Climate change impacts on forests and natural ecosystems in India

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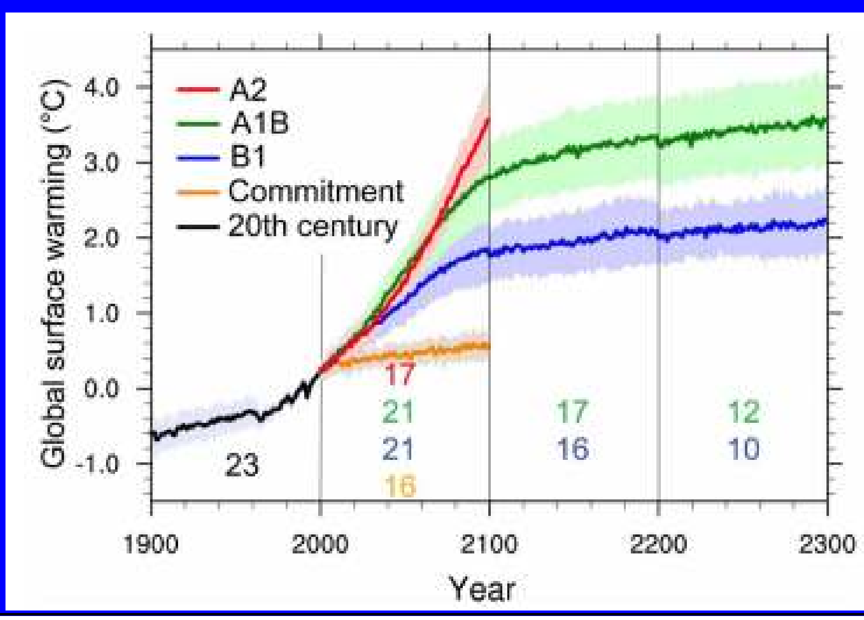
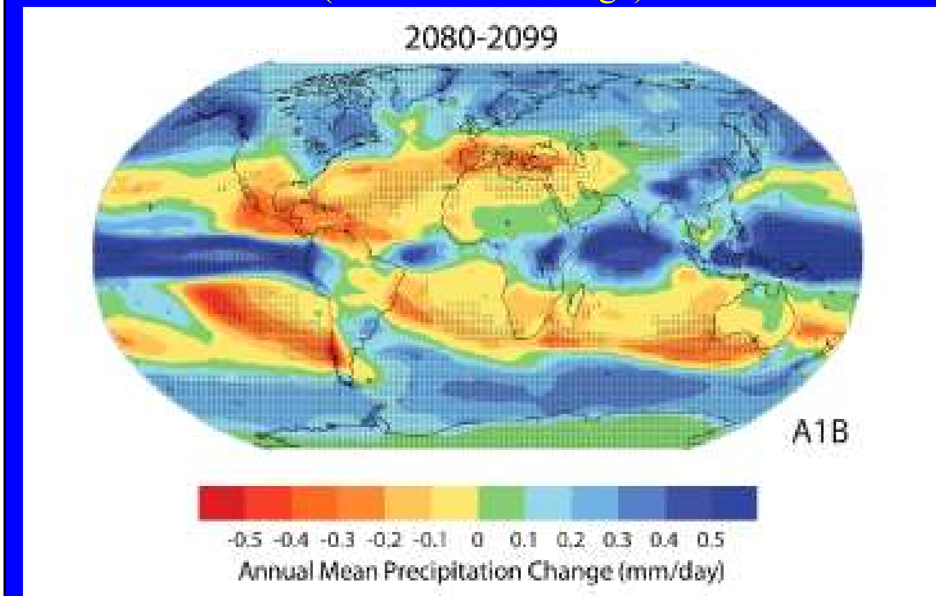
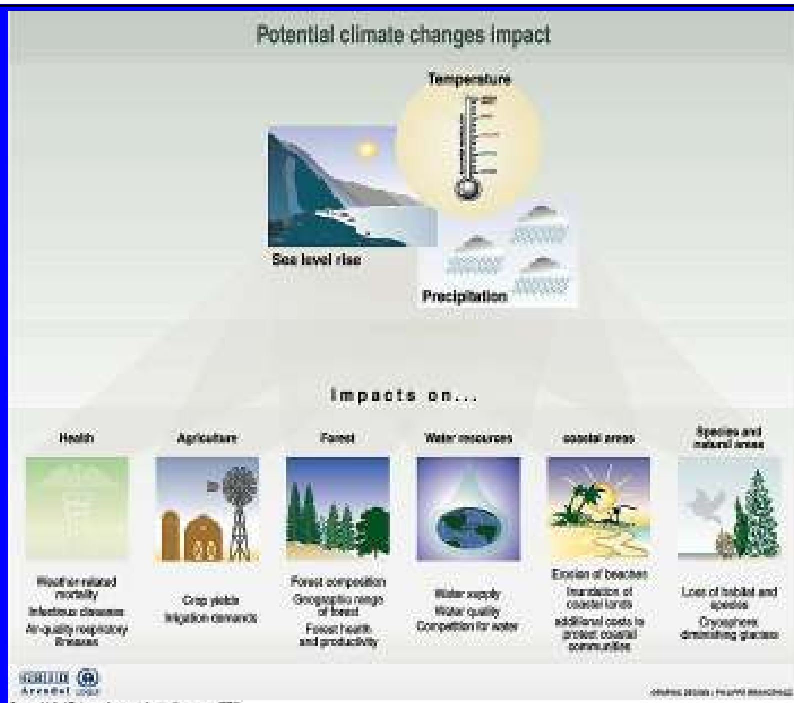
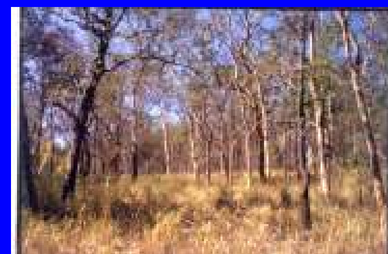


