

# Climate Change Impact and Adaptation in Agriculture [With Special Reference to Himalaya]

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# Course Overview

**This course analyses climate change impacts on agriculture and food security, and present an overview of the main climate change adaptation and mitigation strategies in agriculture**





# Course Content

**This course has been designed to help master level students to develop a comprehensive understanding of the impacts of climate change on mountains agriculture and food security and the possible adaptation options, with special reference to the Indian Himalayan Region [IHR]. There are following Four Lessons in this course:**

**Lesson 1:** Climate Change and Global Warming: This explains the meaning and concept of climate change and how it differs from climate variability

**Lesson 2:** Impact of Climate Change on Agriculture and Food Security: This Lesson assesses the impacts of climate change on agriculture and food security

**Lesson 3:** Fundamentals of Adaptation in Agriculture Sector: This Lesson focuses on the basic concept of climate change adaptation, and adaptation in agricultural sector in context of Himalayan mountains

# Lesson -1

## Climate Change and Global Warming

- This explains the meaning and concept of climate change and how it differs from climate variability
- It discusses the causes and drivers of global climate change and its important effects on the socio-ecological system



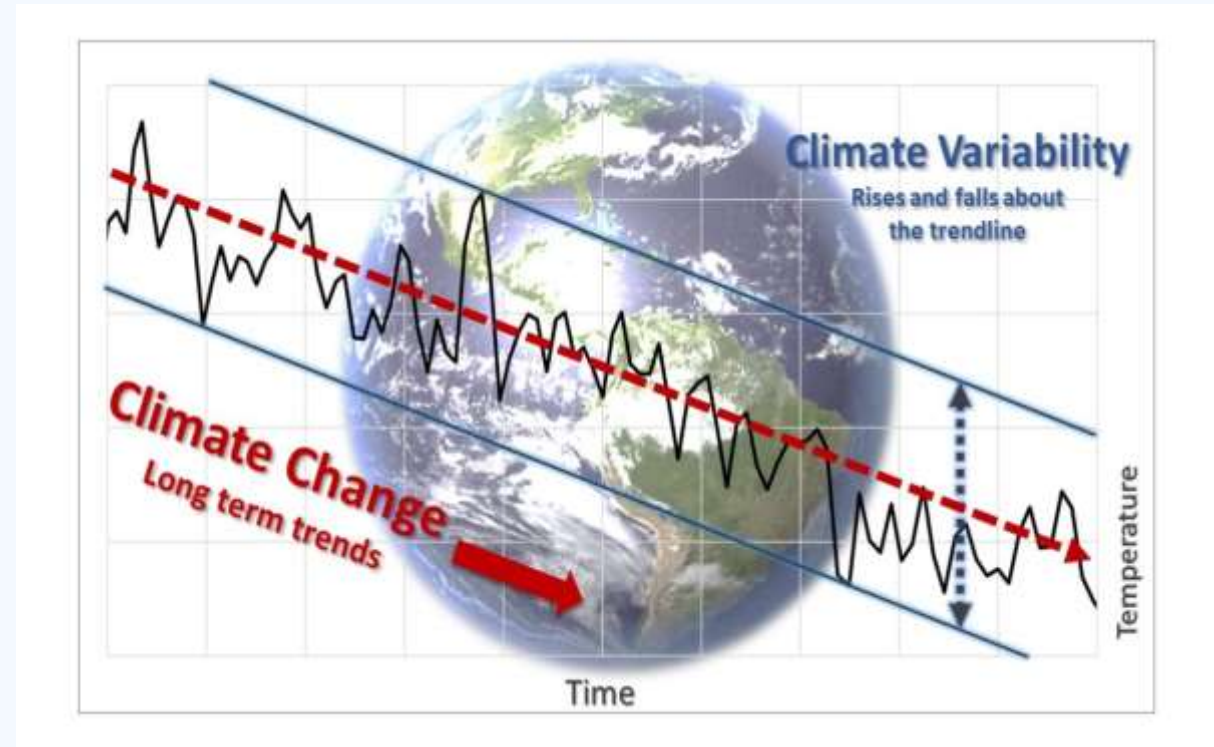


# Climate Change and Global Warming

## Learning Objectives

At the end of the Lesson the students would be able to understand:

- The climate change and the difference between climate change and climate variability
- Global warming and its causes
- The effects of climate change



