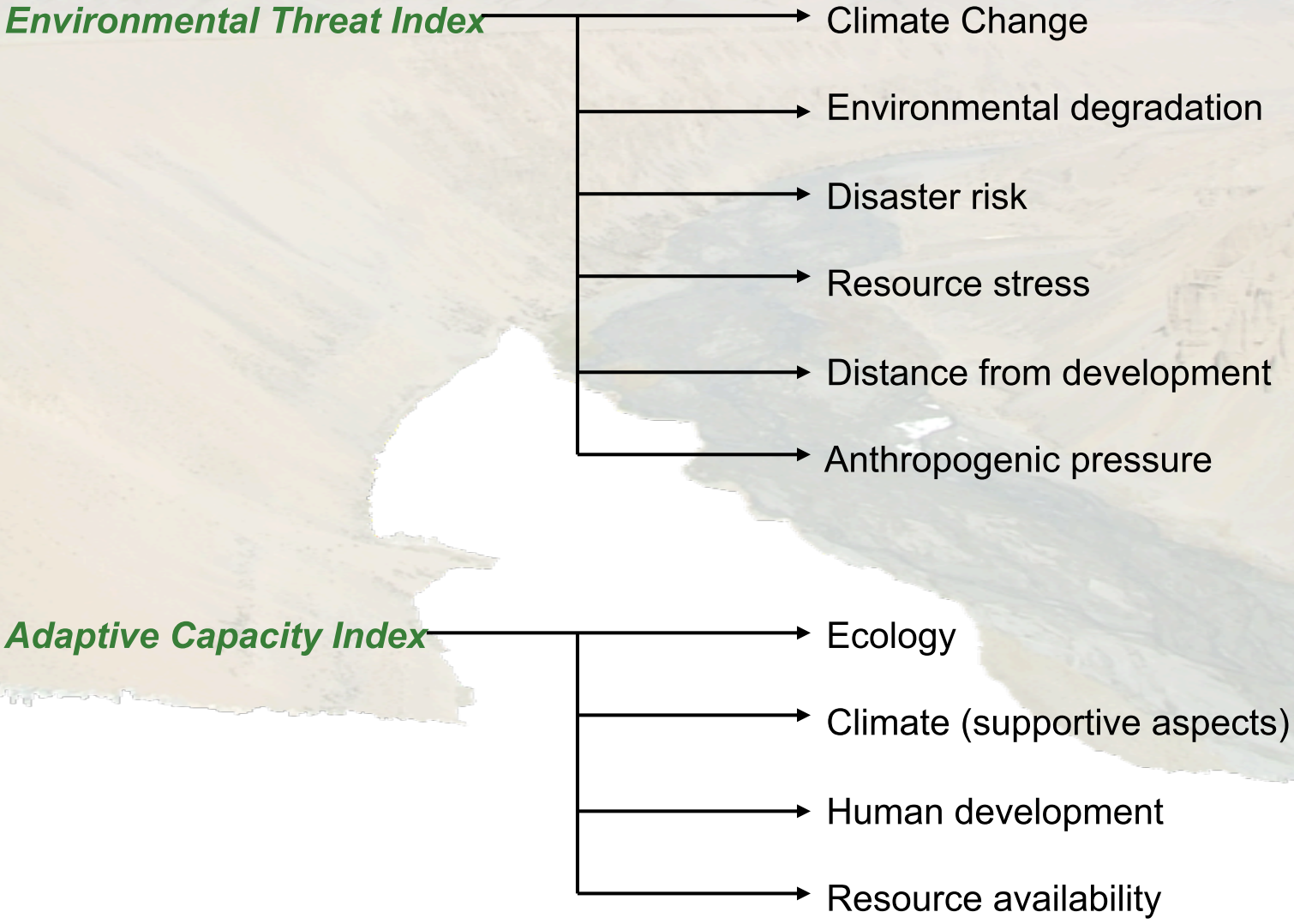
Resources:

• Resource availability & access	access to springs and irrigation resources; access to NTFPs
• Resource stress	demand-supply gaps in irrigation, drinking water, fodder, fuelwood, and perceptions of stress

