

# **Climate Change And Its Implications (CCI)**

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**Lecture-11\_12**

# Biodiversity



# Climate Change & Biodiversity

- **Biodiversity** is the 'Full variety of Life on Earth'
- It includes diversity within species, between species and of ecosystem
- The sum total of species richness, *i.e.* the number of species of plants, animals and micro-organisms occurring in a given region, country, continent or the entire globe
- biodiversity includes genetic diversity (Diversity of genes within a species), species diversity (Diversity among species), ecosystem diversity (Diversity at the level of community/ecosystem) and habitat diversity

## **Importance**

- Biodiversity is the very basis of human survival and economic development
- It helps in maintaining the ecological balance
- It plays an important role in the function of an ecosystem by providing many services like nutrients and water cycling, soil formation and retention, resistance against invasive species, pollination of plants, regulation of climate, as well as pest and pollution
- Biodiversity is also the source of non-material benefits like spiritual and aesthetic values, knowledge system, cultural diversity and spiritual inspiration

- It is source of inspiration to musicians, painters, writers and other artists
- Biodiversity is fundamental to ecosystem structure and function and underpins the broad spectrum of goods and services that humans derive from natural ecosystems
- At least 40% of the world's economy, and 80% of the economy of less industrialized nations, is derived directly from biological resources as a function of ecosystem service

- India is one of the 12 mega biodiversity countries in the world and divided into 10 biogeographic regions
- Our country accounts for two hotspots out of the 35 global biodiversity hotspots: the Indo-Malayam which includes the Eastern Himalayas, North-east India and Andaman Islands, and the Western Ghats

It is estimated that over 46,000 species of plants and 81,000 species of animals are found in India

The flowering plants comprise 15,000 species of which about 7000 species are endemic

Among the animal species diversity more than 50,000 species of insects, 4,000 molluscs, 6,500 other vertebrates, 2,546 fishes, 197 amphibians, 408 reptiles, 1224 birds and 350 species of mammals are found in different habitats

- The important causes of threats to biodiversity are the habitat destruction, invasive species, pollution, population and overexploitation of natural resources
- Other prominent factor for the depletion of biodiversity is the rampant poaching
- At the global level, the MEA documented that over 60% of ecosystem services were deteriorating or already overused (Larigauderie and Cesario et al., 2009), and it has been worsened by the impact of increasing climate change

# **Pressure on biodiversity from human activities**

1. Increased demand for resources
2. Selective exploitation or destruction of species
3. Land use and land cover change
4. Accelerated rate of anthropogenic nitrogen deposition
5. Soil, water and air pollution
6. Introduction of non-native species
7. Urbanization and industrialization

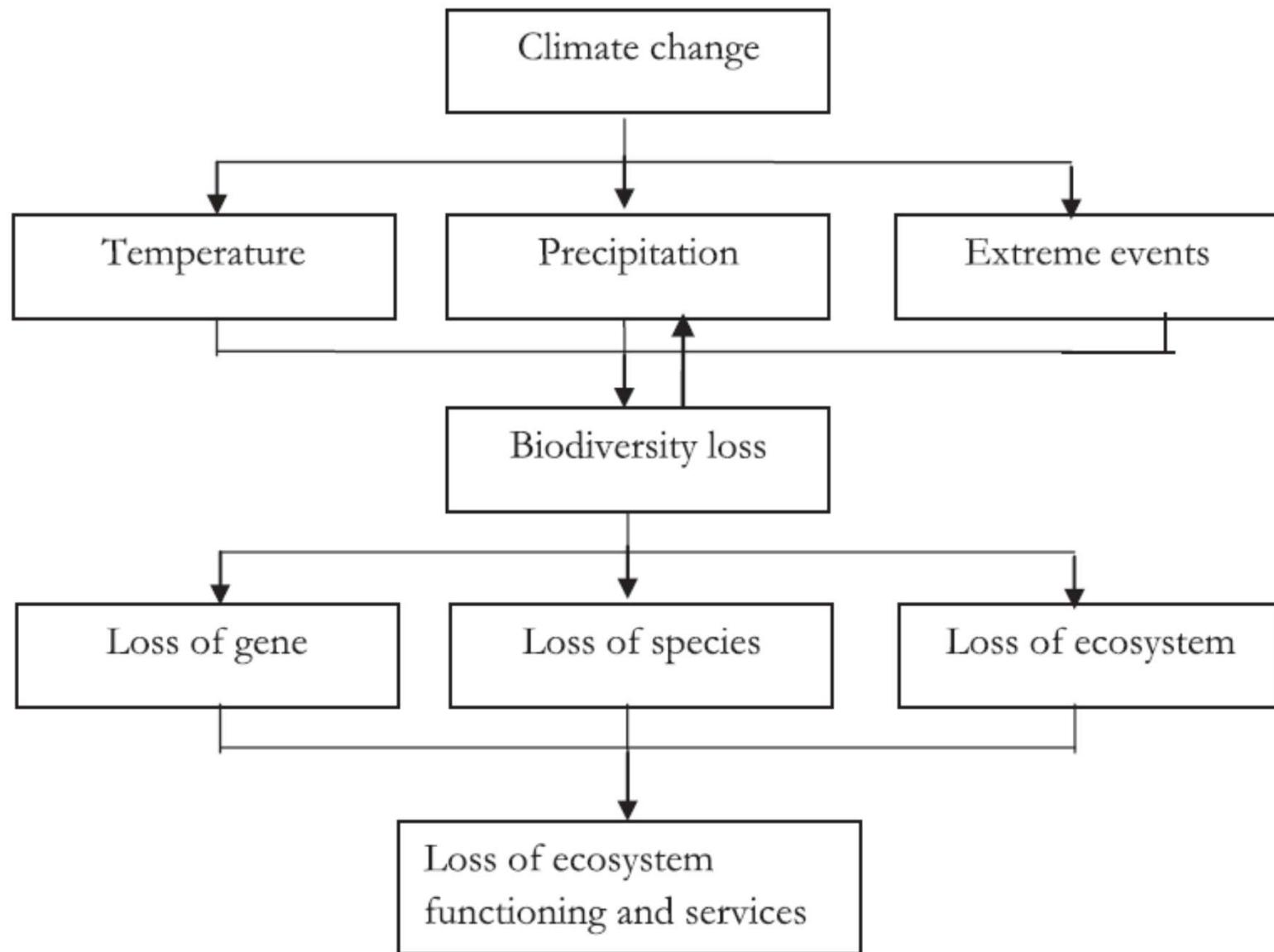
➤ Climate change

- Climate change affects individual species and the way they interact with other organisms and their habitats, which alters the structure and function of ecosystems and the goods and services that natural systems provide to society
- Periodic assessments of current and future climate change impacts on ecosystems are important for developing and updating natural resource management plans and evaluating adaptation actions