# Introduction

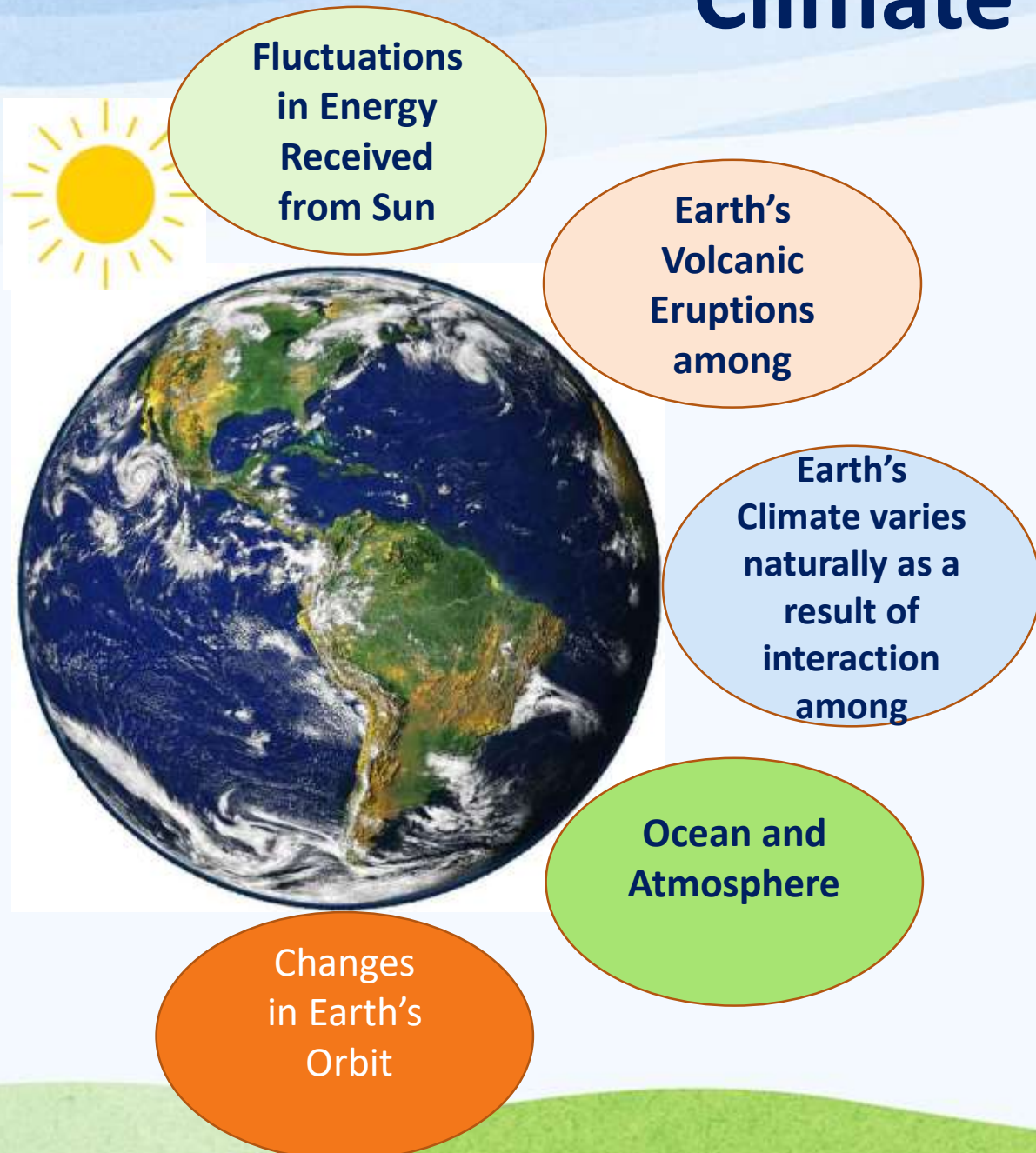
## Climate Change

- It has been observed that the global temperature has changed, the precipitation pattern altered, and the frequency and severity of extreme weather events have increased significantly over the last 150 years.
- This phenomenon is called climate change





# Climate Variability



Fluctuations  
in Energy  
Received  
from Sun

Earth's  
Volcanic  
Eruptions  
among

Earth's  
Climate varies  
naturally as a  
result of  
interaction  
among

Ocean and  
Atmosphere

Changes  
in Earth's  
Orbit

This phenomenon is known as climate variability which refers to natural climate fluctuations, and include changes of mean state and occurrence of weather extremes. This indicates that climate of the earth has been changing constantly

Climate variability refers to variations in the mean state and other statistics of the climate at all spatial and temporal scales beyond that of individual weather events. Variability may be due to natural internal processes within the climate system, or to variations in natural or anthropogenic external forcing

# Climate Change

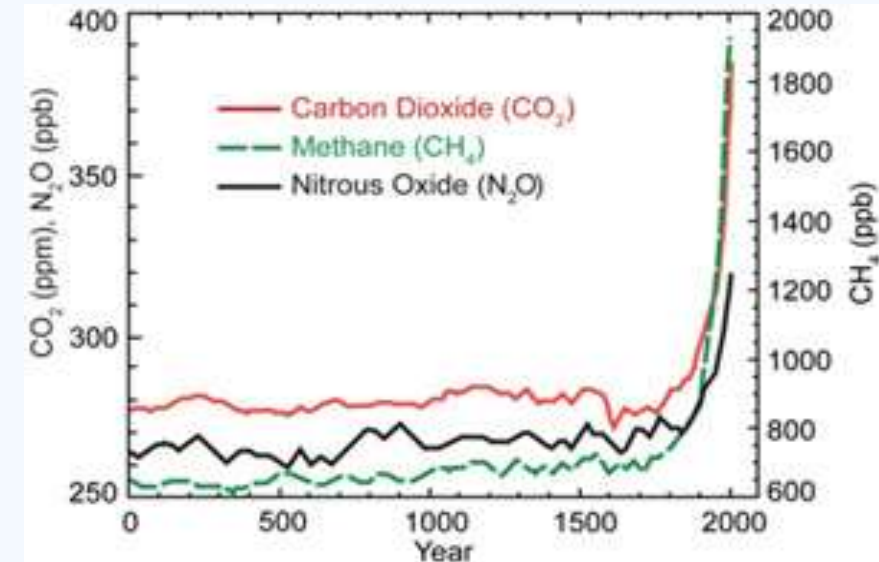
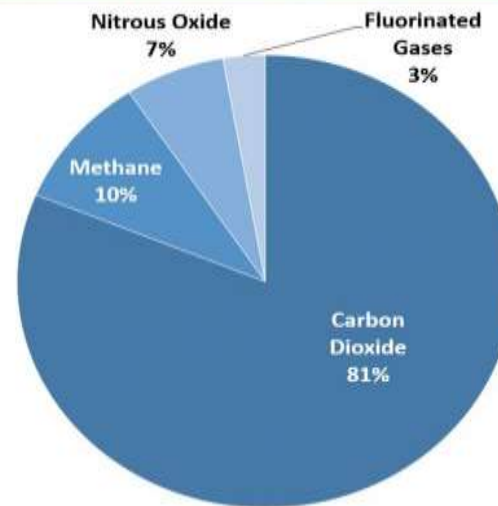


Climate change refers to a change in the state of the climate that can be identified (e.g., by using statistical tests) by changes in the mean and/or the variability of its properties and that persists for an extended period, typically decades or longer. Climate change may be due to natural internal processes or external forcings such as modulations of the solar cycles, volcanic eruptions and persistent anthropogenic changes in the composition of the atmosphere or in land use. Climate change is a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods’.

Human activities contribute to climate change by causing by modifying the composition of Green House Gases in the Atmosphere. After the industrial revolution there has tremendous increase in the amount of CHGs in the earth's atmosphere. This resulted in green house effect and global warming



