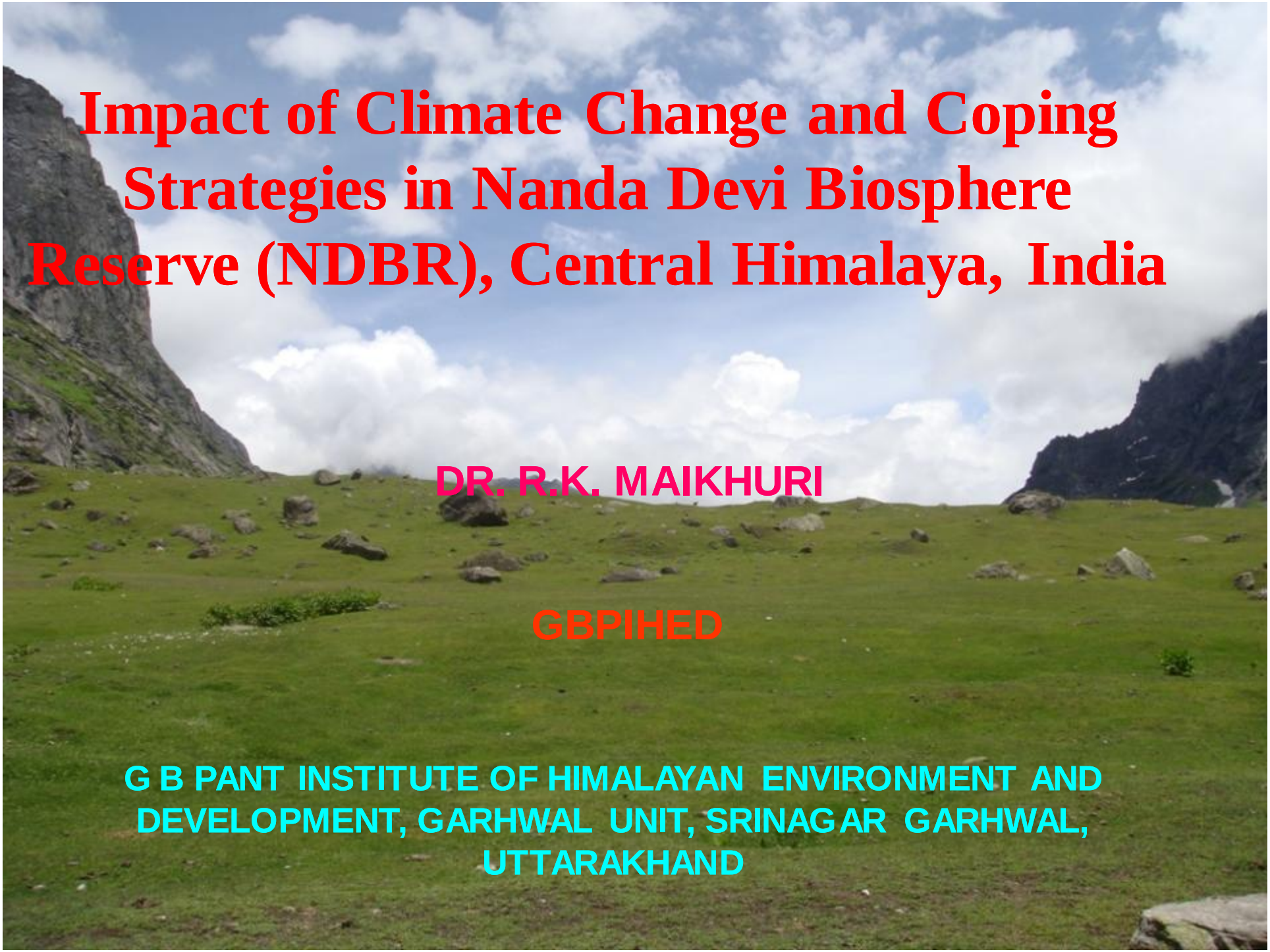


Impact of Climate Change and Coping Strategies in Nanda Devi Biosphere Reserve (NDBR), Central Himalaya, India