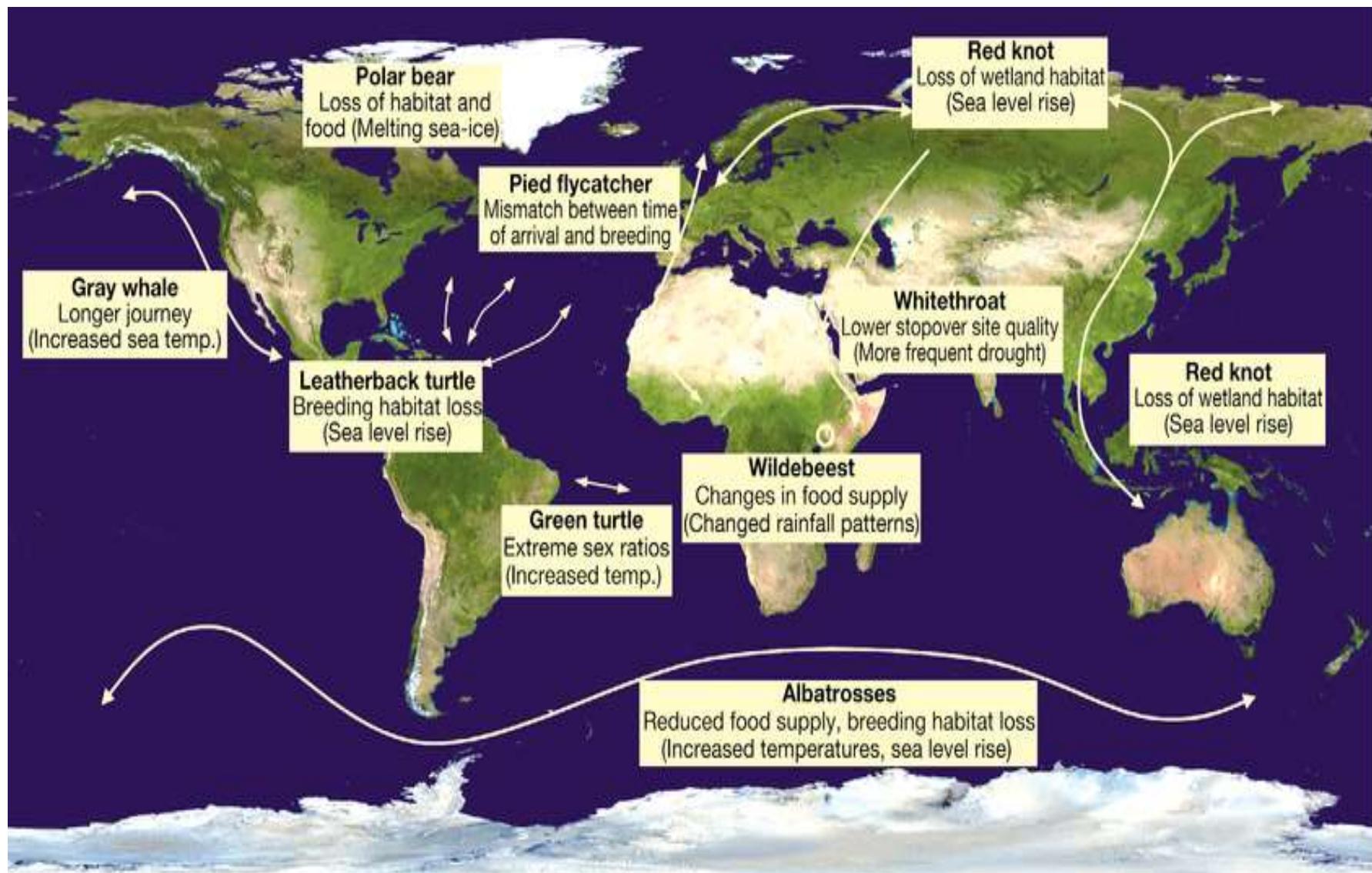
## Millennium Ecosystem Assessment (MA) 2005:

Biodiversity change is evaluated in terms of its implications for

- (a) Supporting: nutrient cycling, primary production
- (b) Regulating: climate and disease regulation
- (c) Cultural: spiritual values, recreation
- (d) Provisioning: food, fuel, fiber, and fresh water services