Pressure:

• Anthropogenic pressure	per capita NR; NR dependence; population & tourist pressure; grazing; development
• Eco-degradation	soil & water quality, erosion; reduction in water and forests

Criterion Variables



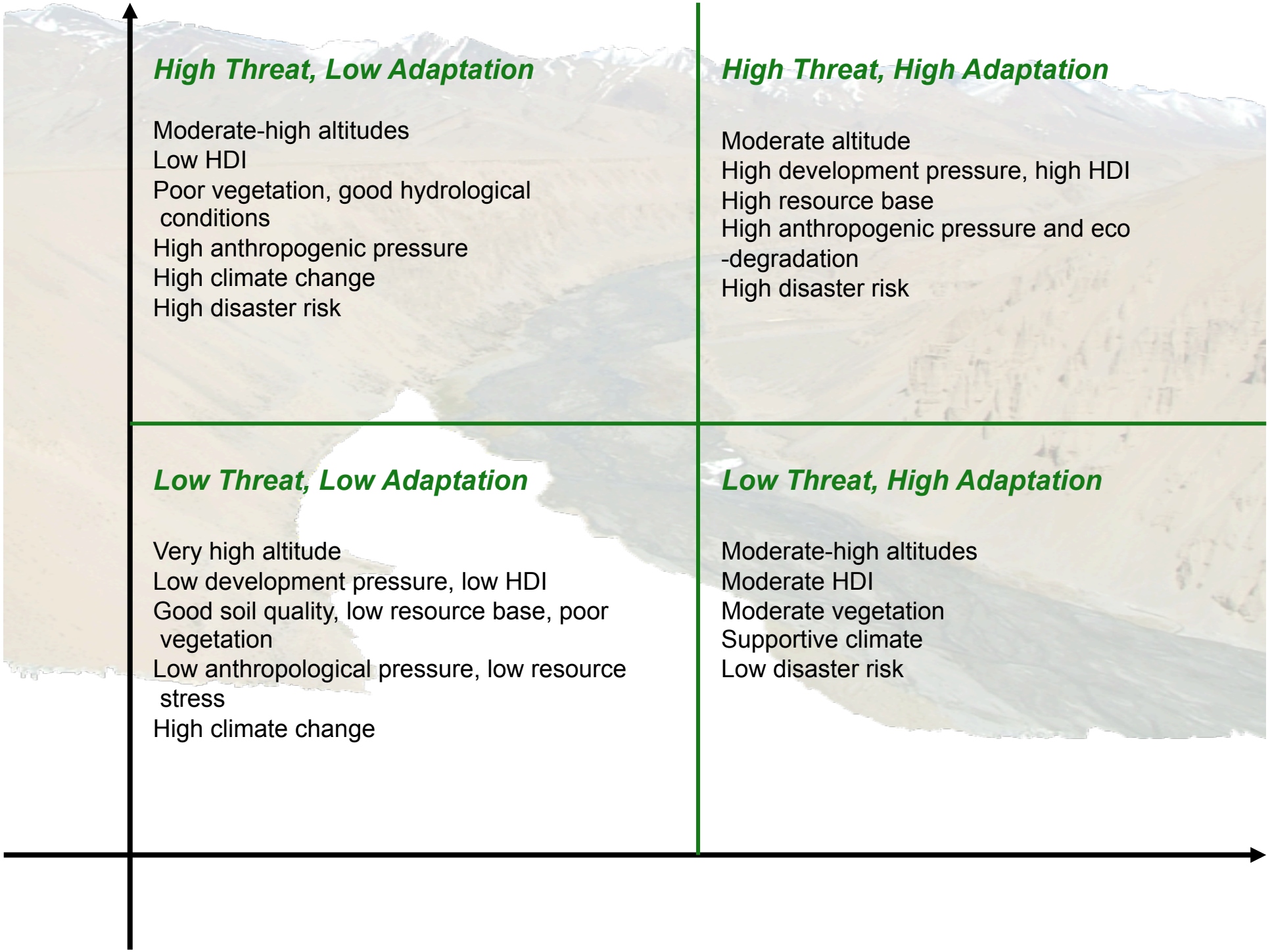
The Findings

Environmental Threat Index

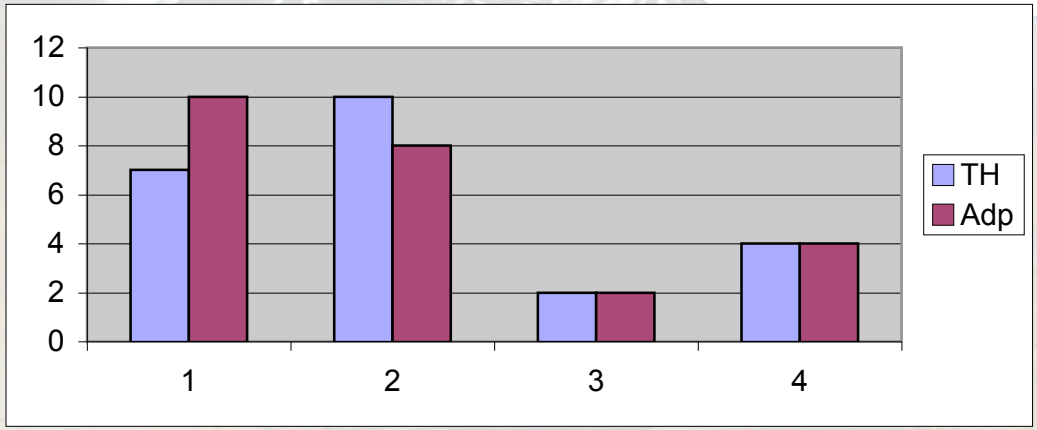
Threat Level	*Score range*	*Features*
Very Low Environmental Threat	-.23 to -.99	High altitude (around 3500-4000m) Lower population; Very low anthropogenic disturbance Low resource base; Good quality soil
Medium Environmental Threat	0.52 to -.23	High altitude (around 3500-4000m) Lowest level of stress (demand&supply gap + disaster occurrence) Good hydrological conditions
High Environmental Threat	1.27 to 0.52	Medium altitudes (3000-3500m) Moderate resource base High anthropogenic pressure; High disaster threat Very high degree of climate change Poor ecological conditions