DR. R.K. MAIKHURI

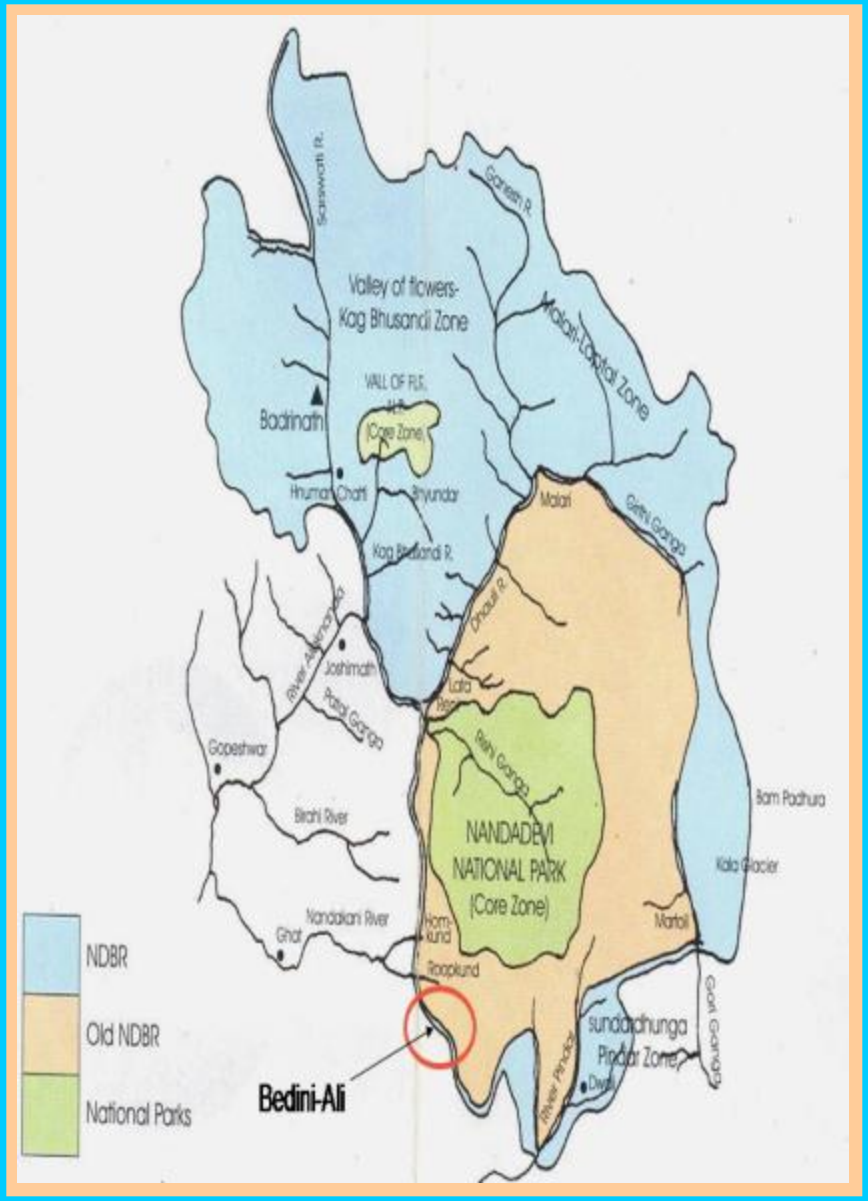
GBPIHED

G B PANT INSTITUTE OF HIMALAYAN ENVIRONMENT AND DEVELOPMENT, GARHWAL UNIT, SRINAGAR GARHWAL, UTTARAKHAND

Biological, cultural and religious significance of NDBR

- The NDBR is covered in Himalayan highlands biogeographic province (2A) of India and represents a platform to promote biodiversity conservation in diverse ecosystems and vegetation types (temperate, sub alpine and alpine)
- The area harbours very rare and endangered floral and faunal elements.
- The reserve covers a sub-catchment including a large number of glaciers feeding the tributaries of the Holy river Ganges.
- Rich in ethnic diversity (Indo-mongoloid i.e.Tolcha, Marchha, Nitwal, Johari, Darmi and Indo-Aryan) and cultural heritage.
- The entire landscape of NDBR referred to as very sacred (land of Gods and Goddess)- Dev Bhumi.

The total area and number of buffer zone villages of NDBR as per revised notification	
Total area	5860.69 sq.km.
Core zone	717.50 sq.km.
Buffer zone	5148.57 sq.km.
No. of buffer zone villages	47
Other settlement in Buffer zone	Badrinath Dham & Hemkund Sahib
Altitudinal range	1800- 7817
Total population of buffer zone villages*	10909




Yak


Musk Deer


Braham Kamal

Key Vulnerabilities of Nanda Devi Biosphere Reserve (NDBR)

The NDBR is rich in biodiversity which includes agrobiodiversity – livestock diversity and forest diversity (temperate, sub-alpine, timberline and alpine meadows). The key vulnerabilities have been identified and are listed below:

- The diverse ecosystem of NDBR with unique biodiversity is at risk with rise in temperatures.
- The reserve covers a large number of glaciers feeding the tributaries of the river Ganges and is critical for maintaining the hydrological balance of the Gangetic plains, one of the most thickly populated and productive region of the South Asia and temperature rise will increase glaciers-retreat.

- The overall precipitation will be increased and its higher intensity becomes more erratic and disastrous. This will make fragile landscape susceptible to cloud burst, prone to soil erosion etc.

- Timberline and alpine vegetations not only rich in biodiversity particularly of medicinal and aromatic plants (MAPs) and also rich in soil organic matter (SOM) and good carbon sequester. Climate change will threatens their existence and make them vulnerable to extinction.

- Agriculture and livestock will be affected and will force local communities to shift to newer crops and fodder species.