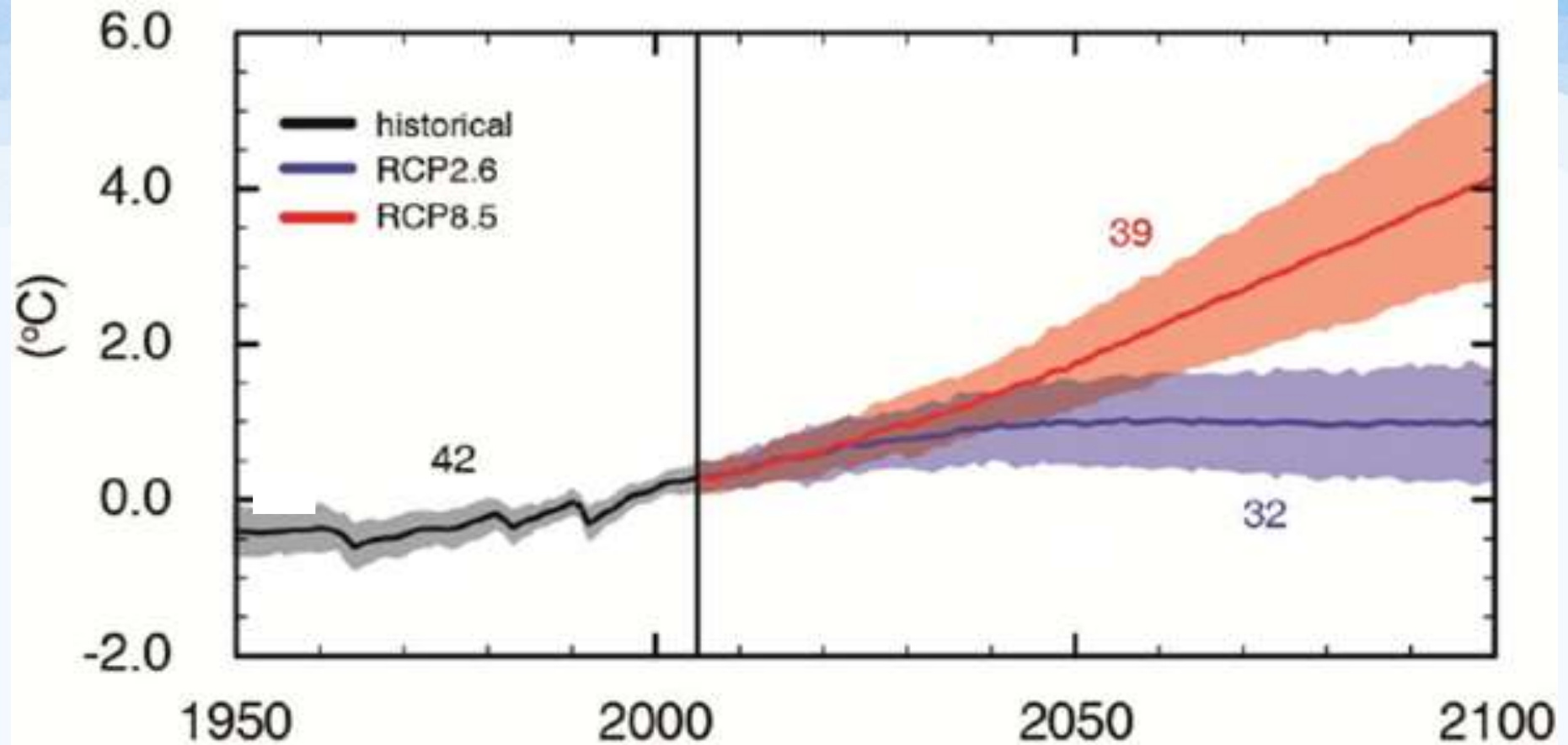
Overview of Greenhouse Gas Emissions in 2018



The major Green House Gases in earth's atmosphere are: Carbon Dioxide [CO<sub>2</sub>], Methane [CH<sub>4</sub>], Nitrous Oxide [N<sub>2</sub>O], Chlorofluorocarbons [CFCs] and Water Vapour [H<sub>2</sub>O]



# Global Warming



Global mean temperature is increasing due to climate change. This phenomenon is called global warming

The global temperature has increased by  $0.74^{\circ}\text{C}$  in the past 100 years, and is expected to increase by 1.5 and 4.0 by the end of the century. Depending upon projected scenarios

# The Causes of Global Warming

Sunlight Passes through atmosphere and warms earth



Some infrared radiation is trapped by CHGs keeping the earth warm enough to sustain the life

Earth releases back the heat in the form of infrared radiation allowing the earth to cool

The natural Green House Effect traps heat from the sun, thereby increasing the earth's mean temperature from -18 C to the current average of about 15 C

Between 1970 and 2010 the emission of CHGs increased by 70% due to human activities

Enhanced Green House Effect Human induced emission of additional CHGs amplify the amount of energy retained by the earth causing the increase in global temperature



# The Major Effects of Climate Change

The increase in global temperature alters the general circulation of the atmosphere and oceans and modifies normal weather conditions. These changes have large impact on different components of natural system

## Melting of Glaciers and Snow



## Increase in Weather Extremes



## Sea Level Rise



## Changes in Hydrological System



## Changes in Precipitation Pattern



## Glacial Lake Outburst Flood





## South Asia's Hotspots

Impacts of Temperature  
and Precipitation  
Changes on Living  
Standards

- The World Bank report South Asia's Hotspots brings new research on the impacts of climate change in South Asia by analyzing how rising temperatures and changing precipitation patterns affect living standards.
- The report identifies climate "hotspots" as defined geographical areas where living standards will be most adversely impacted by changes in average weather.
- The report breaks new ground by combining spatially granular simulations of future changes in temperature and rainfall with household survey data linking living standards to weather conditions.

- The world is likely to experience rising temperatures and changing precipitation patterns in coming years
- The entire world will experience more intense rainfall and more frequent and intense droughts, floods, heat waves, and other extreme weather events
- The impacts of climate change could cost India 2.8% of GDP and depress the living standards of nearly half the country's population by 2050