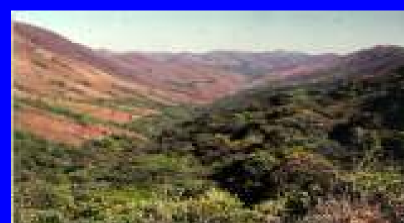
Projections in precipitation (relative to 1980-99) (Multimodel average)





India has 16 major forest types, varying from the alpine pastures in the Himalayas to temperate, sub-tropical and tropical forests, and mangroves





Forest cover of India

Source:
Forest Survey
Of India

Modelling cc impacts on forests

- Evaluate and select models to assess climate impacts on forests
  - Regional Climate Model;
  - Vegetation Response Model;
- Assess impacts of climate change on forest ecosystems at national level
- Assess impacts on biodiversity and socio-economics through case studies
- Analyze policy implications of climate impacts
- Strategies for future
  - Research, modeling and database
  - Adaptation strategies

SELECTION OF VEGETATION MODEL

- Equilibrium models: BIOME 3
- Dynamic model: HYBRID 4.2
- BIOME3 selected due to input data limitations for the HYBRID Model

CLIMATE DATA FOR BIOMES

Model used: Hadley Centre Regional Model; Had RM3

Mean monthly temperature, rainfall, cloud cover

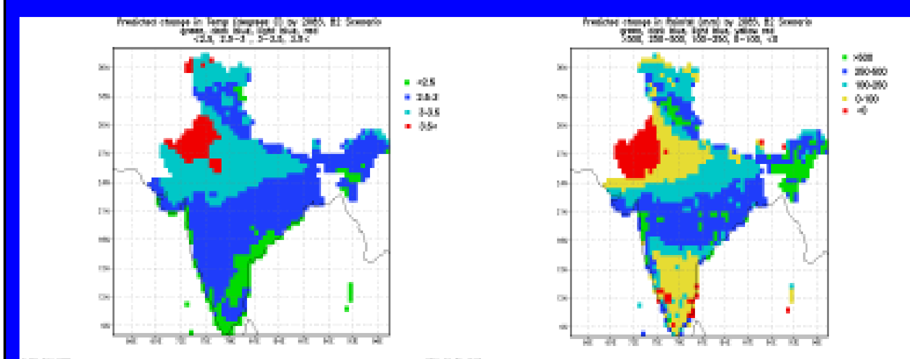
Scale: 0.44 x 0.44 degree RCM grid

Scenarios: SRES; A2 and B2

Period: 2071-2100 (mid-period 2085)