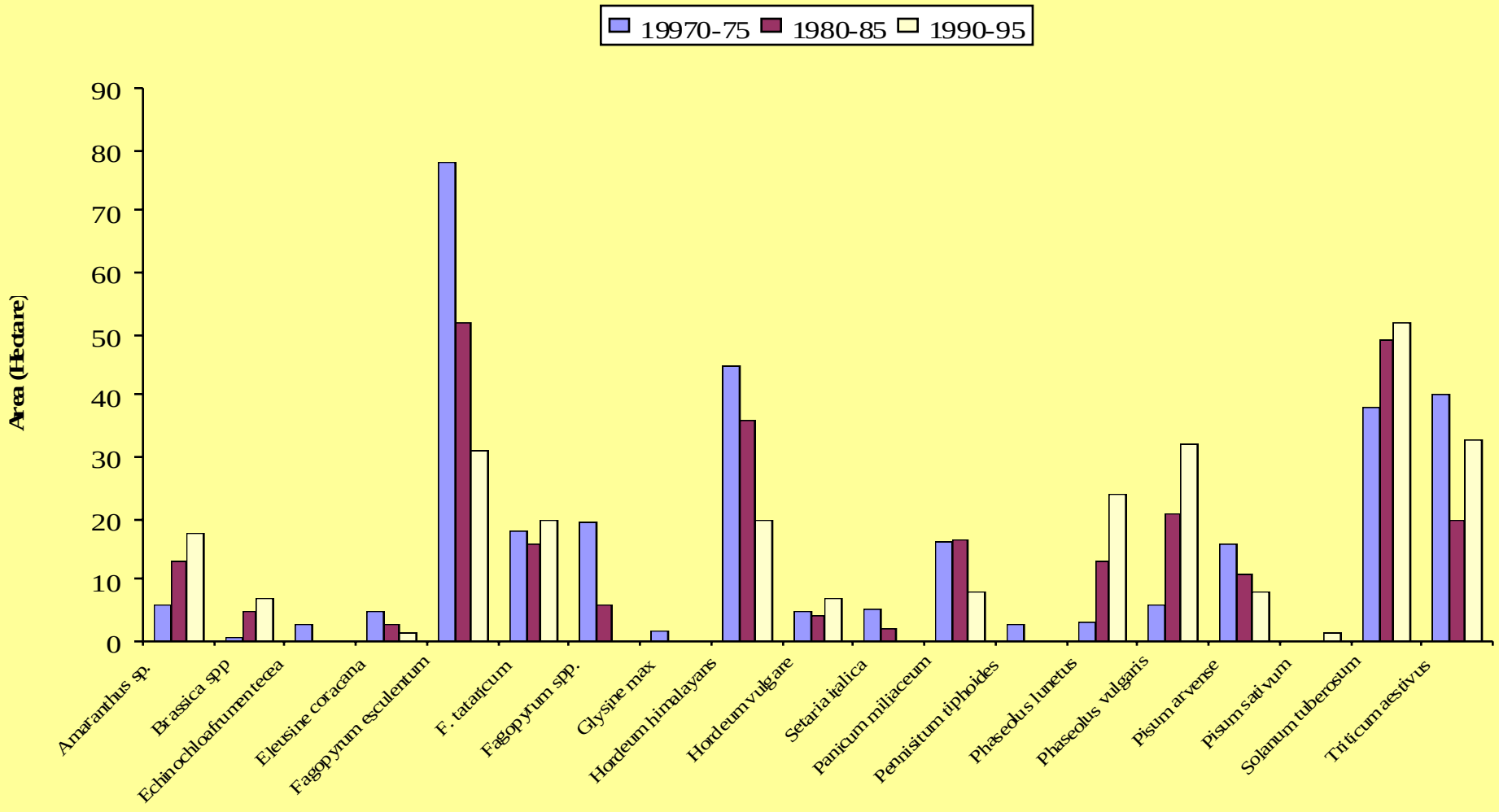
- The tourism activities likely to increase and will affect severely to environment and socio-cultural attributes of the region.

Climate Change Impact

(A) Agriculture in Buffer Zone and Adjoining Areas

(I) Negative impact: Diseases, insects/pests etc.

- **Decline in area under cultivation of various traditional crops at three points of time.**



Reduction in winter snowfall, spring rainfall and melt water → low soil moisture → low crop yield. Minor changes in the temperature could have a major impact on the severity of diseases.

***Amaranthus* spp. vulnerable to climate change – disease called *Hymenia rickervalis* (parn jalak keet) (between 1000 – 1800 masl), high temperature and humidity during 1 – 2 week of September which provide favourable conditions to insect whereas no occurrence of disease between 2200 – 2800 masl (revealed by farmers).**

- Cow pea and Vigna spp: Important summer mountain grain legumes fruit setting –shift in peak rainfall.

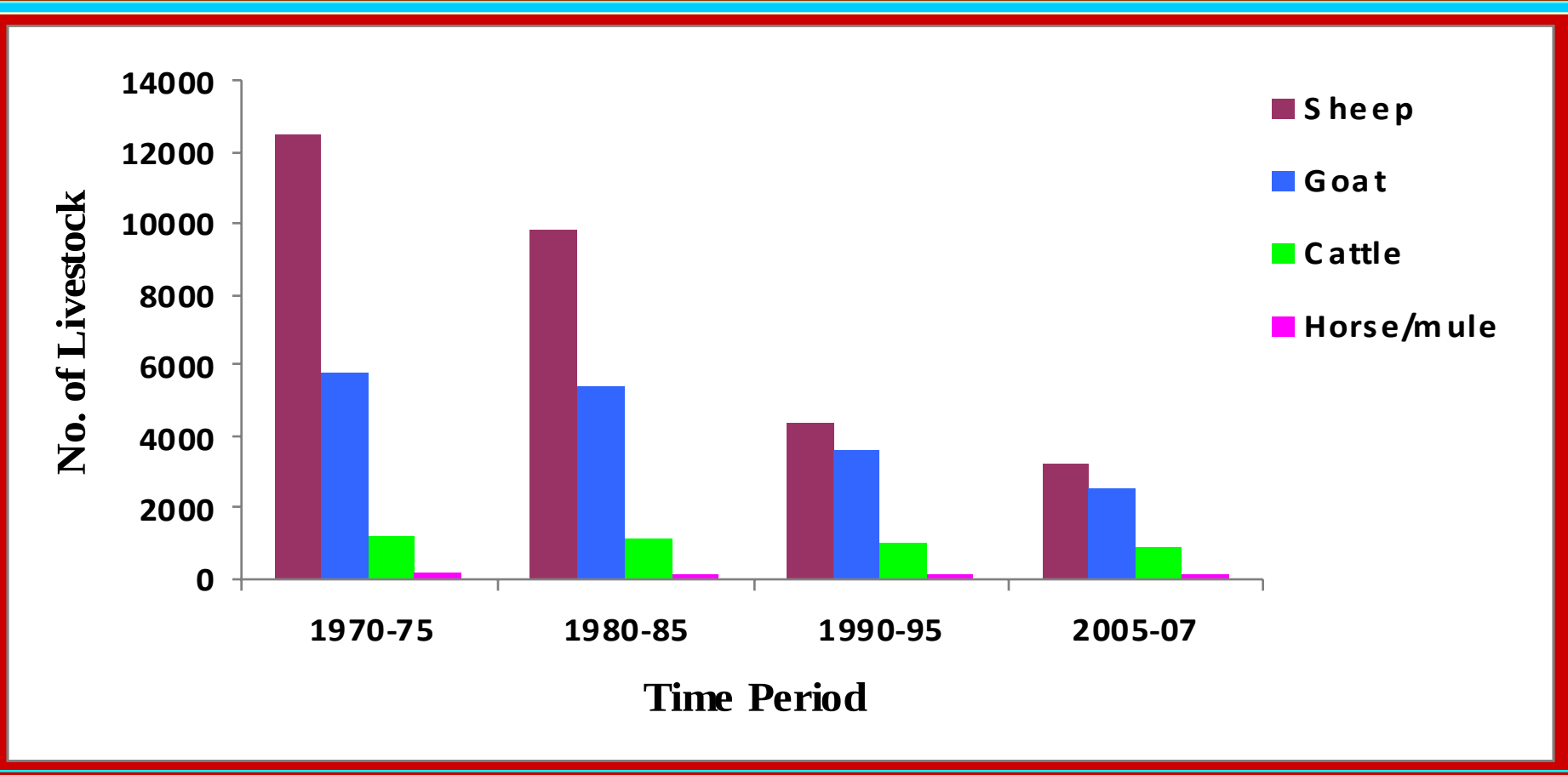
- *Phaseolus* spp. : soil borne insect (Coleoptera) locally called Uksa – damage the crop in early stage of seed germination – increase in moisture/humidity/milder winters (between 500 – 1500 masl).