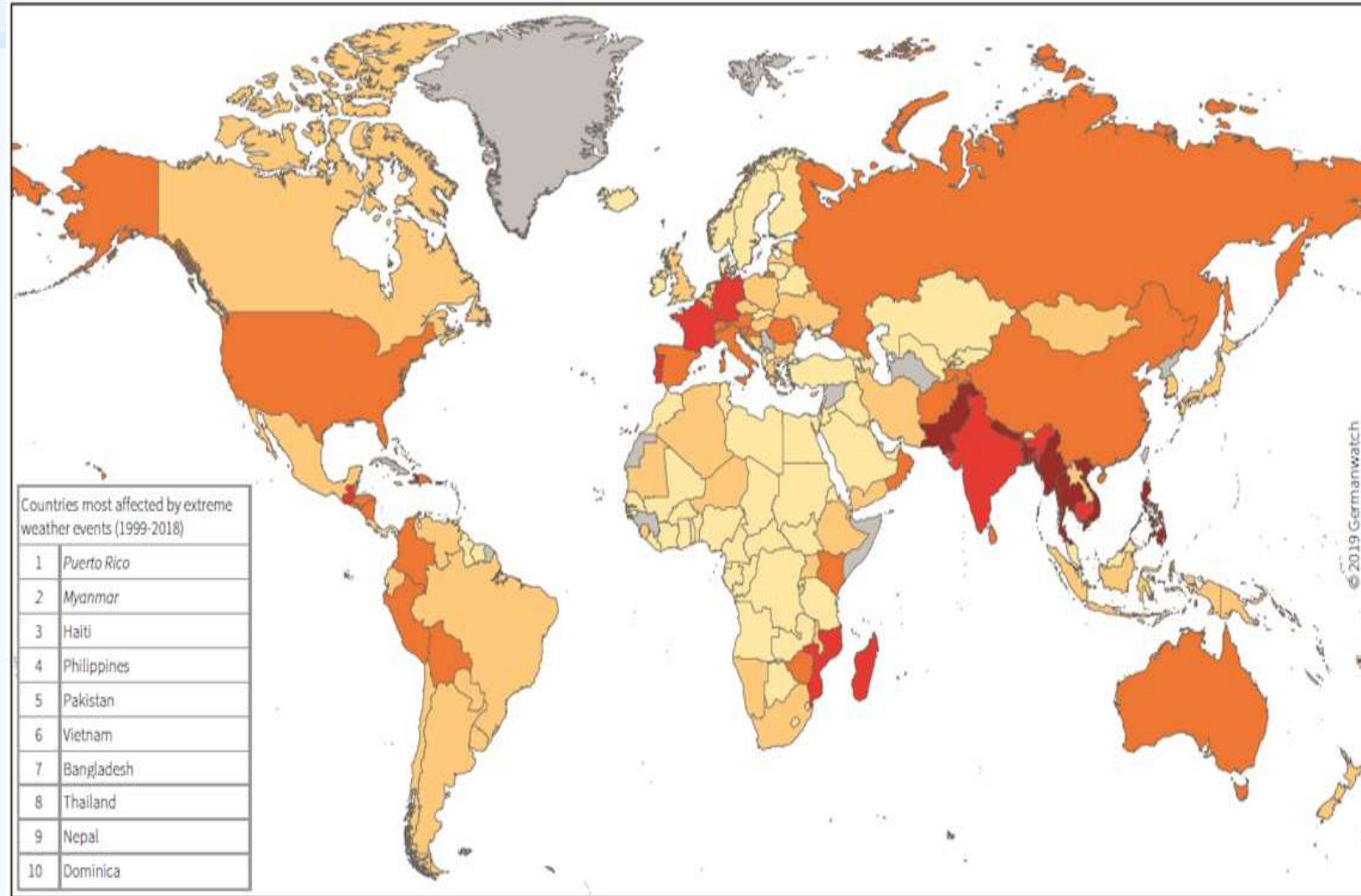


# Global Climate Risk Index 2020 [German Watch, 2019]

Less developed countries are generally more affected than industrialised countries

South and South East Asia with its large population and developing and low developed economies, subsistence farming, poverty becoming the hot-spot of climate change impact

High income countries feel climate impacts more clearly than ever before



*Italics: Countries where more than 90% of the losses or deaths occurred in one year or event*

Climate Risk Index: Ranking 1999 - 2018

1 - 10

11 - 20

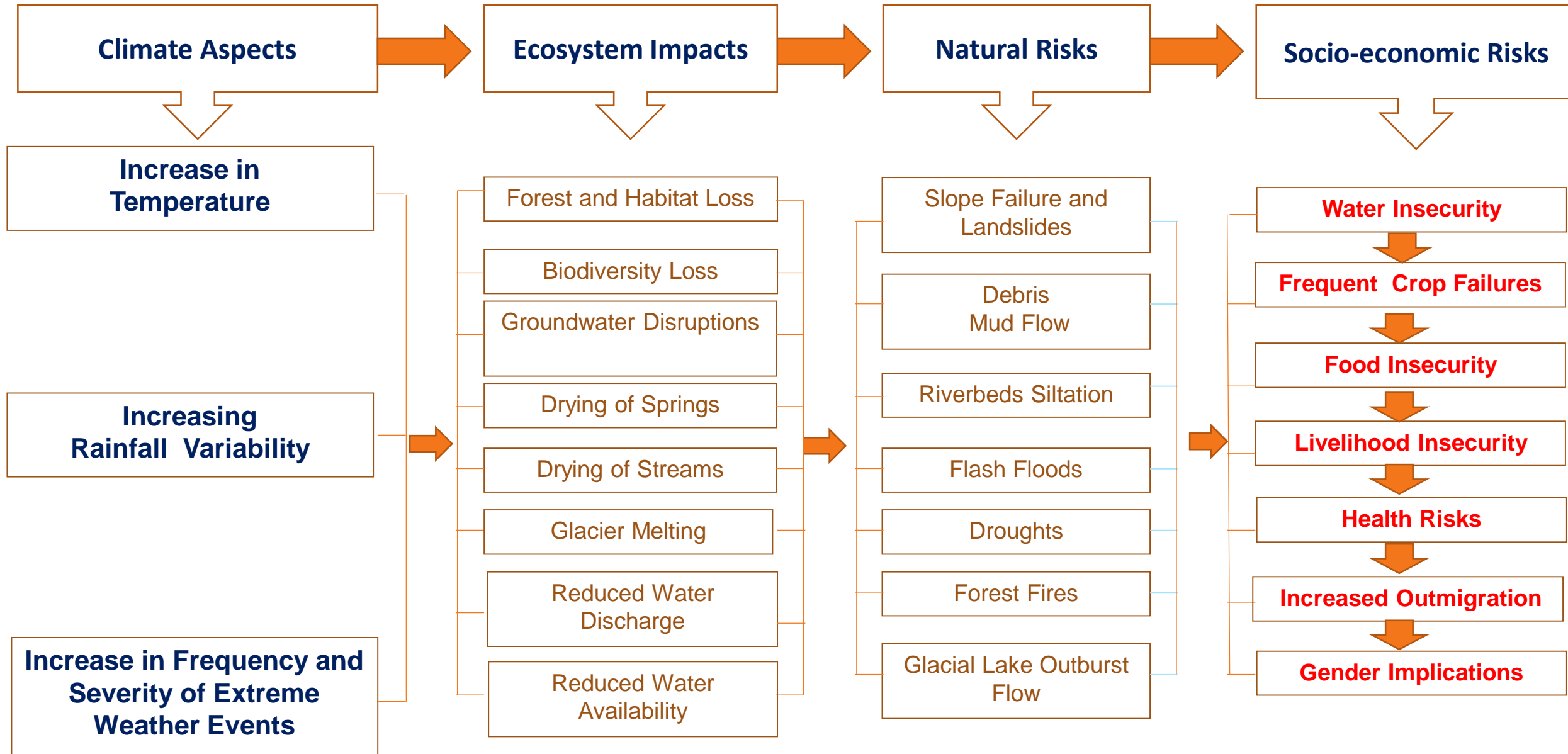
21 - 50

51 - 100

>100

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# The Impacts of climate Change in Himalaya