Observed climate data: CRU (East Anglia) data set for 1901-1995 over India (0.5x0.5 degree grid)

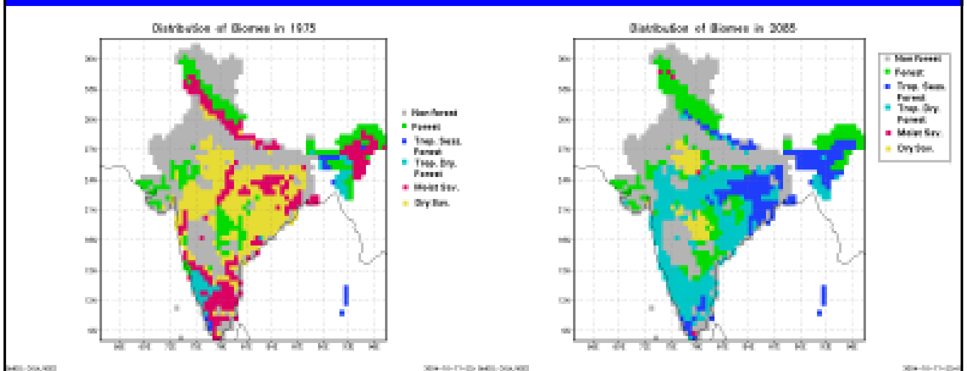
Had RM3 climate projections B2 scenario



Predicted change in temperature (°C) by 2085

Predicted change in rainfall (mm) by 2085

Impact on forest biomes (B-2 scenario)



Even though the models indicate that 85% of our forests could change in vegetation "type" we have a poor understanding of the direction and nature of change (needed for adaptation measures)

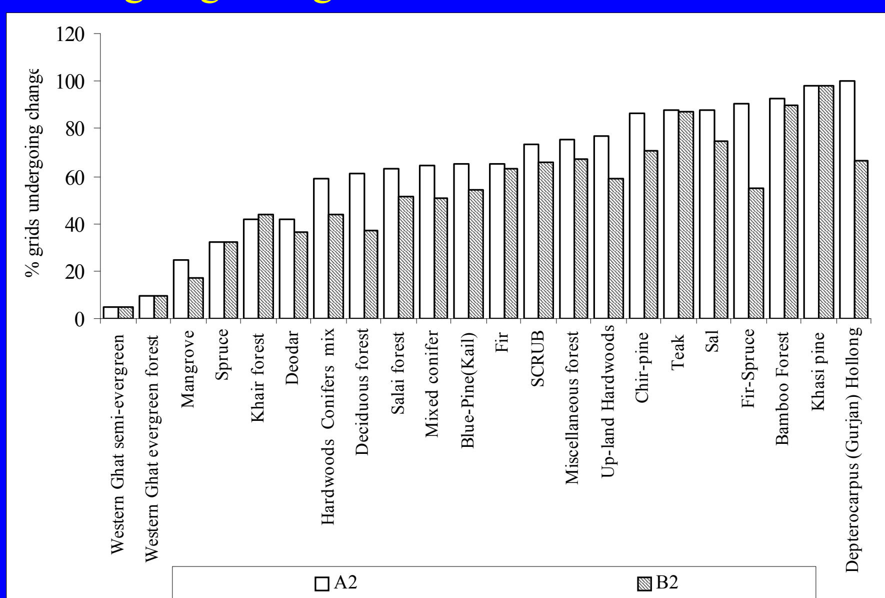
Annual rainfall and temperature changes in the different forest types of India (FSI) under B2 GHG scenario for the year 2085