Very High Environmental Threat	2.03 to 1.27	Moderately lower altitude High stress level (demand & supply gap + disaster occurrence) High level of developmental activities Moderately high degree of climate change Larger population; High pressure levels (anthropogenic+eco-degradation) High HDI High resource base; Good soil quality

Adaptation Capacity Index

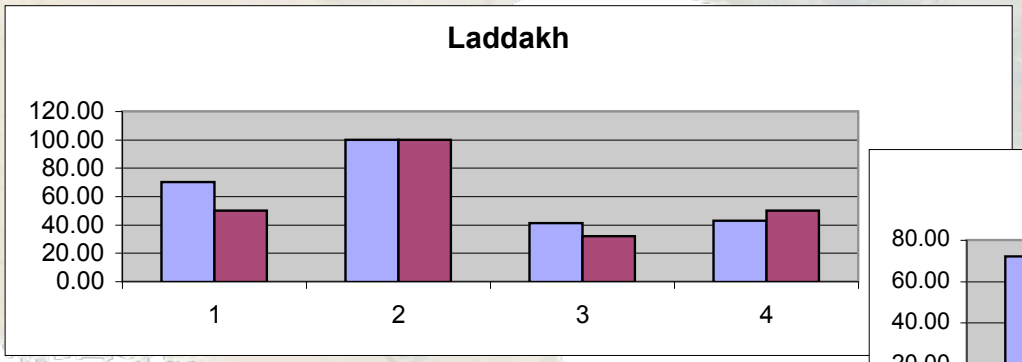
Adaptation Capacity	*Score range*	*Features*
Very Low Adaptation Capacity	-1.04 to -.28	High altitude (3500-4000 m) Very poor vegetation Lowest resource base; Low stress (demand supply gap&disaster) Less supportive climate; Very high climate change Lowest anthropological pressure; Low developmental activities Low HDI Good soil quality
Medium Adaptation Capacity	-.28 to .48	High altitude (3500-4000 m) Very poor vegetation; Moderate soil and climate Low HDI
High Adaptation Capacity	.48 to 1.24	Lower altitudes (2500-3000 m) Supportive climate Moderate vegetation Moderately good HDI
Very High Adaptation Capacity	1.24 to 2.00	Good vegetation Very high HDI Very high stress (demand supply gap&disaster); Highest resource base Very high pressure (anthropogenic + degradation) Lowest climate change High developmental activities