# Summary

- Climate change is a significant measurable change in the mean state of climate for a long period of time
- Climate change is caused by the increased concentration of Green House Gases in the earth's atmosphere due anthropogenic activities resulting into green house effect and global warming
- Climate change event are of two types: [i] Slow onset events, such as changes in the temperature and precipitation pattern, and [ii] extreme weather events, such as droughts and high intensity rainfall
- The increase in atmospheric temperature alters the general circulation of the atmosphere and oceans and in normal weather phenomenon affecting the natural processes and ecosystem components

# Climate Change Impact on Agriculture and Food Security

**[With Special Reference to Himalaya]**

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# Course Overview

**The Lesson analyses the impacts of changing climatic phenomenon on agricultural resources, farming system, food productivity and community food security, with special reference to the Himalayan mountains**



# **Climate Change Impact on Agriculture and Food Security**

## **Learning Objectives**

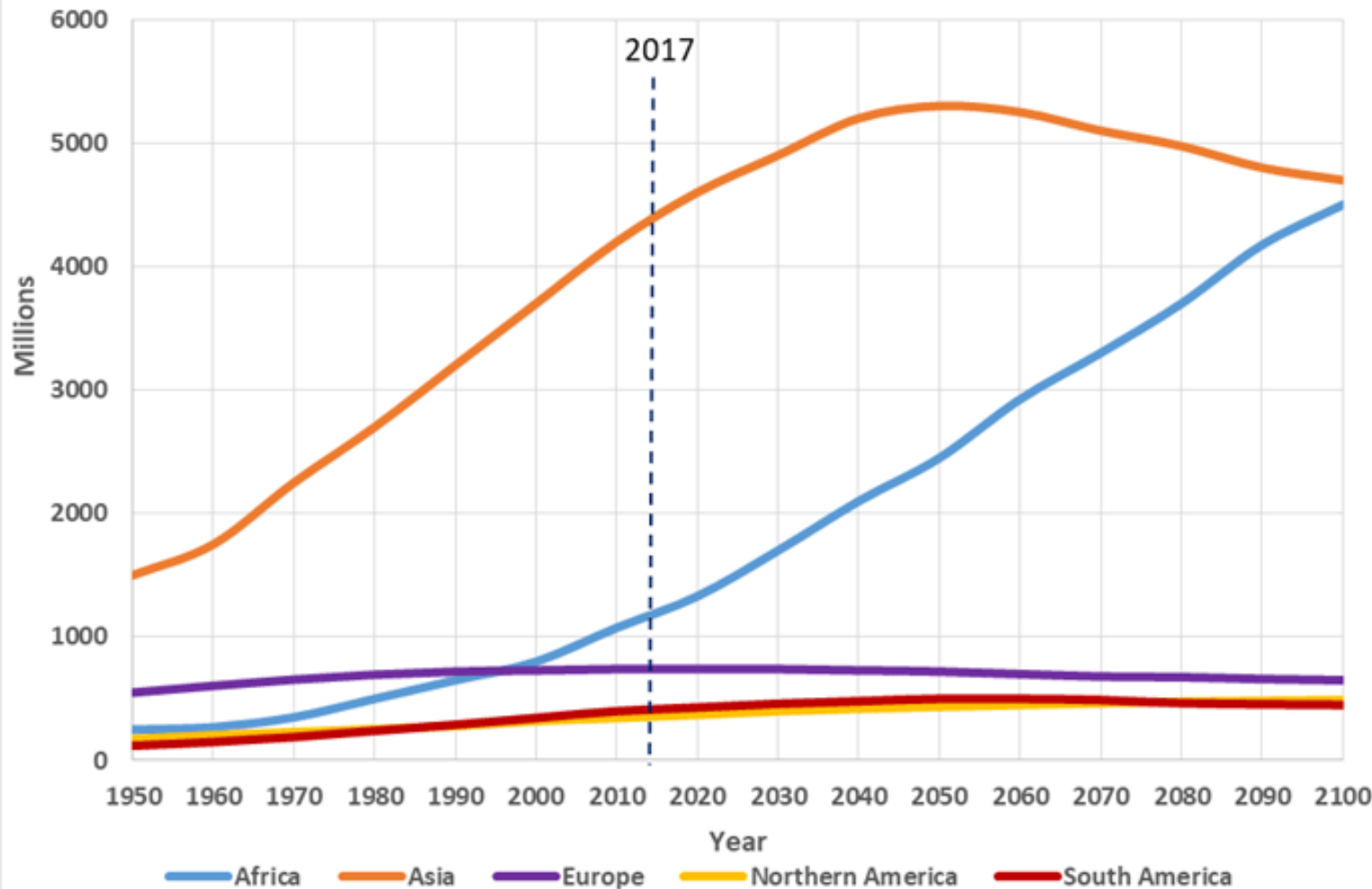
**At the end of the Lesson the students would be able to understand:**

- **The impacts of climate change on agriculture**
- **The impacts of climate change on food security**
- **The impacts of climate change on agriculture and food system in Himalaya**



# Introduction

Population Projections Major World Regions



The world population is expected to increase to 9.7 billions by the year 2050.

FOA has estimated that the global food demand is expected to grow by a minimum of 50% by 2050

The demand of food would increase more than 50% in developing and less developed countries due to their high population

It will be a great challenge to meet the steadily increasing food demand in densely populated regions where the agricultural resources have already depleted due to various socio-economic drivers

# Climate Change Impact on Agriculture

- The agricultural system is under increasing stress owing to climate change, particularly increase in temperature, altered precipitation pattern and increasing frequency and severity of extreme weather events all over the world
- In view of this, it would be a great challenge to meet the increasing demand of food in coming years as due to climate change the productivity in each sector of agriculture is declining