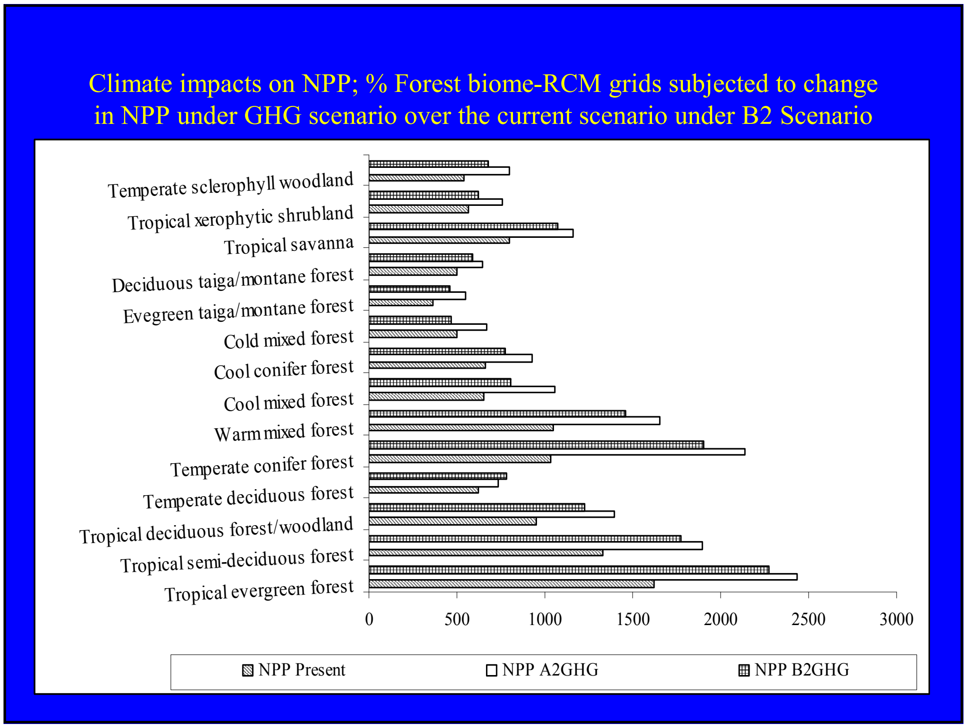
Forest type	Number of grids	% area	Mean annual rainfall (mm)	Change in rainfall (mm)	Mean temperature (°C)	Change in temperature (°C)
Fir	290	0.82	730.1	221.6	9.5	3.0
Blue-Pine (Kail)	311	0.88	763.0	223.5	10.5	3.0
Chir-pine	791	2.25	1373.4	437.4	17.1	2.8
Mixed conifer	1071	3.04	930.1	375.9	9.3	3.0
Hardwoods Conifers mix	296	0.84	1560.7	585.6	13.1	2.8
Upland Hardwoods	881	2.50	1523.8	476.9	16.4	2.7
Teak	3364	9.56	1314.6	353.0	26.1	2.9
Sal	4251	12.08	1435.2	348.3	24.6	2.7
Bamboo Forest	567	1.61	2268.3	564.9	23.8	2.7
Mangrove	201	0.57	1734.3	280.8	26.6	2.5
Miscellaneous forest	22339	63.48	1679.8	374.5	23.0	2.7
Western Ghat evergreen forest	163	0.46	3111.3	368.7	25.4	2.4

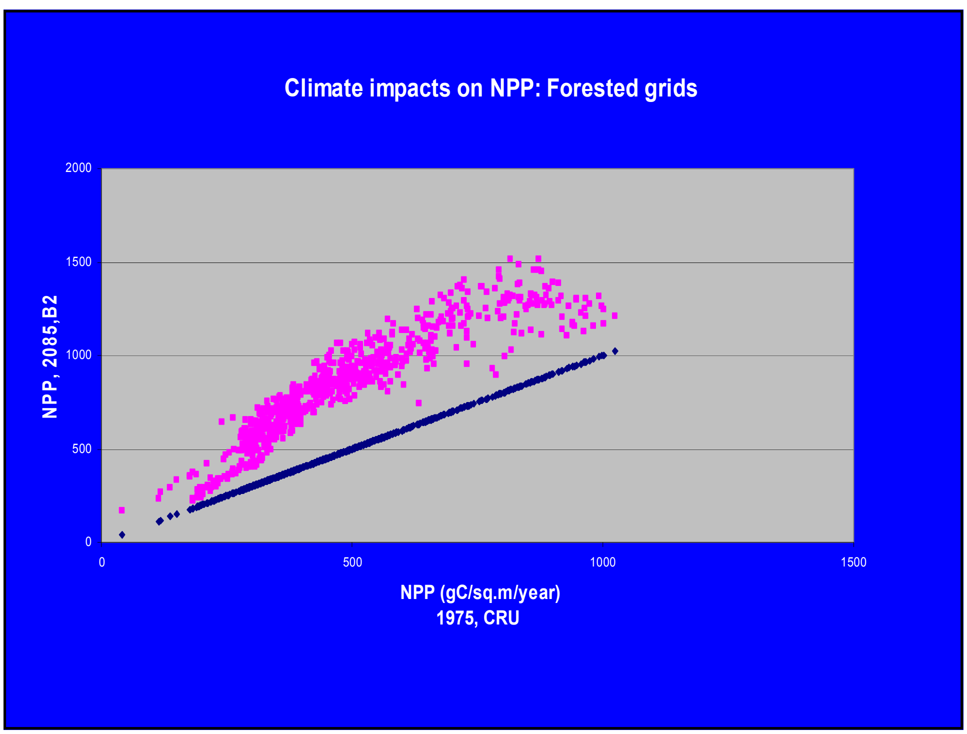
Number and percent of forested grids undergoing change in vegetation types under A2 and B2 GHG scenarios, compared to the Current (non-GHG) scenario