(II) Positive impact:

1. Opportunities for cash crops like tomato, cabbage, chilly, peas, beans and horticultural crops like apple, apricot
2. Medicinal and aromatic plants

B. Transhumance Pastoralism

- Decline of livestock population due to various reasons (i.e. conservation policies, socio-economic changes, decline in carrying capacity of the alpine pasture etc.).



Changes in livestock population between the 1970-75 to 2005-07 period as reported by the people of Niti valley (10 villages).

- Pastoralism also involves important relationship with low altitude (Tarai – Bhabar tract) forests.

- Currently, the lowland experience dry conditions from Dec. – May (with the exception of winter storms) and low rainfall adversely affect the growth and productivity of herbaceous vegetation.
- Climate change at high altitude would affect the production of forage quantity and quality, increase disease and disease spreading pests, reduce water availability etc. and would make these communities to face difficult situations.

Sheep, goat grazing alpine meadows

Horse, mule garzing in alpine meadows

(C) Forest and Timberline Vegetation

- *Pinus wallichiana* (kail) and *Cedrus deodara* (keystone species) used by buffer zone villages for timber, fuelwood, medicine etc. Decrease in snowfall and rainfall probably negatively affecting the regeneration of deodar.

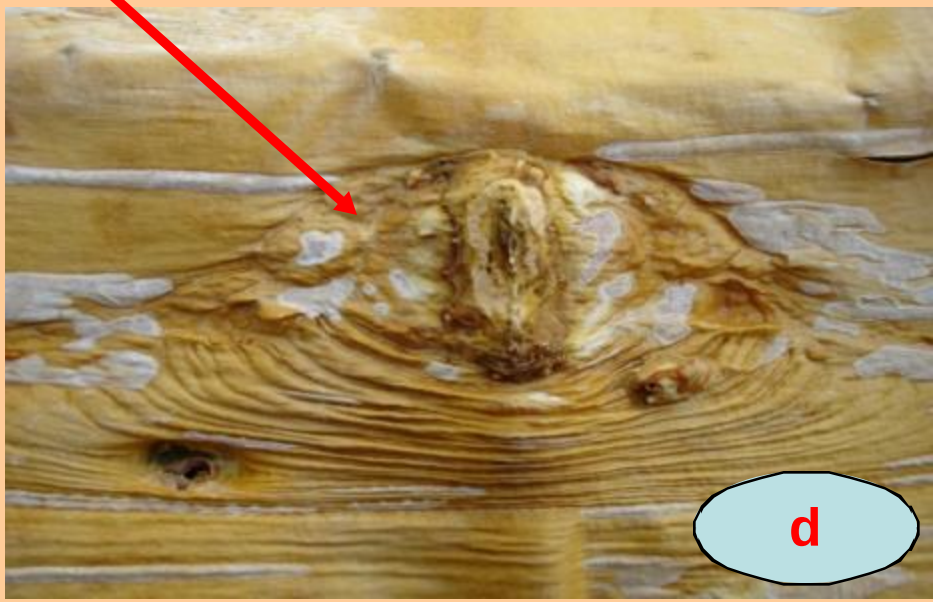
- *Pinus wallichiana* has a wider altitudinal range as compared to other conifers and has potential to survive in a wide range of environmental conditions. This species is regenerating and spreading faster than other species (noticed by us as well as by villagers).

- The stem and leaves of *Betula utilis* growing in association with *Abies*, *Rhododendron*, *Taxus* (3300 – 3600 masl) damaged severely by defoliators (moth/insect) since last 8 – 10 years and this probably due to less snowfall and gradual increase in temperature.

Natural forest stand *Betula utilis*

Single tree of *Betula utilis*

Bark of *Betula utilis*



Disease caused on the bark of *Betula*

D. Alpine Meadows

- The alpine landscape in some of the areas of Niti and Mana valleys is eroded due to glacier melting, avalanches and landslides, which favour the spread/expansion of *Polygonum* spp. fast growing weeds.

- The other successful invaders found in these habitats includes species such as *Lonicera,* and *Ephedra*.

- The transformation of an alpine meadows has far reaching impacts on the livelihood of the traditional transhumant communities. The alpine meadows of NDBR could also be impacted by rising temperature that would promote the upward migration of woody plants from sub-alpine and temperate forests.

E. Tourism

- Climate change could generate both some serious problems but also opportunities for the tourism sector.

- A wider appreciation of the impact of a leisure culture increasing numbers of people are remaining in buffer zone of the reserve for much longer duration (i.e. in Badrinath, Mana, Hemkund Saheb, Valley of Flowers, Niti, Tapovan etc.).

- Tourism in the reserve may provide better income generation opportunities as other primary and secondary production sectors (i.e. agriculture, livestock, NTFPs collections) decline.

- Culture of the traditional communities is itself open to pressure which have uncertain outcomes.