**Fisheries**



**Crop Production**

**Agricultural  
Sectors**



**Livestock**



**Forestry**



# Impact of Climate Change on Agriculture

## Rainfall and Water availability



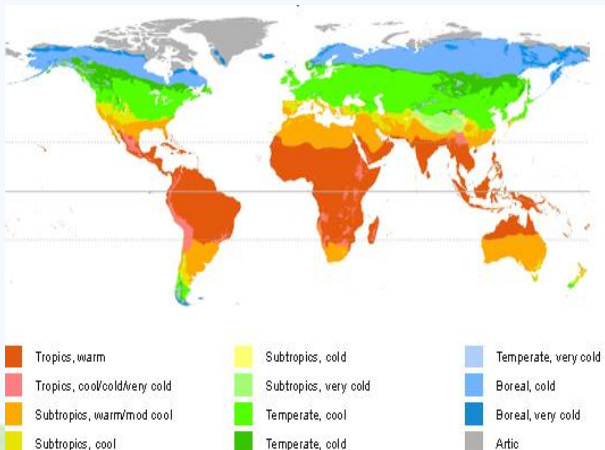
## Land Quality and Soil Moisture



## Agro-biodiversity



## Agro-climatic Diversity



## Crop Pests and Diseases



## Crop Growing Season





# Impact of Climate Change on Agriculture

Increasing temperature in high latitude and high altitude regions and soaring food demand is likely to push the agriculture upward and higher mountains across the world. However these effects will not help in balancing the adverse impacts of climate change. The agricultural resources and agriculture and food system will be under increasing stress of climate change and climate change induced risks

Yield of Major Crops will Decline by 2100, and risk of Forest Fire Increase in North America

High Temperature and Humidity Increase Risk of Livestock Mortality and Low Productivity in Europe

Loss of Forest and Biodiversity and Fish will Decrease Traditional Livelihood Opportunities in Sub-Saharan Africa

Higher Temperature, Floods and Droughts will Decrease Food Production in Asia

Changes in Freshwater Fish Habitat and Species and 40% Mangrove will Face Risk of Extinction in South America and Caribbean

Forest and Fish Productivity will decline due to decrease in Summer Rainfall in Africa

Livestock Production will Decline Substantially in New Australia and Zealand



# Impact of Climate Change on Food Security

- Food security is defined as a condition that exists when the entire population of a geographical region has physical, social and economic access to adequate, safe and nutritious food that meets its dietary needs, nutrition requirements, and food preference for an active and healthy life at all times
- Further, the global food productivity may decline substantially by 2080 due to climate change
- The developing and less developed countries are likely to face severe food crisis owing to their large population and subsistence agricultural economy owing to rapidly changing climatic conditions





# Impact of Climate Change on Food Security

## Dimensions of Food Security

The Physical Availability of Food which is Determined by the Level of Food Production, Food Stock and Net Trade of Food

- Production
- Import
- Export

Availability

Access

- Resources
- Governance
- Infrastructure

Economic and Physical Access to Food which is Influenced by Food Purchasing Power, Market Trends and Price of Food Items

Utilization of Available Food Items which Depends on Dietary Diversity, Food Habits

- Water
- Energy
- Sanitation
- Health
- Well-being

Utilization

Stability

- Resilience
- Storage
- Alternatives

This Reflect Temporal Dimension of Food Security Requiring Access to Adequate Food at All Times

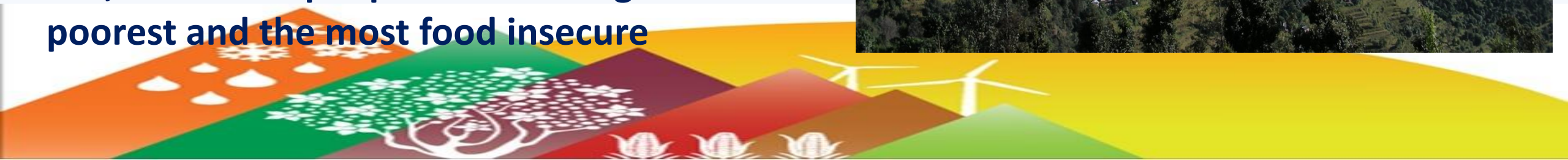
Food Security



# Impact of Climate Change on Food Security

## Food Security in High Mountains

- Mountains cover nearly 24% of global area and are home for 14% world's population
- Mountains have still the largest proportion of world's forests and host nearly 25% of terrestrial biodiversity
- Mountains are the water towers of the world and constitute source of freshwater for nearly 70% of the World's population
- Mountains are most vulnerable to climate change and natural disasters
- But, mountain peoples are among the world's poorest and the most food insecure





# Impact of Climate Change on Food Security

## Himalaya: A Food Deficit Region

- The most densely populated mountain inhabited by poorest people
- Headwaters of some of the largest trans-boundary river basins on the earth that sustain nearly 44% global population in South Asia
- Climate change is disrupting hydrological regimes of Himalayan watersheds and changing discharge, volume and availability of water and increase frequency and severity of extreme events
- This is increasing vulnerability of large population to water, food, health and livelihood insecurity





# Impact of Climate Change on Food Security

## Himalaya: A Climate Change Hot Spot

- In Himalaya, food security depends on local agricultural productivity, food purchasing power, and infrastructural facilities for transportation and distribution of food
- Due to constraints of terrain and climate, subsistence agriculture constitutes main source of food and livelihood
- Owing to constraints of subsistence economy a large proportion of adult male population out-migrates the region in search of viable means of livelihood and employment leading to feminization of mountain agriculture and food production system
- The remittances sent by the migrated population constitute the principal source of cash income and food purchasing power of majority of the rural population across the Himalayan mountains





# Impact of Climate Change on Food Security

## Himalaya: Climate Change Impacts on Food Security

- The incidences of high intensity rainfall are increasing damaging agricultural land, crops, irrigation system and agricultural infrastructure
- The number of rainy days are declining affecting the farming which is mainly rain-fed
- The amount of rainfall in winter and spring seasons has declined drastically affecting food productivity
- Droughts have become very common and causing frequent crop failure
- The pattern of rainfall has become highly erratic affecting both the crop season and cropping pattern





# Impact of Climate Change on Food Security

## Himalaya: Food Security

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# Impact of Climate Change on Food Security

## Summary

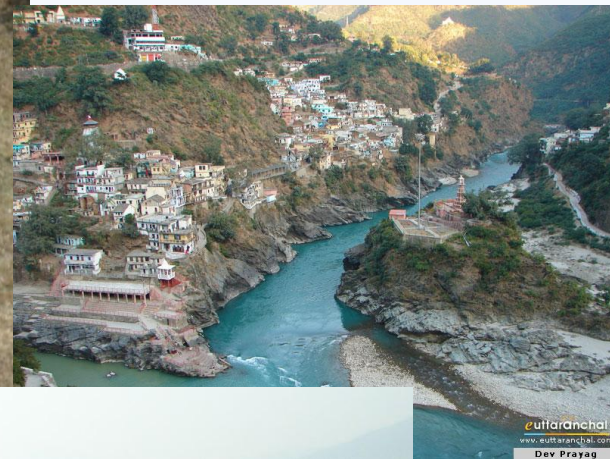
- Climate change has significant implications for agriculture and food security creating new risks and challenges and exacerbating the exiting stresses of resource depletion and socio-economic vulnerabilities
- Increasing temperature, rainfall variability and increasing frequency and intensity of extreme weather events is altering the natural resource base of agriculture and declining productivity of food
- Himalaya being ecologically fragile, densely populated and poverty is highly vulnerable to climate change
- The poor households communities dependent on climate sensitive livelihood, such as farmers with limited adaptive capacity are the most vulnerable to climate change induced food insecurity
- In Himalaya, women are the worst affected by climate change and climate change natural disasters owing prevailing gender gap