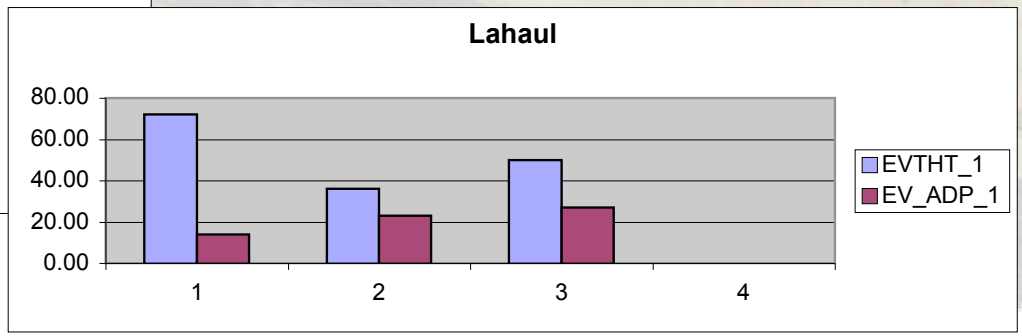

High Threat, Low Adaptation
Moderate-high altitudes
Low HDI
Poor vegetation, good hydrological conditions
High anthropogenic pressure
High climate change
High disaster risk
High Threat, High Adaptation
Moderate altitude
High development pressure, high HDI
High resource base
High anthropogenic pressure and eco-degradation
High disaster risk
Low Threat, Low Adaptation
Very high altitude
Low development pressure, low HDI
Good soil quality, low resource base, poor vegetation
Low anthropological pressure, low resource stress
High climate change
Low Threat, High Adaptation
Moderate-high altitudes
Moderate HDI
Moderate vegetation
Supportive climate
Low disaster risk

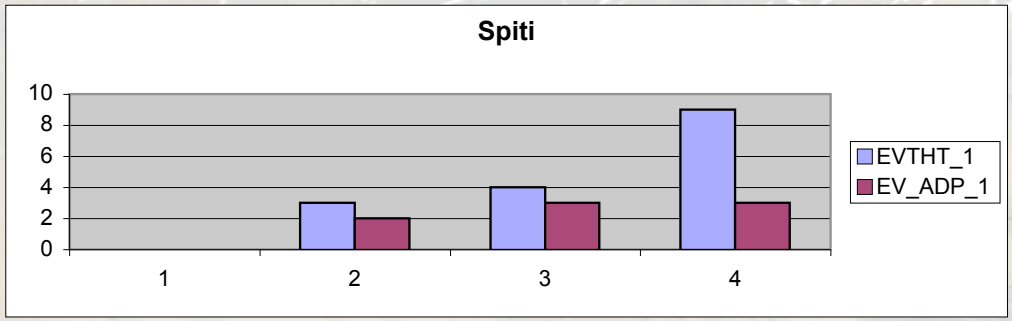
An overview:



There are inter-regional variations:



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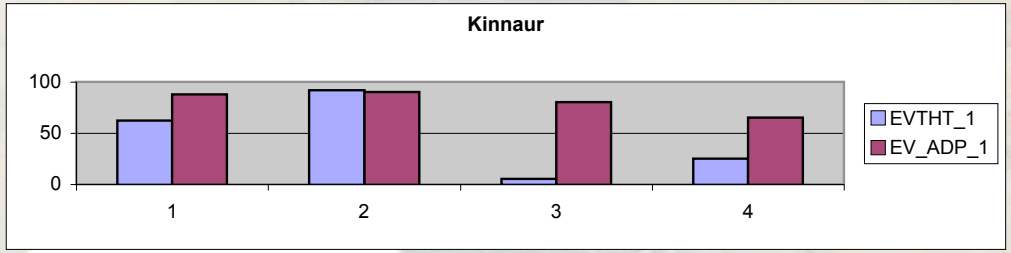
EVTHT_1
EV_ADP_1


Kinnaur
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50
0
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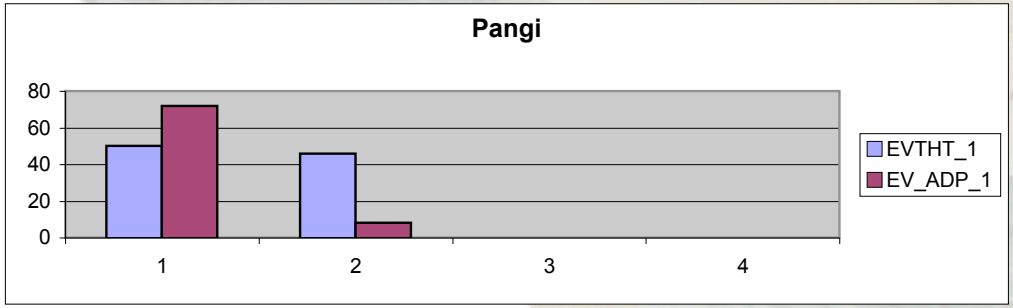
3
4
EVTHT_1
EV_ADP_1


Pangi
80
60
40
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4
EVTHT_1
EV_ADP_1

Relationships

Ecology:

Ecology (hydro, soil and vegetation) has a strong positive correlation with supportive climate and distance from water bodies, and lower anthropogenic pressure.

It is however negatively associated with developmental activities, resource stress and extent of climate change.

Better ecology also implies low Environmental Threat.

Resource Stress:

Stress levels increase with growth in livestock population, developmental activities, climate change.

Lower stress levels are associated with higher ecological status, more supportive climate, higher resource availability lesser the environmental stress, higher HDI levels.

Climate:

Climate change is strongly associated with developmental activities, and with increasing environmental stress and environmental threat. Climate change has a negative association with availability of natural resources.

Relationships

Environmental Threat

Environmental Threat has a strong positive correlation with developmental activities, climate change, resource stress (increasing demand of natural resources).

Environmental Threat has a negative association ecological status, and availability of natural resources.

Adaptation Capacity

Adaptation Capacity has a strongly positive correlation with ecological status, supportive climate, and availability of natural resources.

It has negative associations with developmental activities, ecological degradation, climate change, and resource stress.

Watershed Vulnerability

Vulnerability is low when there is evident of ecological balance, availability of natural resources, and a supportive climate.

Vulnerability is high when developmental activities are high, resource stress is high, climate change and its impacts greater.

NEED FOR VULNERABILITY MANAGEMENT

- ***There are critical issues to be addressed with respect to vulnerability of cold deserts***: Climate Change, Desertification & Environmental Threat, Anthropogenic Pressure, Resource Stress, Technology and Institutional Gap, and Low Development and Capacity.

- ***Special focus in required on two natural resources on which ecological balance and human development status depend***:
  - Water, for which suitable harvesting, distribution, utilization, and conservation strategies need to be crystallised.
  - Land, for which appropriate startegies need to be developed aimed at erosion control and moisture conservation, wasteland/watershed development, and conservation of CPRs.

- ***Hotspots and Greenspots***: There are variations within the target region in resource stress and potential that call for area-specific responses. There are ‘safe zones’ and ‘high risk zones’.

- ***There is a need to devise adaptation mechanisms to manage vulnerability***: There is an urgent need to look at this vulnerable region and devise potential methods/ technologies adapted to topography, climate, resources, that help manage the vulnerability.