SOCIO- ECONOMIC IMPACT OF FOREST AND ALPINE MEADOWS DUE TO CLIMATE CHANGE

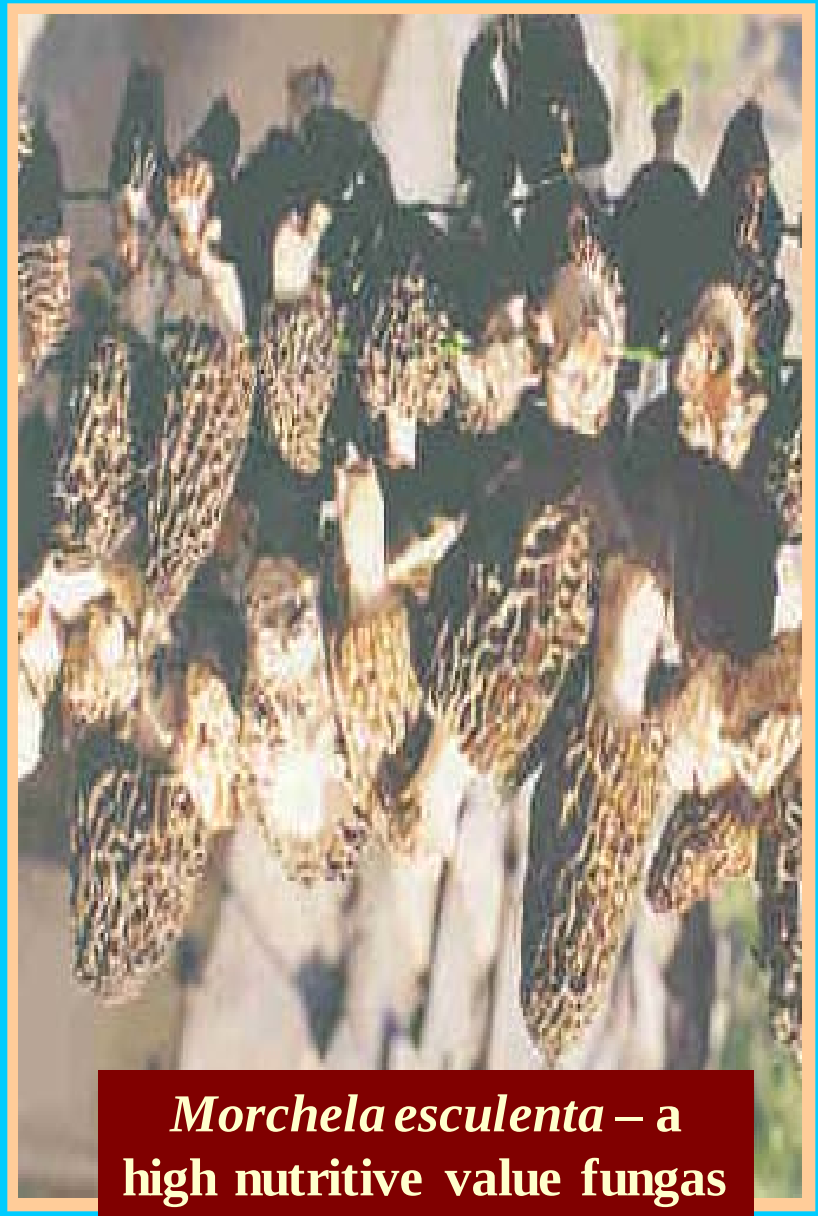
Harvest (mean±SE) of important wild products in buffer zone villages of the NDBR.

Warming would negatively affect species those require higher level of soil moisture to grow, leading to a decline in their area or would shift towards higher elevation where their existence will be in danger.

Botanical name	Estimated price (Rs/kg)	Harvest Kg/hh/yr	Change in status/availability
Allium spp.	200	1050±0.97	Stable
*Angelica glauca**	150	3.16±1.09	Decline
Cedrus deodara	50	1.10±0.25	Stable
Juglans regia	50	2.52±0.24	Stable
Megacarpaca polyandra	30	14.24±1.56	Stable
Morchella esculenta	6000	0.97±0.35	Decline
Poeonia emodi	30	6.27±0.56	Stable
Pleurospermum angelicoides	150	1.60±0.72	Decline
Prunus persica	200	1.20±0.25	Stable
*Thamnocalamus spathiflorus**	5	110.50±15.87	Decline
*Taxus baccata**	250	4.96±0.65	Decline
Cordyceps sinensis	2.5 – 3.0 lacs	0.89±0.31	Decline

Socio- economic value of wild collection

Yar tsa Gumbu (*Cordyceps sinensis*)



Morchela esculenta **– a high nutritive value fungas**

Common changes in forests/meadows and driving factors identified by people/reported in scientific studies in Central Himalayan region.

Kind of change	Change driving factors
Conversion of dense to open forest	Population pressure, market forces and erosion of traditional forest management institutions etc.
Dense forest converted to agricultural land	Intensive timber extraction on steep slopes with poor regeneration capacity, market forces
Degraded forest converted to agricultural land	Increase in livestock population, erosion of traditions favouring diffusion of grazing pressure, failure of formal institutions to check illicit grazing, policies limiting direct economic benefits from forests.
Scrub land converted to forest	Protection and plantation of multipurpose trees by local communities
Conversion of grasslands to scrubs	Decline in nomadic grazing due to enforcement and/or cultural change

Continued….

Increase in multipurpose trees in farm land	Degradation of natural forests, restrictions on access to meadows and forests, policies favouring timber and other industrially important trees.
Increase in forest species richness	Strict enforcement of protection
Conversion of oak to pure pine stands	Commercial charcoal making, selective protection of pine to maximize government revenue, ground fire
Domestication of new crops	Emerging market for medicinal plant products, restrictions on extraction from the wild
Expansion of weeds and invasive spp.	Habitat changes together with climate change
Phenological changes	Shift in flowering time of *Rhododendron* from March/April to Feb – March due to climate change
Increase and spread of insect/ pest infestation	Various new diseases have been noticed in crops/ vegetable/ trees due to adverse weather conditions .