Vegetation types	Current		A2		B2	
	No. of grids	% grids	No. of grids	% grids	No. of grids	% grids
Tropical xerophytic shrubland	14160	40.24	706	2.01	902	2.56
Tropical deciduous forest/woodland	9389	26.68	8141	23.13	14906	42.36
Warm mixed forest	4753	13.51	3210	9.12	3782	10.75
Tropical semi-deciduous forest	2790	7.93	1069	3.04	744	2.11
Tropical savanna	1549	4.40	9225	26.21	6485	18.43
Tropical evergreen forest	962	2.73	12309	34.98	7563	21.49
Temperate conifer forest	274	0.78	297	0.84	413	1.17
Temperate sclerophyll woodland	258	0.73	30	0.09	59	0.17
Cool conifer forest	234	0.66	22	0.06	74	0.21
Evegreen taiga/montane forest	221	0.63	55	0.16	73	0.21
Cold mixed forest	183	0.52	31	0.09	47	0.13

Percentage of grids under different forest types undergoing change in A2 and B2 GHG scenarios




Climate impacts on NPP; % Forest biome-RCM grids subjected to change in NPP under GHG scenario over the current scenario under B2 Scenario
Temperate sclerophyll woodland
Tropical xerophytic shrubland
Tropical savanna
Deciduous taiga/montane forest
Evegreen taiga/montane forest
Cold mixed forest
Cool conifer forest
Cool mixed forest
Warm mixed forest
Temperate conifer forest
Temperate deciduous forest
Tropical deciduous forest/woodland
Tropical semi-deciduous forest
Tropical evergreen forest
0
500
1000
1500
2000
2500
3000
NPP Present
NPP A2GHG
NPP B2GHG


Climate impacts on NPP: Forested grids
NPP, 2085,B2
2000
1500
1000
500
0
0
500
1000
1500
NPP (gC/sq.m/year)
1975, CRU

SUMMARY OF IMPACTS

Had RM3 Model outputs using SRES: A2 and B2 scenarios & BIOME3 show;

1. Over 85% of forest grids will undergo changes in forest type (similar trend using Had RM2)
2. Regional assessment shows;
   - Higher impact on Savanna biomes, Teak and Sal forests of central and east, temperate biomes of Himalayas
   - Lower impact on Western ghats and North-east; Evergreen biomes
3. Large increase in Net primary productivity
   - 70% (B2) to 100% (A2)

SOCIO-ECONOMIC IMPACTS

- Case studies in Western Ghats and Central Himalayas
  - *Large dependence of communities on forests and agro-forestry practicies*
  - *Livelihoods of poor and women depend on biodiversity*
- Positive and negative socio-economic impacts likely
- Increased timber production and supply in the short & medium term; increased NPP
- Large timber supply due to forest die-back in the short and medium term
  - *Shorea* (Sal) and *Tectona* (Teak)
- Loss of biodiversity leading to loss of livelihoods