# Climate Change Adaptation in Agriculture

[With Special Reference to Himalaya]

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# Course Overview

- The Lesson focuses explaining the concept and meaning of climate change adaptation
- It also help in identifying effective strategies and framework for adaptation in agricultural sector, specifically in context of the Himalayan mountains





## **Lesson -3**

# **Climate Change Adaptation in Agriculture**

## **Learning Objectives**

**At the end of the Lesson the students would be able to develop a complete understanding of the following:**

- **The concept and meaning of climate change adaptation in agriculture**
- **Important measures of climate change adaptation in agriculture**
- **The impacts of climate change on agriculture and food system in Himalaya**

# Climate Change Adaptation in Agriculture

## Introduction

- Climate change has exerted severe impacts on agricultural productivity and food security in many parts of the world through increase in temperature, altered precipitation pattern
- The developing and less developed countries are becoming particularly vulnerable to food insecurity due to water scarcity, loss of biodiversity and extreme weather events
- The agricultural and food system in high mountains, such as Himalaya is particularly vulnerable to climate change primarily due to fragility of natural ecosystem, subsistence farming, high population density, poverty and marginalization
- The poor households communities dependent on climate sensitive livelihood, such as farmers with limited adaptive capacity are the most vulnerable to climate change induced food insecurity





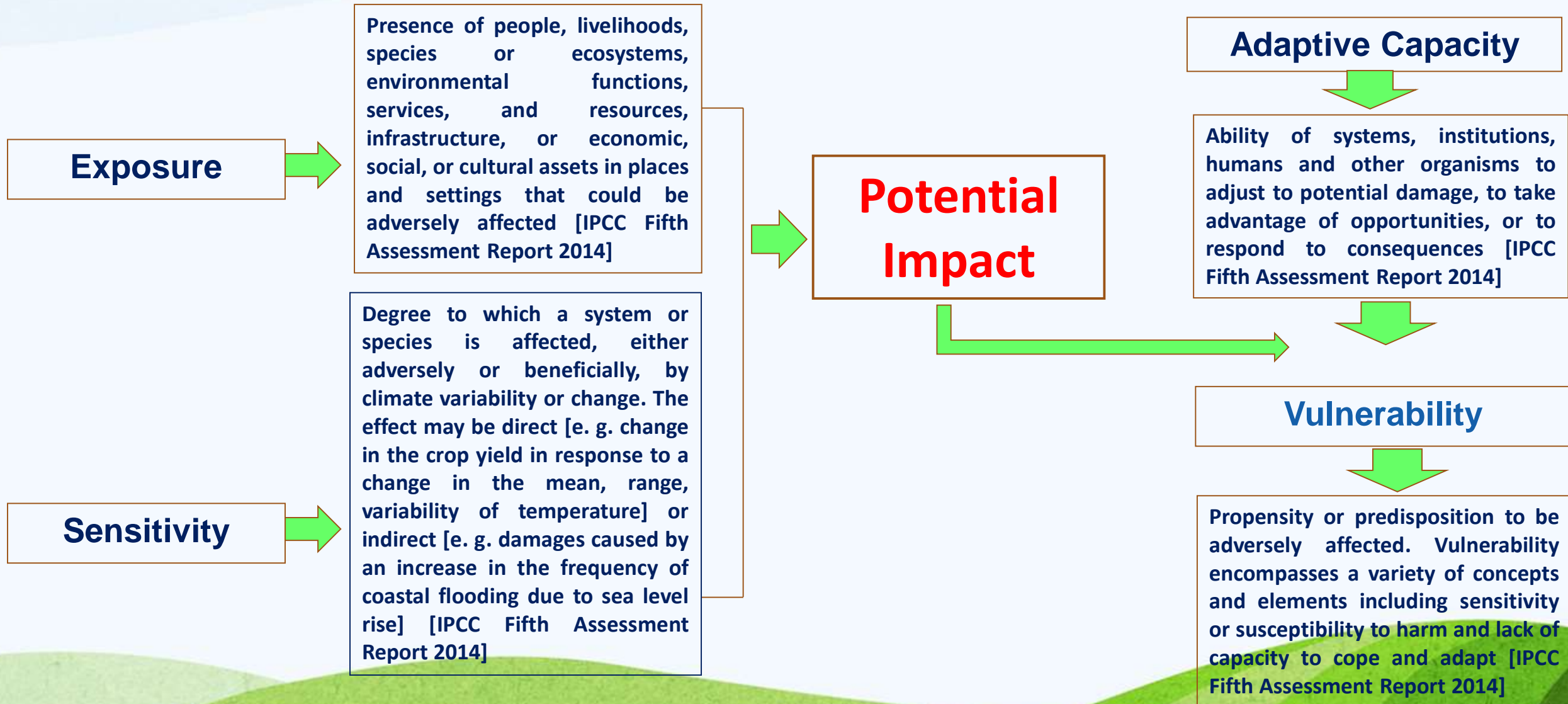
# Climate Change Adaptation in Agriculture

## Climate Change Adaptation in Agricultural Sector : Actions Required

- The process of adjustment to actual or expected climate and its effects. In human systems, adaptation seeks to moderate or avoid harm or exploit beneficial opportunities. In some natural systems, human intervention may facilitate adjustment to expected climate and its effects [IPCC Fifth Assessment Report 2014]
- Climate change adaptation is human-driven adjustments in ecological, social or economic systems or policy processes, in response to actual or expected climate stimuli and their effects or impacts. Various types of adaptation can be distinguished, including anticipatory and reactive adaptation, private and public adaptation, and autonomous and planned adaptation [IPCC Fourth Assessment Report 2007]
- In order to reduce the impact of climate change on agricultural productivity and food security, we need to adapt the agricultural system to changing climatic conditions

# Climate Change Adaptation in Agriculture

Adaptation activities aim to reduce the vulnerability of human and natural systems to climate change impacts, either by altering exposure and reducing sensitivity to climate change or by increasing the adaptive capacity