People's perceptions on climate change in central Himalayas.

Kind of change	Evidence
Warming	Decline in snowfall period, depth and persistence, decline in apple yield, success of cabbage/pea/tomato cultivation in high elevations in recent years, shortening of maturity period of winter crops, increased pest infestation.
Decline in rainfall during March – May	Large scale mortality, abandonment of *Panicum milliaceum* in rainfed area, declining yields of Amaranthus.
High rainfall during August/September instead of the normal peak in July/August	Damage to rainy season crops when they are close to maturity, increased frequency and severity of landslides
Winter precipitation in January/February instead of December/January and decline in intensity of snowfall	Delayed sowing of winter crops, decline in barley and wheat yields
Increase in instances of cloud burst	Heavy losses of life and property

COPING AND MITIGATION STRATEGIES

- Indian Himalayan region has one of the largest network of PAs and comprises of 3 BRs (cold desert BR is under consideration), 18 NP and 71 WS (9.2% area of the Himalaya is legally protected), our knowledge on people-biodiversity vulnerability linkages is very limited.

- Coping with climate risks is an important factor in shaping indigenous biodiversity management. Nevertheless, indigenous practices may succumb to new global forces.

- Participatory research/ management could turn people's callous/ negative attitudes to positive attitudes towards protected area together with improvement in scientific knowledge related to potential uses of biodiversity for adaptation and mitigation.

Risks and coping mechanisms in mountain regions

Type of risk	Coping mechanisms
Risks arising from inaccessibility	Local production based food self-sufficiency as the primary goal of agriculture, export of farm/wild products limited to income needed to procure essential products not produced locally.
Risks arising from climate variability and extremes: landscape scale adaptation strategy	Agricultural land use limited in extent and adapted to ecological opportunities/ constraints; maintenance of a variety of agroecosystem types differing in their abilities to withstand different types of risks, low intensity disturbance in natural ecosystems.
Risks arising from climate variability and extremes: farm scale adaptation strategies	More intensive cropping in valleys compared to that on slopes, reducing erosion due to cropping by terracing, huge manure input, maintaining proper drainage, diversified crop system and balance between negative (crop-weed competition) and positive effects (availability of fodder, nutrient conservation, soil conservation) of weeds to avoid absolute crop failure in bad climate years.
Risks arising from climate variability and extreme events: forest management	Forest resource uses limited to subsistence needs, strict protection of forests and meadows (in the form of sacred forests/meadows) around critical areas.
Risks arising from climate variability and extremes: socio-cultural adaptation strategies	Traditions favouring agricultural sustainability, forest resource utilization-regeneration balance and environmental services, privileges to small holders in respect of income from forest products, exchange of seeds without any profit motive.

G. Eco-tourism option for biodiversity conservation and socio-economic development.

- Eco-tourism has been identified as a potential option for income generation and environment management and can benefit BRs/PAs in three ways:
- Generating economy to manage and conserve NRs and biodiversity
- Enhance marketing of local products
- Income generation at local level

H. INSTITUTIONAL COOPERATION, COORDINATION, COLLABORATION AND CAPACITY BUILDING TO ADDRESS CLIMATE CHANGE IN VARIOUS SECTORS

- Research and Development institutions with significant infrastructure and scientific/ technical capacity.
- So far not much focused on climate change research.
- Inadequate capacity and skill.

Initiatives taken by GBPIHED (Garhwal Unit) through participatory action research towards mitigation and adaptation of climate change impact.

Value addition to the medicinal plants (*Allium spp., Angelica glauca, Pleurospermum spp*) locally through semi-processing facilities as a spice and condiments as eco-tourism products.

Integrated medicinal plant cultivation as part of an ecological rehabilitation strategy and demonstrated in buffer zone and adjoining villages (i.e. Lata, Peng, Tolma, Bhiri, Ufalda etc) through participatory approaches so as to meet conservation goal. A total of 14 training programme were organized and 548 participants were trained.