POLICY IMPLICATIONS OF CLIMATE IMPACTS ON FORESTS

Why and need for adaptation

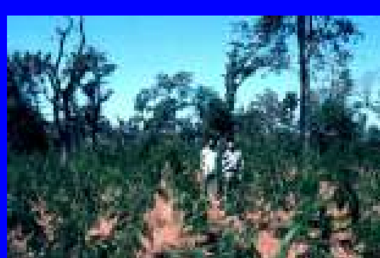
- Climate change could cause irreversible damage to unique forest ecosystems and biodiversity
- Inertia in climate and ecological systems
- Long gestation period in developing and implementing adaptation strategies

THUS, NEED TO DEVELOP AND IMPLEMENT ADAPTATION STRATEGIES

Need for identifying forest management practices and forest policies that

- enhance vulnerability of forest ecosystems
- reduce vulnerability of forest ecosystems

Plantations as win-win solution



- Anticipatory planting along latitudinal and altitudinal gradient using genetic stock from lower latitudes and elevation
- Promote mixed species forestry under afforestation programmes – at least some of these species are likely to survive climate change

Protected Area Network

- India has nearly 600 Protected Areas (National Parks/Sanctuaries)
- These perhaps offer the best insurance for adaptation to CC because diverse forests/ecosystems are more likely to have species that have climate tolerance
- Need to redesign Protected Areas taking into consideration possible changes in ecosystem structure and function as a result of future climate change

Linking Protected Areas through Corridors

- Both plant and animal species need to adapt through migration along latitudinal and altitudinal gradients
- Habitat fragmentation would be a constraint to migration, especially in species with limited dispersal abilities
- “Corridors” across large landscapes are needed for effective dispersal and establishment of species

Corridors across the Nilgiri Elephant Landscape in S. India

Natural ecosystems (non-forest)

- Grasslands
- Wetlands

  Marine wetlands (mangroves and coral reefs)

  Freshwater wetlands (lakes, marshes, rivers)

Grasslands

- Natural grasslands are of several types and include:

a) Alluvial floodplains of rivers as in northeastern India

b) Semi-arid zone grasslands as in the Deccan plateau and Indo-Gangetic basin.

c) Montane grasslands as in Western Ghats and Himalayas

- Impacts of climate change on these grasslands would naturally vary according to the type of grassland and regionally.

CC impact on grasslands

Moist grasslands on alluvial floodplains:

a) The frequency and intensity of floods of the rivers would determine the fate of these moist grasslands. If flood frequency and intensity increase in tune with the projected increase in climate variability, these grasslands would be maintained or even increase.

b) Local precipitation changes would also determine the composition of grassland versus woodland in the floodplains.

CC impact on grasslands …

- Dry zone grasslands

a) The dry zone grasslands are already under severe pressure from livestock grazing and subsistence agriculture. Many areas have been converted into plantations of exotic species.

b) The persistence and composition of these grasslands would be governed by the changes in regional precipitation, fire frequency and associated human impacts.

CC impacts on grasslands……..

- Montane grasslands

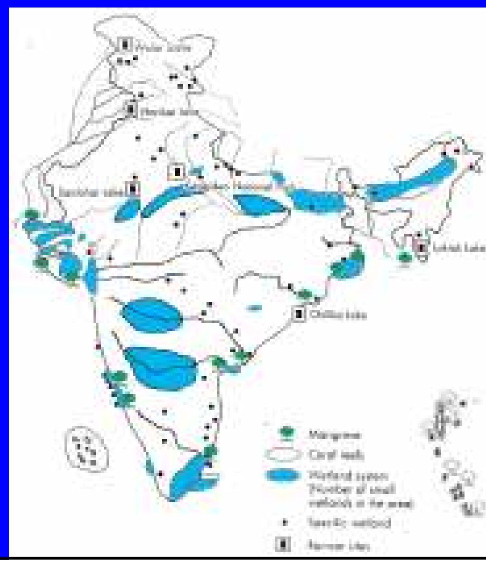
a) Grasslands at elevation of 1500-2500 m in the Western Ghats are a mixture of C3 and C4 grasses. Increased CO2 would favour the C3 plants over C4 plants; thus not only the composition of these grasslands would change but also there could be invasion by C3 woody plants.

b) Alpine meadows at high elevation in the Himalayas may be adversely affected by increased temperatures that would facilitate the upward migration of woody plants and associated fauna into these habitats.