# Impact



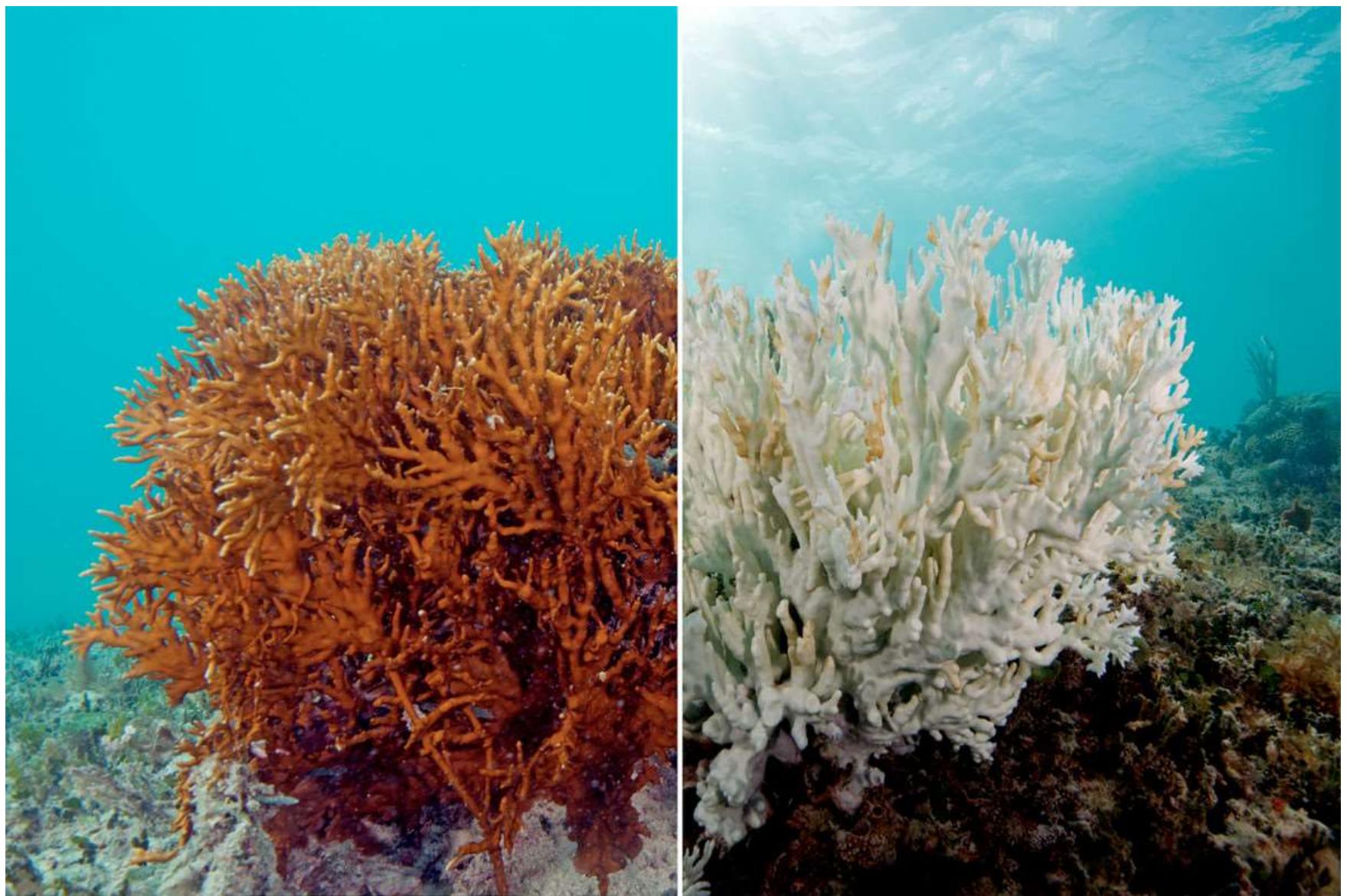


- In the Northwest, abnormally warm temperatures have led to losses of migrating and spawning salmon in the Columbia River ([NOAA Fisheries, 2016](#))
- In Alaska, some salmon populations have benefited from warmer temperatures, earlier spring, and increased density of zooplankton prey ([Schindler et al., 2005](#))
- Coho salmon on the west coast of the U.S. are expected to shift their range north by 2050 ([Cheung et al., 2015](#))
- Under a high greenhouse gas emissions scenario, projected stream temperature increases could lead to a 22% reduction in salmon habitat in Washington by late century ([Niemi et al., 2009](#))

## **1. Ocean Acidification:**

- We can only blame ourselves for the 30% drop in the pH of oceans—they absorb nearly a third of the carbon released into the atmosphere through human activity
- This acidification renders some crustaceans and coral unable to produce their protective shells and skeletons
- Coral reefs, which serve as habitat for thousands of marine species, are being destroyed by bleaching due to ocean acidification
- This destruction of marine life is a threat to the entire ecosystem including humans





## **2. Water resources:** Climate change affects the water resources

- Increased evaporation rates are expected to reduce water supplies in many regions
- The greatest deficits are expected to occur in the summer leading to be decreased soil moisture levels and more frequent and severe agriculture drought
- More frequency and severe droughts arising from climate change will have serious and management implication for water resource users
- Such droughts also impose costs in terms of wildfires both in control costs and lost timber and related resources



- In drought areas, habitats are altered, and plants and forests suffer from the lack of water
- Increased wildfire activity due to hot, dry conditions poses a risk for safety of wildlife
- It destroys important wildlife habitats, like the nesting habitat for Mexican spotted owls and forest habitat of endangered Amur tigers and critically endangered Amur leopards in Russia
- Stronger and more frequent storms affect the distribution and concentration of the low links on the marine food chain—plankton and krill—thus having a domino effect on many ocean species

### **3. Melting Sea Ice:**

- Arctic temperatures are rising twice as quickly of the rest of the world and sea ice is melting at an alarming rate
- Some of the world's iconic species like polar bears, ringed seals, emperor penguins, and beluga whales all experience distinct pressures due to melting sea ice
- For these and other species, disappearing ice disrupts the food chain, hunting habits, reproduction, protection from predators, and the ability to travel long distances—in other words, the foundations of their existence

#### **4. Sea-Level Rise:**

- Coastal wetlands are among the most productive of all natural ecosystems and so the impacts of climate change will be extremely important in coastal regions and have ramifications far beyond them
- The Sundarbans is the largest natural low-lying mangrove ecosystem in the world, distributed over 10000 square kilometres
- The sea level rise recorded over the past 40 years is responsible for the loss of 28 percent of the mangrove ecosystem