Turmeric cultivation

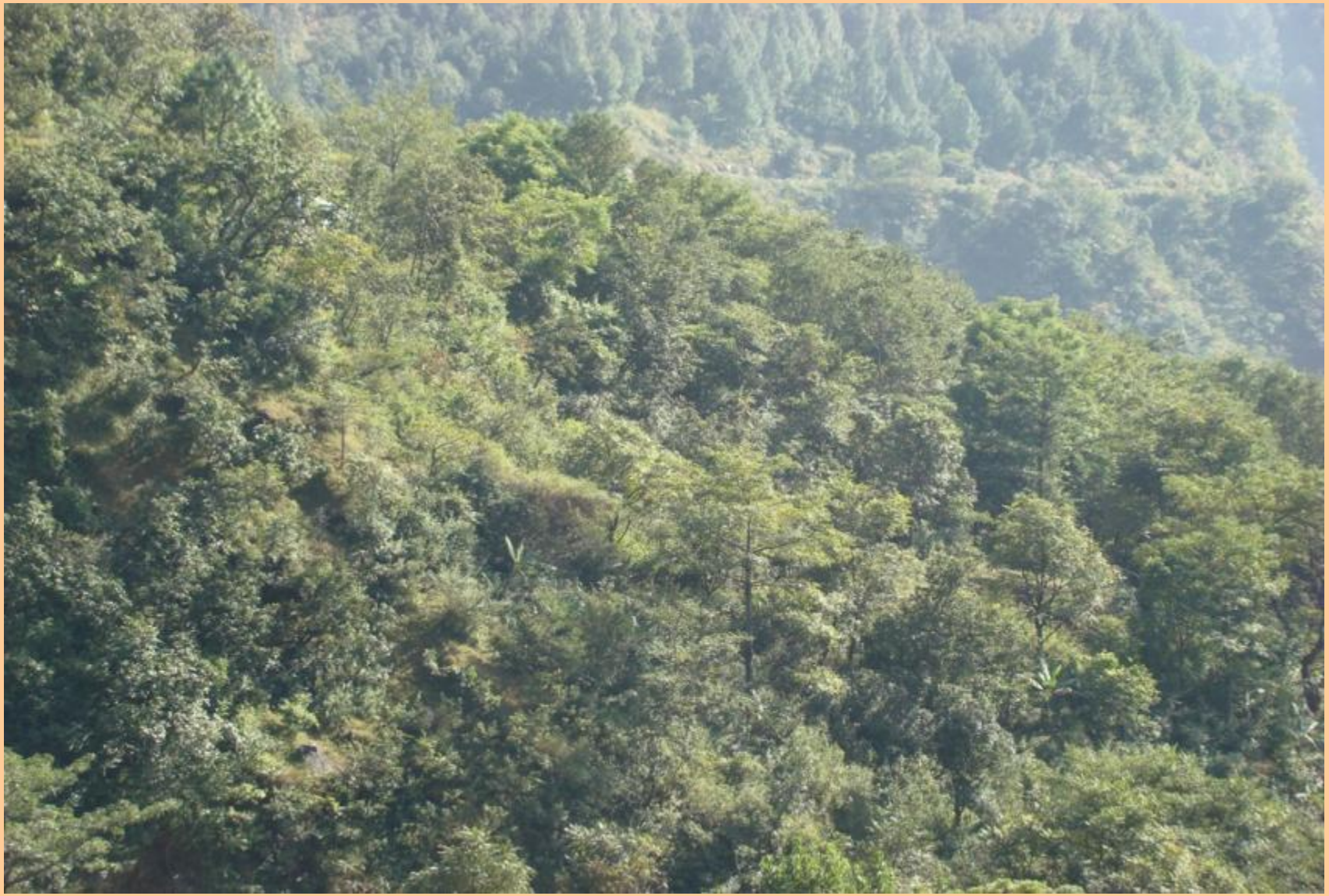
Medicinal plant cultivation and nursery development at Suraithota (2300 m asl)

Medicinal plant cultivation and nursery development at Tolma (2800 m asl)

Large scale cultivation of *Arnebia benthamii*

Large scale cultivation of *Picrorrhiza kurrooa*


Adoption
Total covered area 6 ha



Total covered area 2 ha

People participation in land rehabilitation – carrying seedlings for plantation

A view of Amaranth stalk used to protect saplings from snowfall planted under rehabilitation programme in high altitude areas

Close view of Amaranth stalk

Adoption

Adoption

Value addition to NTFPs

- Bioprospecting and value addition of more than twenty five wild edible plant species/ NTFPs while making a variety of edible and other products (i.e. Jam, Jelly, Sauce, Squash, Pickles etc.) as a source of income.

- Sustainable harvesting of some potential wild edibles has been worked out. A total of **405 participants were trained.**









Himalayan Pickle

Himalayan Pickle

Himalayan Pickle

Himalayan pickle

Himalayan Sauce

Himalayan Sauce

Jam preparation

Juice Extraction

Demonstration and Participatory Action Research Centre

Established demonstration and participatory action research and training centre at three different locations to develop capacities of the various stakeholders in the field of eco-friendly rural technologies, conservation education and climate change impact related issues. Since last 8 years a **total of 2325 participants were trained.**