Montane grasslands in W.Ghats

- Montane grasslands in the WG are the only habitats of the Nilgiri tahr.
- Enhanced CO_2 could fertilize the growth of C3 plants such as wattles and scotch broom.
- Warmer temperatures could likewise facilitate the spread of woody plants.
- Grasslands could further reduce with adverse consequences for the tahr.

Lakes and other freshwater ecosystems



CC impacts on freshwater ecosystems

- Increase in temperature will alter thermal cycles of lakes, oxygen solubility and other compounds, and affect ecosystem function

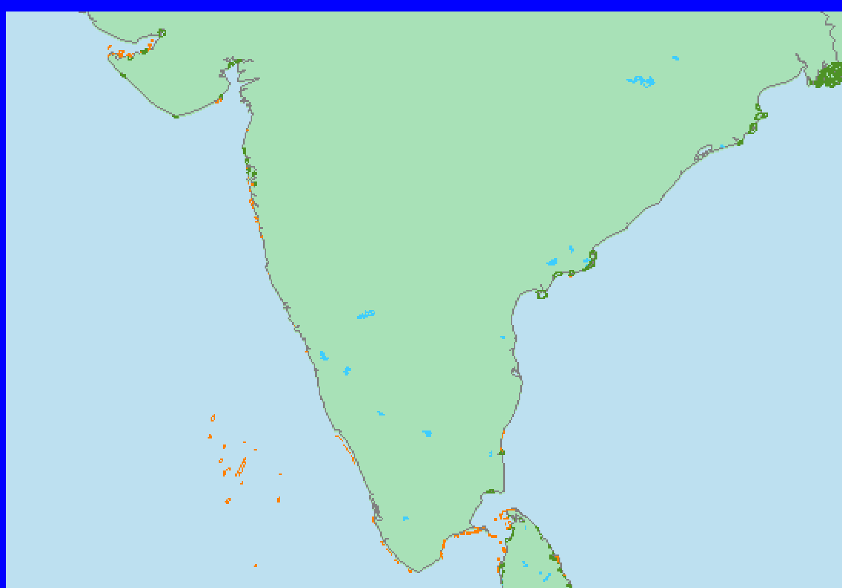
a) In high altitude lakes an increased temperature would result in loss of winter ice cover

b) Reduced oxygen concentration could alter community structure, characterized by fewer species, especially if exacerbated by eutrophication from surrounding land-use

- Lake level changes from increased temperature & changes in precipitation would alter community structure

Possible sea level rise in India

- More than direct land loss due to seas rising, indirect factors are generally the main difficulties associated with sea-level rise. These include erosion patterns and damage to coastal infrastructure, salinization of wells, sub-optimal functioning of the sewerage systems of coastal cities with resulting health impacts, loss of littoral ecosystems and loss of biotic resources.

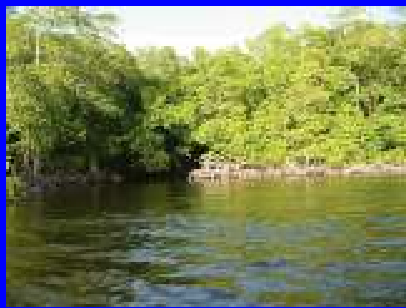


Coral reefs, mangroves,surface water in orange,green and blue respectively
Source:http://www.reefbase.org/ReefGIS/mapper.asp

Mangroves

- Mangroves are found along the east and west coasts as well as the Andaman and Nicobars
- Sundarbans (40% in West Bengal) is the largest mangrove in the world
- Mahanadi (Orissa), Godavari, Krishna (Andhra),

  Cauvery (Pichavaram & Muthupet in Tamilnadu),
- Gulf of Kachchh & Khambat (Gujarat)
- Total forested area of 5000 km^2



Area under mangroves

Location	Total area(ha)	Forest(ha)
Sundarbans	426000	212500
Mahanadi	67000	21500
Godavari	33250	24100
Krishna	25000	15600
Pichavaram	1300	900
Gulf of Kachchh	58200	85400
Gulf of Khambat	53123	17700
Others (W.coast)		11600
Andamans		92900
Nicobars		3700
Total		**487100**

Major mangrove types

- Tide-dominated (Sundarbans & Mahanadi)
- River dominated (Godavari, Krishna & Cauvery)
- Drowned bedrock valley (Gulf of Kachchh & Kambat)
- Carbonate platform on low energy coast (Andaman and Nicobar islands)