## **5. Disease and Pests:**

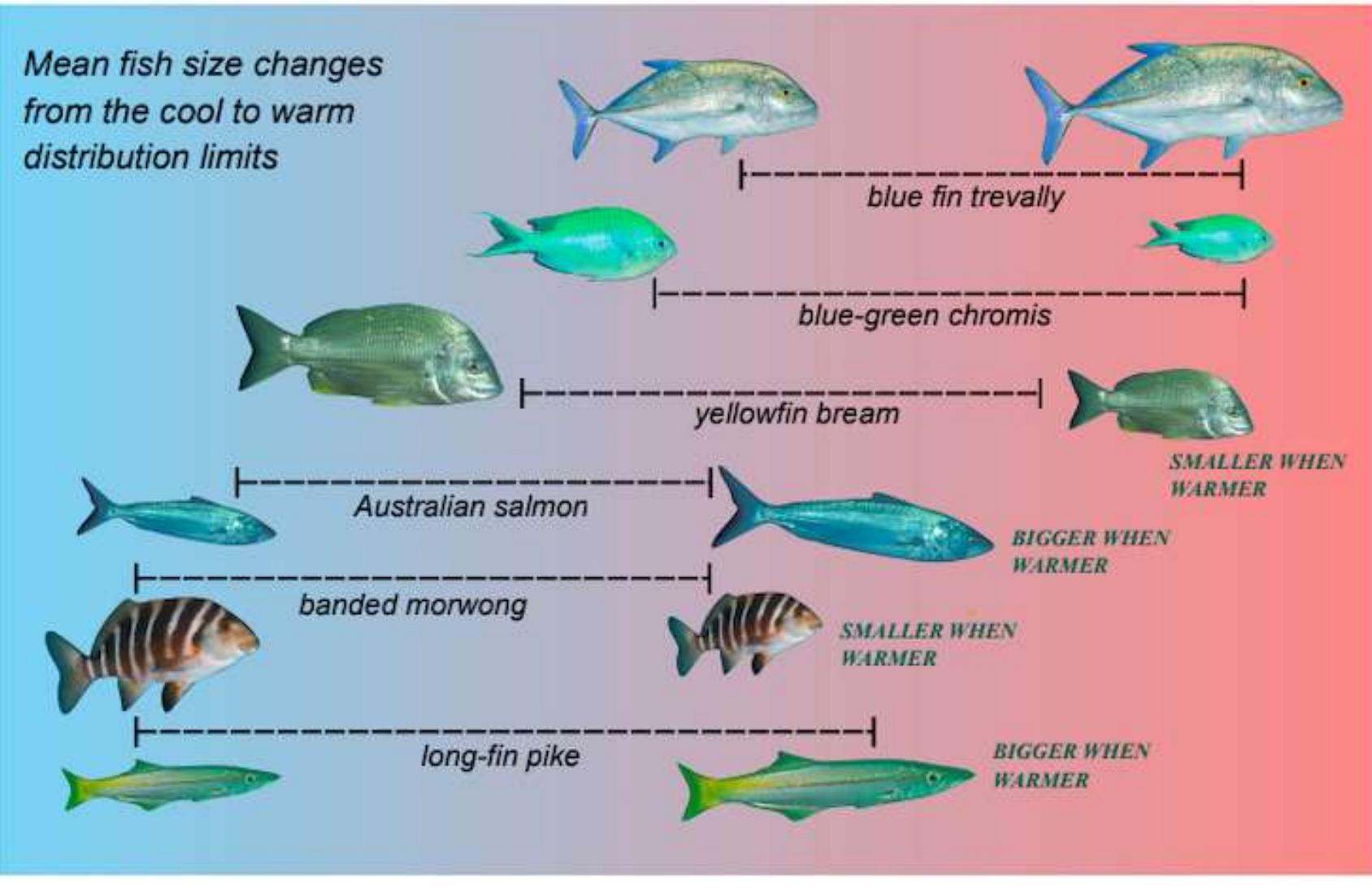
- Not only does climate change affect disease in human populations, it also alters the disease behavior in animals as well
- The devastating amphibian disease chytrid fungus, likely exacerbated by warmer temperatures, has left many amphibian populations dwindling or extinct
- Seasonal pests, like bark beetles in the US, breed longer in warmer weather and thirsty, drought affected trees are more susceptible to infestation

# Possible adaptations

## **1) Behaviour and morphology:**

- One way that organisms cope with changes in climate is by altering their behavior or morphology
- **Behavioral responses:** seeking shades, altering feeding timings, changing site use etc
- **Morphology:** changes in body size

*Mean fish size changes  
from the cool to warm  
distribution limits*



Temperate  
(~13C)