वर्मीखाद
VERMICOMPOST


जैविक खाद
BIOCOMPOST


एजोला
संवर्धनि

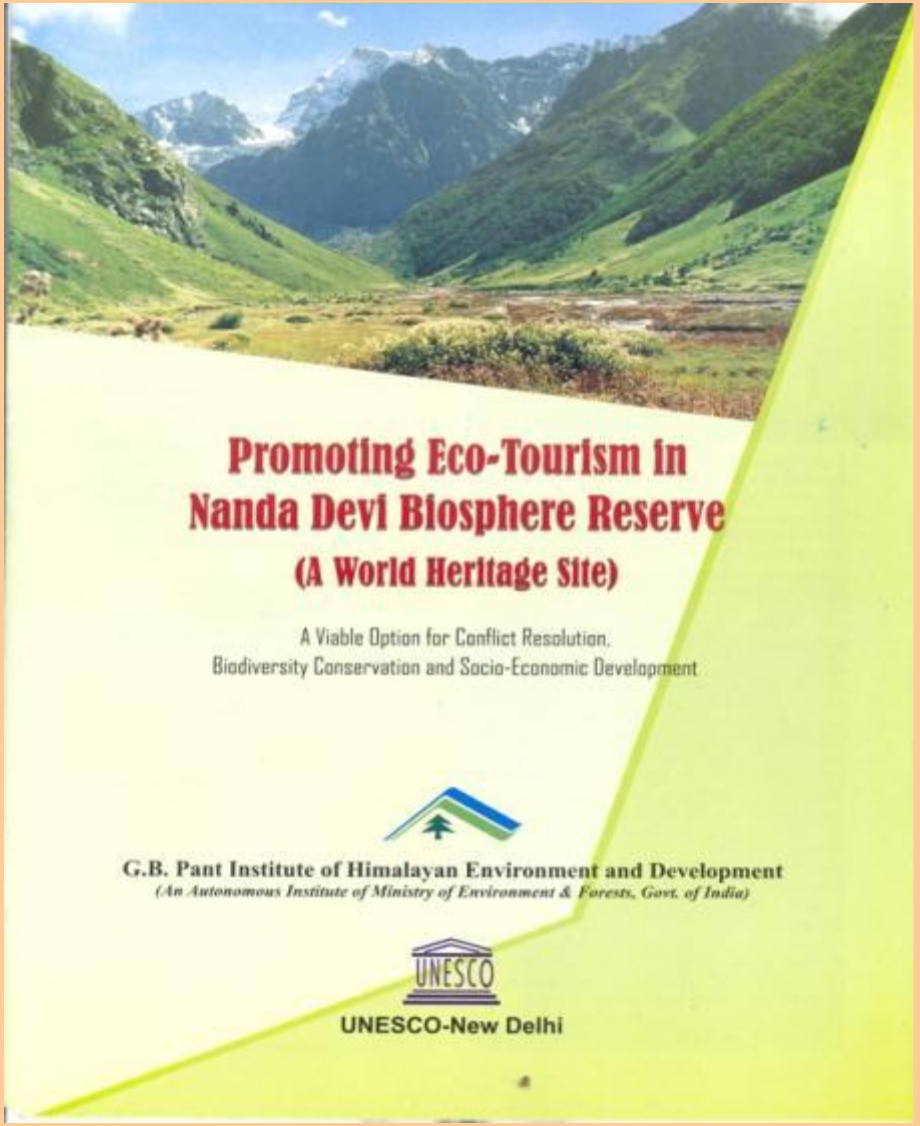

जल
वर्मीवाश
VERMIWASH

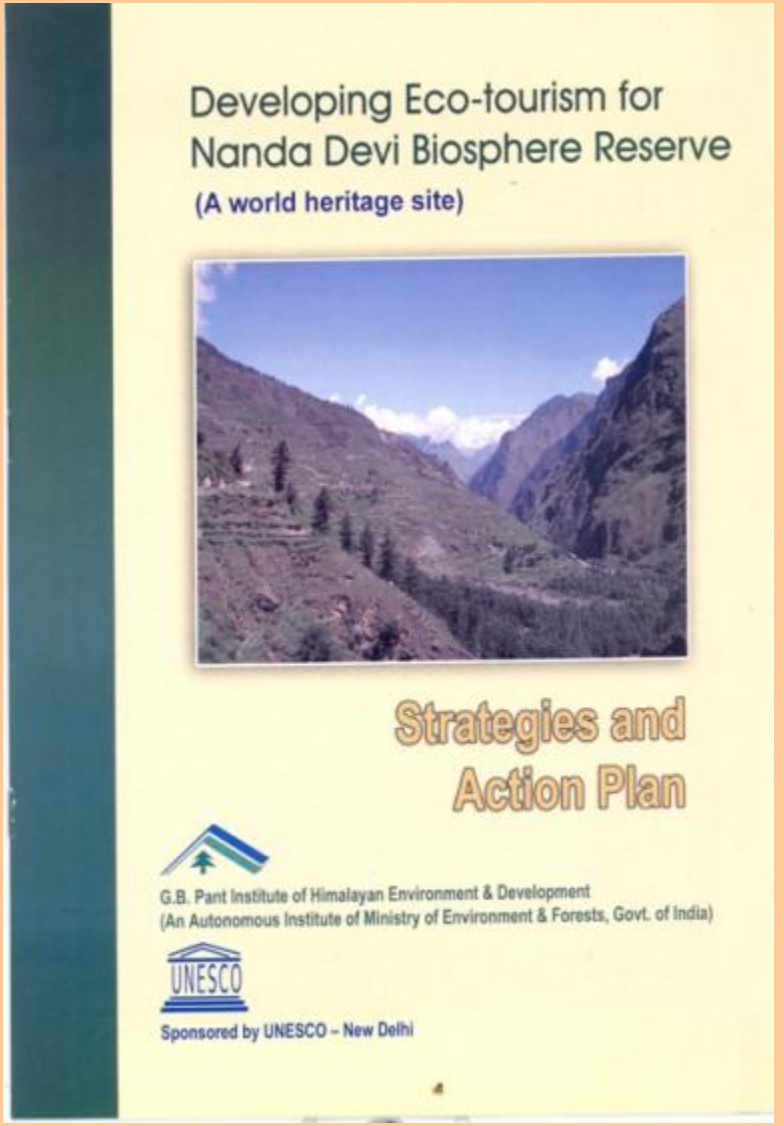
Promoting protected cultivation

Promoting Eco-tourism

- Involved and encouraged local communities in eco-tourism promotion and different approaches were used to improve their capacities for managing their own resources and assets.
- These includes bioprospecting and value addition to cultivated crops, serving traditional food items during home stay and trekking, conservation education and use of alternative fuel, safety hygiene and sanitation etc.

Developed guidelines, strategies and action plan for eco-tourism promotion and management in NDBR





Use of pack animals in reducing CO_2 emission

- In six valleys the CO_2 savings has been estimated as 14, 45,130 kg Co_2 and in terms of cost of fuel saving to be Rs 2,12, 72, 448 . Hence, pack animals can play an important role in reducing the emission of greenhouse gases such as CO_2.
- Although construction of roads is a top priority for people from such remote and far-flung regions, incentives should be there to encourage the use of pack animals for transportation.

FUTURE RESEARCH

- Monitor biodiversity and productivity of alpine meadows and shift of sub-alpine meadow-forest boundary as signal of climate change.
- Monitor spread of invasive species in BRs and adjoining areas and develop early detection mechanism (management strategies on the landscape level)
- Documentation of TEK as well as people knowledge ad experiences about the pattern of climate change and its impact on forest, agriculture, livestock and humans through participatory approaches so as to provide possible indicator of change.
- Effect of climate on seasonal variability and reliability and climate extremes affecting agriculture production, forestry and water resources.
- Interface with policy issues, administration, local communities and research and academic institutions regarding the broad aspects of adaptation options and livelihood.
- Establish permanent sample plots in different forest types along an elevational gradients for effective and comprehensive monitoring programme to track the response of both at community and species levels to changing climate.
- Capacity building of the researchers/scientists in the field of climate change and modeling studies.

- Develop appropriate weather and meteorological stations on important and sensitive biomes and ecosystems type with regional projections of climate


Thank you