Source: Selvam, V. Current Science, 84:757 (2003)

CC impacts on mangroves

- Climate change impacts on mangroves will be influenced by various factors including:

  a) Sea level rise

  b) Changes in river flows due to changes in snow melt (from warming) and precipitation in the catchment and locally

  c) Changes in local temperature

  d) Changes in storm surges

Sea level rise

- Sea level rise of up to 1m has been projected for the period 1990-2100 with substantial regional variation (IPCC WG1).
- Mangroves would be vulnerable to sea-level rise; a 1m rise for instance would result in the complete submergence of the mangroves of Sunderbans. Species affected would include the tiger, otters, estuarine crocodiles, five marine turtles, etc. However, mangroves in low-island coastal regions where sedimentation loads are high & erosion processes low can adapt better.
- SLR would also result in intrusion of salinity into low-lying floodplains as well as freshwater aquifers.

Climate change impacts on coral reefs

- Bleaching of coral reefs due to increase in SST of >1° C is well known.
- One of the most widespread coral bleaching worldwide, including in the Indian coral reefs, occurred during 1997-98 when SSTs increased by an average of 3° C in the Indian Ocean in conjunction with a major El Nino event.

Coral reefs

- Coral reefs are distributed mainly in six regions of the country (Gulf of Kachchh, Malwan coast, Gulf of Mannar Palk Bay, Lakshadweep islands, Andaman and Nicobars) and are of several types:

a) sea level atolls (e.g. Lakshadweep archipelago)

b) fringing reefs (e.g. Gulf of Mannar & Palk Bay in Tamilnadu, and Andaman and Nicobars),

c) reef barriers (e.g.Andaman and Nicobars),

d) elevated reefs and

e) submerged reef platforms

Warming of the Indian Ocean

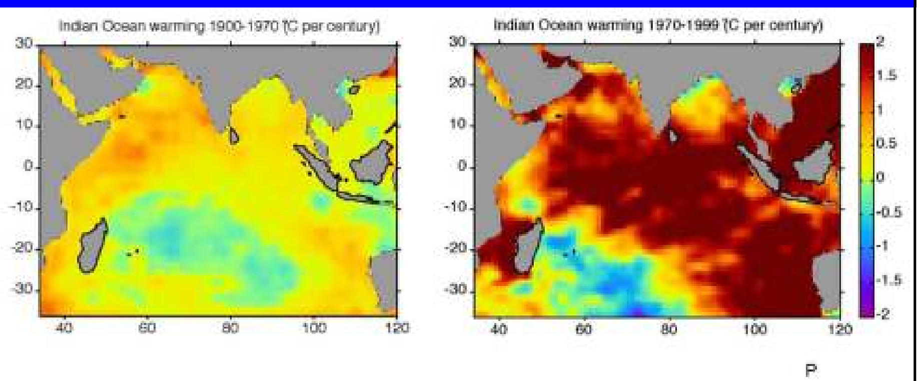


Figure 5.3.5. Linear trend of SST in the Indian Ocean for (a) 1900–1970 and (b) 1970–1999 estimated from the HADISST temperature data (after Rayner *et al.*, 2003).

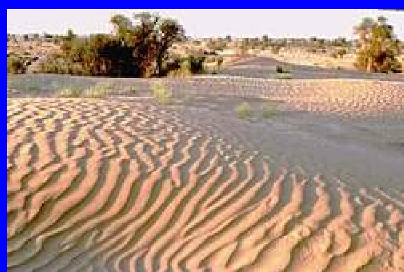
Flooding events in northeast India?

- Increased precipitation and variability could increase the risk of severe flooding in the Brahmaputra
- This could be exacerbated by the rapid deforested taking place in the catchment
- Floodplain habitats of endangered species such as rhino could be under threat

Altitudinal migration in the Himalayas?

- Increasing temperatures could cause upward migration of the snow line, and of vegetation types.
- Certain high altitudinal biomes such as tundra could disappear altogether.
- Associated fauna would be at risk.

Increased aridity in northwestern India?



- Increasing temperature and decreasing precipitation in NW India could cause further desiccation of the habitat and shift towards more arid vegetation types