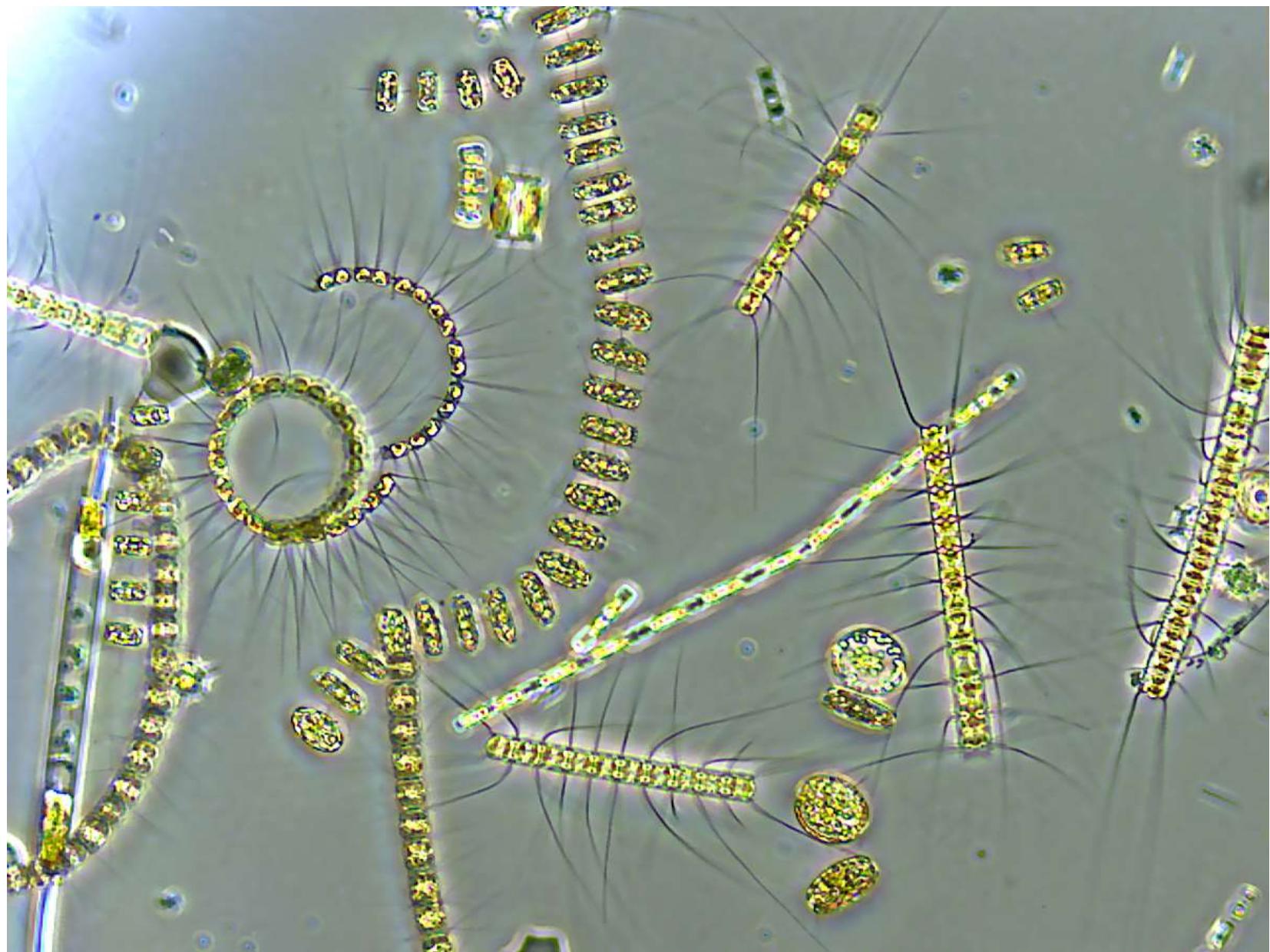
Mean sea temperature

Tropical  
(~29C)

## 2) Phenological shift:

- Changes in phenology or the seasonal timing of life events have been observed in response to variations in temperature, precipitation, and photoperiod
- Phenological events include changes in leaf growth, flowering and blooming in plants, and shifts in the timing of spawning, reproduction, and migrations in animals

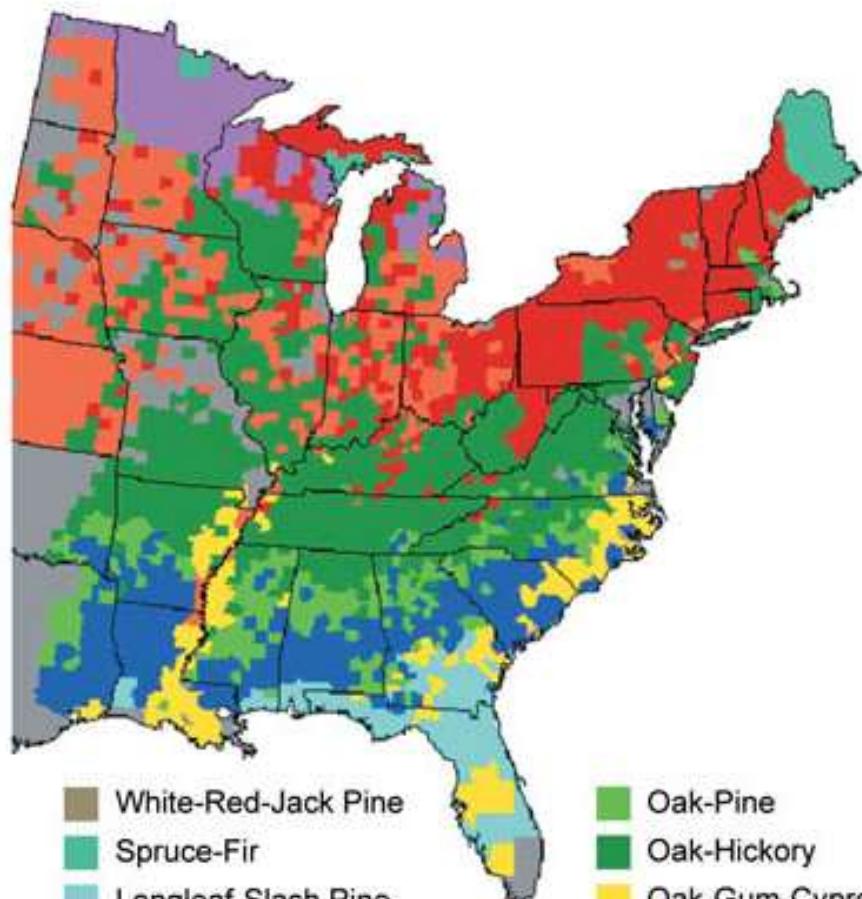
- Marine phytoplankton can respond rapidly to such abiotic changes, resulting in altered timing of phytoplankton blooms ([Wasmund et al., 2019](#)), which in turn can create a mismatch with secondary consumers and change the food web structure
- Phytoplankton, also known as microalgae, are similar to terrestrial plants in that they contain chlorophyll and require sunlight in order to live and grow. Most phytoplankton are buoyant and float in the upper part of the ocean, where sunlight penetrates the water



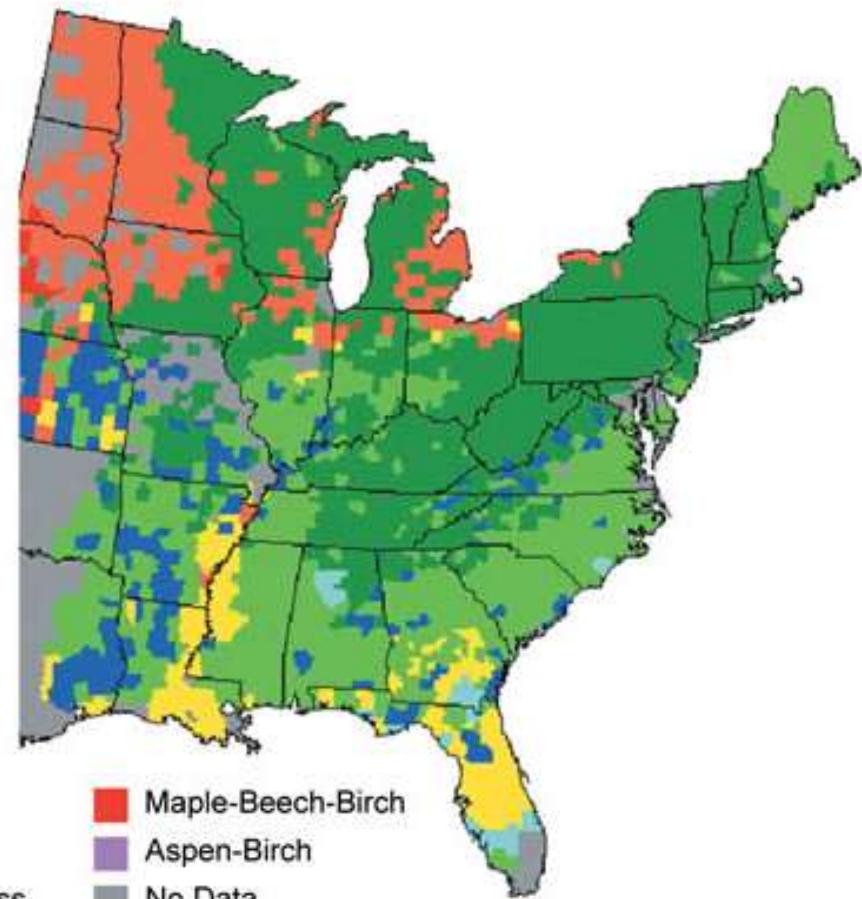
### **3) Shifts in species distribution:**

- Studies show that many species have shifted their geographic ranges in response to rapid changes in temperature and precipitation regimes
- The current rates of migration of species will have to be much higher than rates during postglacial periods in order for species to adapt to the changing climate
- Climate change has the potential to alter migratory routes (and timings) of species that use both seasonal wetlands (e.g., migratory birds) and track seasonal changes in vegetation (e.g., herbivores), which may also increase conflicts with humans, particularly in areas where rainfall is low

Recent Past  
1960-1990



Projected  
2070-2100



Forest species distribution

- Due to increase in temperature, several plant species like *Berberis siatica*, *Taraxacum officinale*, *Jasminum officinale* etc. have shifted towards higher altitude in Nainital
- Teak dominated forests are predicted to replace the Sal trees in central India and also the conifers may be replaced by the deciduous types
- According to Gates (1990)  $3^{\circ}\text{C}$  increase in temperature may leads to the forest movement of **2.50 km/year** which is **ten times** the rate of natural forest movement.

#### **4) Demographic responses:**

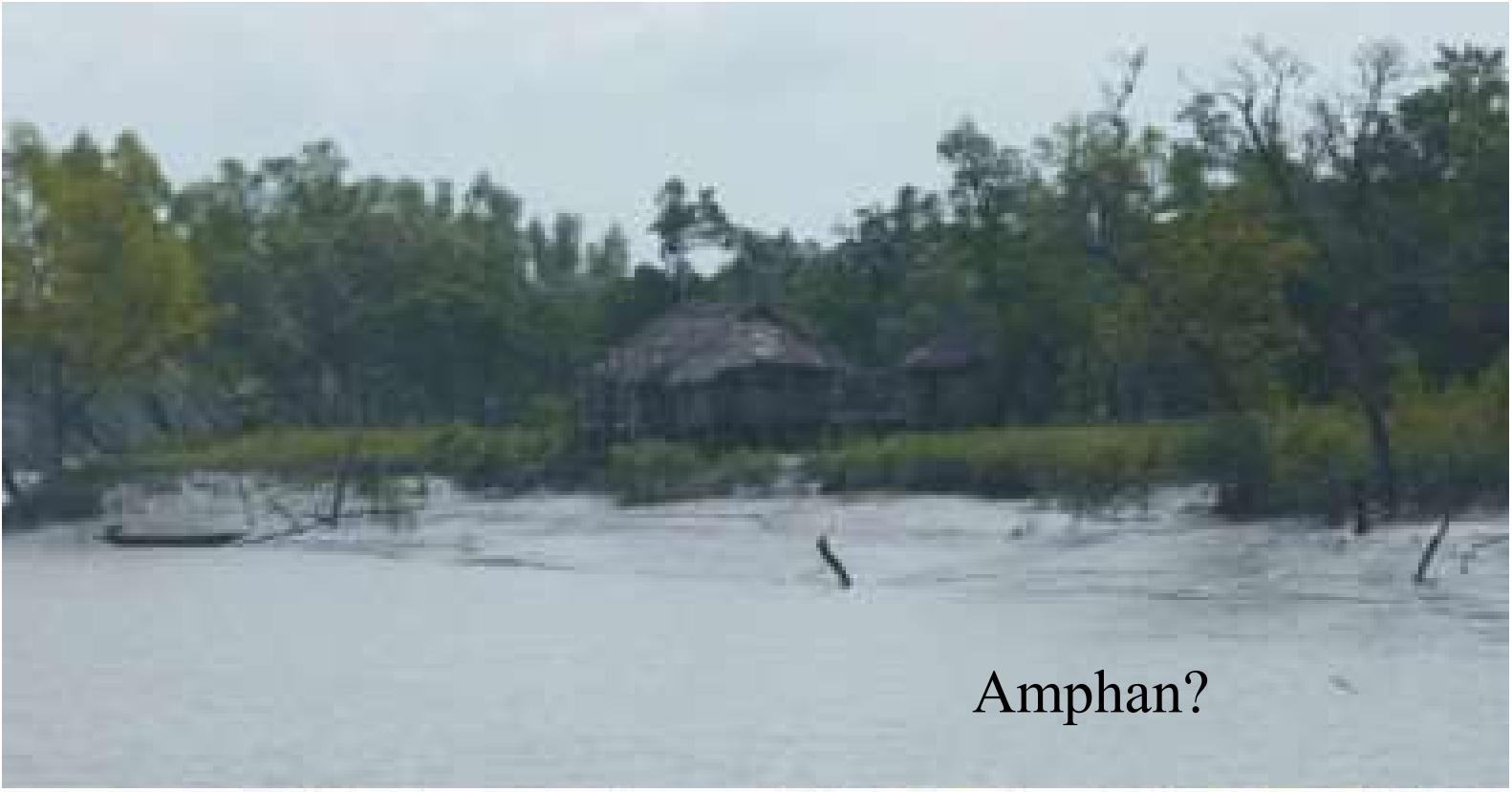
- Loss of natural habitats and shifting habitat ranges to more suitable ones as a result of climate change could have profound
- Shift in species distribution can also result in rapid decline in species population/size

- Slight change in climatic condition leads to the extinction of animal species
- ✓ For example climate change has resulted in *extinction* of animals like golden toad and Monteverde harlequin frog
- ✓ Polar bears are in danger due to reduction in Arctic ice cover; North Atlantic whale may become extinct, as planktons which are its main food have shown declination due to climate change

# Impact on ecosystem-India

## Marine and Coastal ecosystem

- Indian coastal areas vulnerable to climate change are Sunderbans, Maharashtra, Goa and Gujarat (Rann of Kutch)
- Species composition and distribution will surely be affected by such changes (Rathore and Jasrai, 2013)
- The Sundarbans is the largest natural low-lying mangrove ecosystem in the world, distributed over 10,000 square kilometers
- The sea level rise recorded over the past 40 years is responsible for the loss of 28% of the mangrove ecosystem
- Modelling suggests that up to 96% of suitable tiger habitat in the Sundarbans could be lost in the next 50–90 years



## Himalayan ecosystem

- Mosquito are seeing first time in Lhasa and Tibet cities, located 3490 meters above sea level
- There are similar reports of flies at Mount Everest base camp in Nepal
- The presence of these insects suggests the possible spread of vector borne diseases, such as malaria and dengue fever, to areas where cooler temperatures previously protected people from these threats

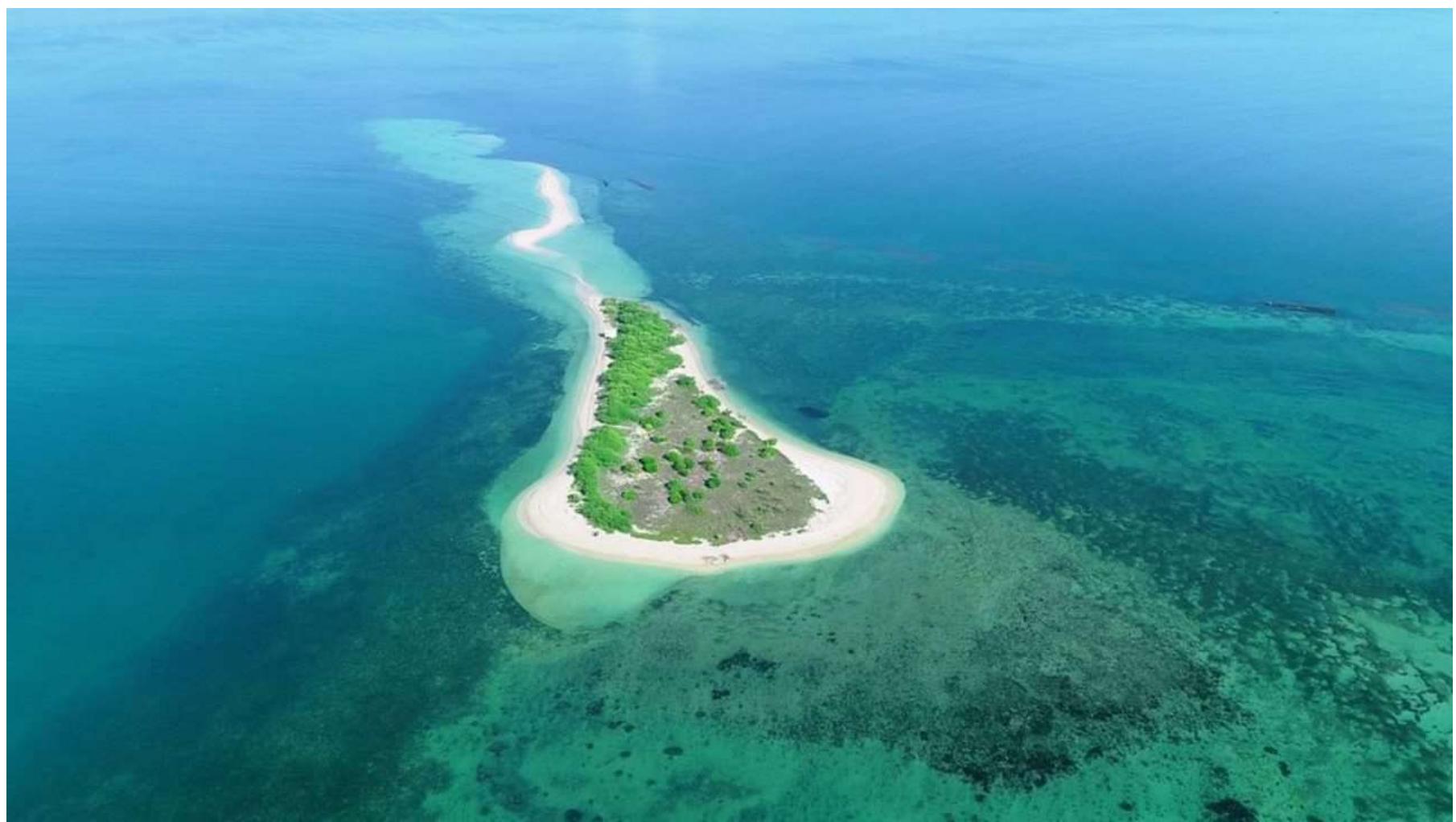


Climate change is roasting the Himalayas

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## Island ecosystem

- Islands are rich in biodiversity and has high economic importance
- But at present due to climate change more than 23% island species are becoming endangered and hence economic loss in the tourism sector



## Inland water ecosystem

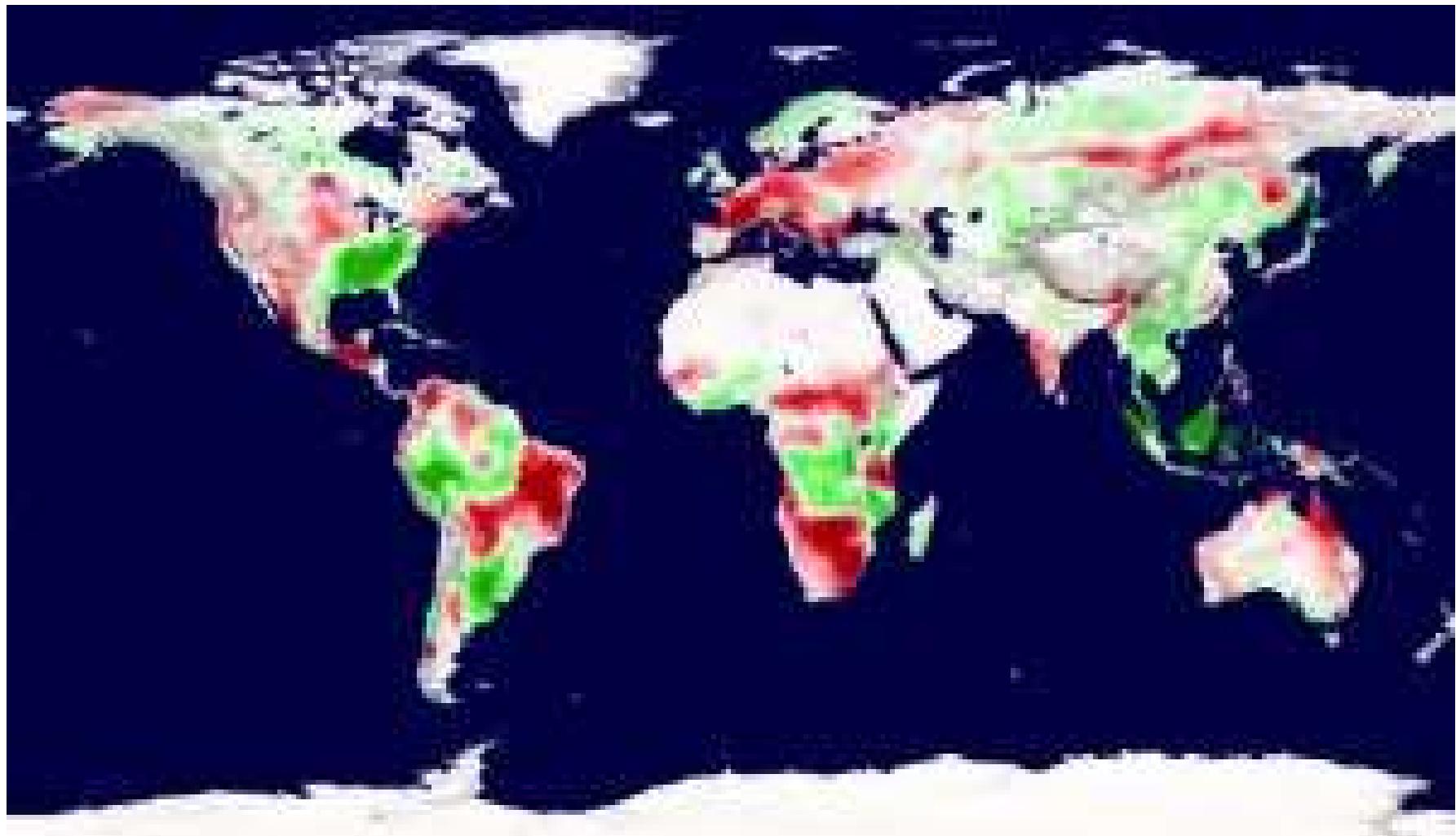
- They are rich source of food, income, employment and biodiversity
- Changing climatic conditions like rainfall and temperature lead to changes in the phenology, physiology and migration trends of some organisms like migratory fishes and birds

## Forest ecosystem

- One third of earth's surface is covered by forest and it is the home place of two third of all terrestrial species
- They are also rich biodiversity hotspots
- Half of the original forest has been cleared up till now
- Green house effect has led to increase in growth of some forest, migration of tree species towards high altitude, increased attack of pest, invasive species and wild fires, hence modifying the composition of forest
- According to FAO, due to these changes many animals, primates and 9% of all known plant species are at verge of extinction

## Dry lands and grass lands

- They have localized species (Wild ass, Kutch etc.) and have varied crops and livestock
- The risk of wild fire is increasing which could change the species biodiversity



Regions of increased productivity (green) and decreased productivity (red)

## Human

- An increase of 1°C in surface temperature is estimated to correspond 10% increase in incidence of insects as pests and resurgence of many diseases like cholera, typhoid etc.
- Spread of tropical and vector borne diseases like malaria, dengue etc
- Androdent borne diseases like plague
- These diseases have shown a persistent increase in the past 50 years.

# Mitigation

- Mixed plantings have the additional benefit that they are likely to be more resilient to future societal (cultural, economical) and environmental (stability facing global change, biodiversity conservation) challenges, including climate change
- For example, mixed species stands have been found to be more resistant to various forms of damage, and to be more diverse in their fauna and flora than pure, single-species stands
- Less diversified systems, such as monoculture plantations, may also be less resistant and resilient to natural disturbance or pests something that global change may exacerbate

- Mixed species can also have some financial advantages that make them more attractive, especially to smallholders
- For example, crops can be grown in the understory or some fast-growing species can be harvested earlier than slower-growing species to generate an early return
- Greater diversity of forest products provides economic certainty for local communities, which promotes land use stability that has subsequent beneficial effects for biodiversity conservation

- Animal diversity is frequently related to plant diversity, thus the presence of a more diverse canopy (or understory) is likely to result in greater biodiversity opportunities within plantations
- Empirically species mixtures have been shown to increase resilience to changing conditions and in some instances they are known to improve productivity in both planted and natural forests
- In addition to productivity and stabilizing influences, mixed species plantation forests can enhance biodiversity opportunities by diversifying habitat within stands

- Crop rotation length
- Removal of residual biomass for bioenergy
- Changes to silvicultural management
- Afforestation/reforestation

# Conclusions

- It is estimated that about 27000 species become extinct every year
- If this will continues, 30% of world's species may be extinct by the year 2050
- The current extinction rate is 100 to 1000 times to that of natural rate of extinction
- Other human activities are: habitat destruction, invasive species, pollution, population and overexploitation of natural resources

- Human activities like deforestation, pollution, overpopulation are ultimately responsible for habitat destruction
- Introduction of exotic species is also responsible for the loss of biological diversity
- The endemic and other local species may not be able to compete with the exotic species and are unable to survive
- Overexploitation, in the form of hunting of animals and plants for their commercial value is one of the major reasons for loss in biodiversity
- Illegal wildlife trade is the single largest threat to biodiversity loss
- Overpopulation of human and over consumption of natural resources is the root cause of all biodiversity loss

# MaxEnt model- species distribution model

[https://biodiversityinformatics.amnh.org/open\\_source/maxent/](https://biodiversityinformatics.amnh.org/open_source/maxent/)