# Climate Change Adaptation in Agriculture

## Components of Climate Change Adaptation Strategies in Agriculture

Local Level Action by Farmers and Households, such as, Change in Agricultural Land Use Cropping Pattern, Crop Types and Crop Rotation

Integration of different Farming Components , such as Crop Production, Livestock, Forestry, Fisheries at Landscape Level

Creation of Enabling Environment, such as, Optimal Land Tenure System, Social Protection and Development of Safety Net



# Climate Change Adaptation in Agriculture

## Components of Climate Change Adaptation Measures in Agriculture

**Adaptive Changes  
in the Framing  
System at Local  
Level**



**Effective Measure  
to Reduce Climate  
Variability and  
Disaster Risk  
Reduction**



**Improved Access  
to Knowledge,  
Technology and  
Information**



**Improved Policy  
and Planning at  
Different Spatial  
Levels**





# Climate Change Adaptation in Agriculture

## Changing Farming Practices

Changing Farming Practices can help to reduce exposure and Sensitivity

Crop Diversification to Distribute the Risk of Climate Change and Climate Change Induced Natural Disasters

Increasing Cultivation of Traditional Resilient Varieties of Crop and Livestock, and Development of New Drought Resilient Varieties

Changing Crop Season and Crop Rotation to Minimize Exposure to High Temperature, Floods and Droughts

Improving Efficient Irrigation System, Water Conservation and Management, Drought Management





# Climate Change Adaptation in Agriculture

Improving Access to Knowledge, Technology and Information

**Improving Access to Knowledge, Technology and Information Improve the Adaptive Capacity of Farming Communities from Local to Higher Spatial Levels**

**Strengthening Meteorological Information Collection and Dissemination and Access at Local Level**

**Introducing and Improving Climate Change Knowledge at all levels of Education and encouraging Knowledge Creation in Institutions**

**Facilitating Knowledge Sharing and Access Mechanism through Organizing Awareness, Training and Field Demonstration Programmes**





# Climate Change Adaptation in Agriculture

## Managing and Reducing Climate Variability and Disaster Risks Reduction

Disaster Risk Reduction [DRR] and Disaster Management are Key Elements of Climate Change Adaptation in Agriculture

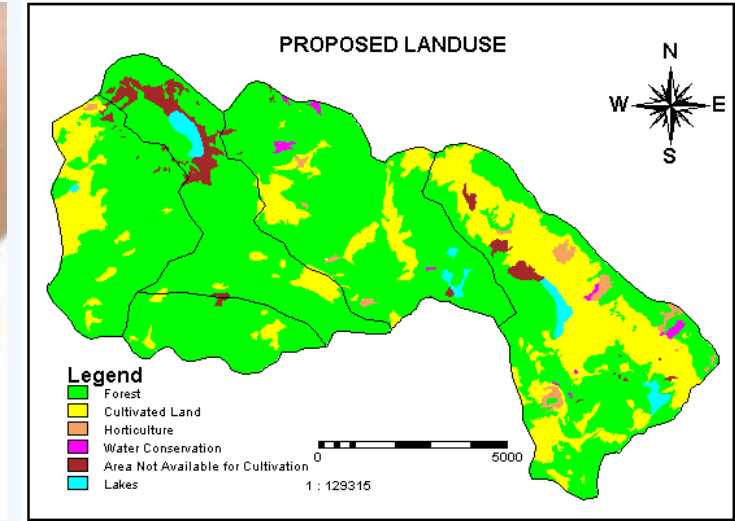
Development of Early Warning and Reliable Weather Forecasting System at Local Level

Introducing Weather Based Crop and Agricultural Land Insurance Policy for Communities

Evolving and Implementation of Optimal Land Use Plan Policies at all Levels

Development and Improvement of Water Management Infrastructure

Strengthening and Improvement of Storage Infrastructure and Transport Network to Safeguard Agricultural Products and Assets



# Climate Change Adaptation in Agriculture

## Improving Policy and Planning

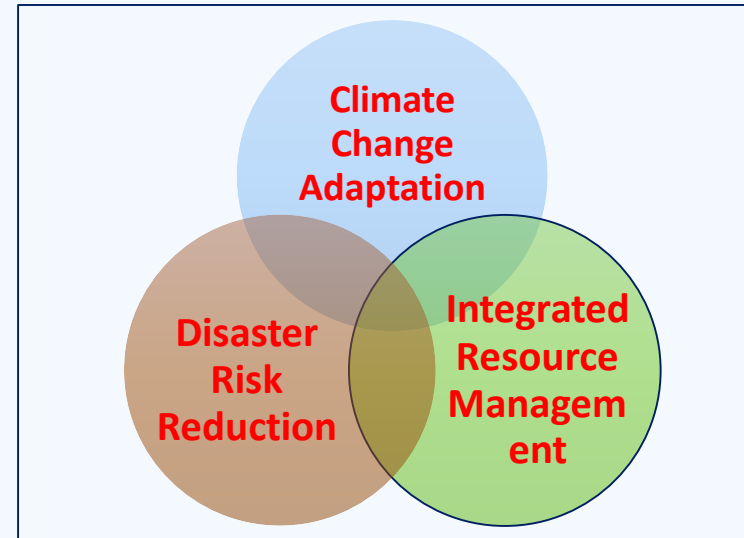
Appropriate and Effective Policy and Planning Framework is Pre-requisite for Climate Change Adaptation in Agriculture

Formulating and Implementing Effective Climate Change Adaptation Action Plans

Mainstreaming Climate Change Adaptation and Disaster Risk Reduction into Overall Development Planning at Watershed Level in Mountain Regions

Reviving, Strengthening and Formulation of Institutions for Climate Change Adaptation in Mountain Regions

Development Integrated Climate Change Disaster Resilient Farming System in Mountain Regions





# Climate Change Adaptation in Agriculture

## Integrated Farming System in Himalaya

Integrated Farming could transform the Himalayan subsistence agriculture into climate and natural disaster resilient farming and food system

- Integrated farming is an interconnected land, forest, water, biodiversity and livestock based production system
- It is an agricultural and food systems that integrate crop production, livestock, horticulture, fisheries and various other locally suited farm enterprises with conservation of natural resources along diversified agro-ecological mountain transect
- The system optimizes various farm components and integrate them into multi-enterprise farming systems in a set of agro-ecological regimes and adaptation to climate change
- It is an adaptive natural resource management framework and resilient agricultural system to climate change as well to climate change induced natural disasters in mountain regions, where a considerably large proportion of population still depend on climate sensitive subsistence farming system agriculture for its food and livelihood

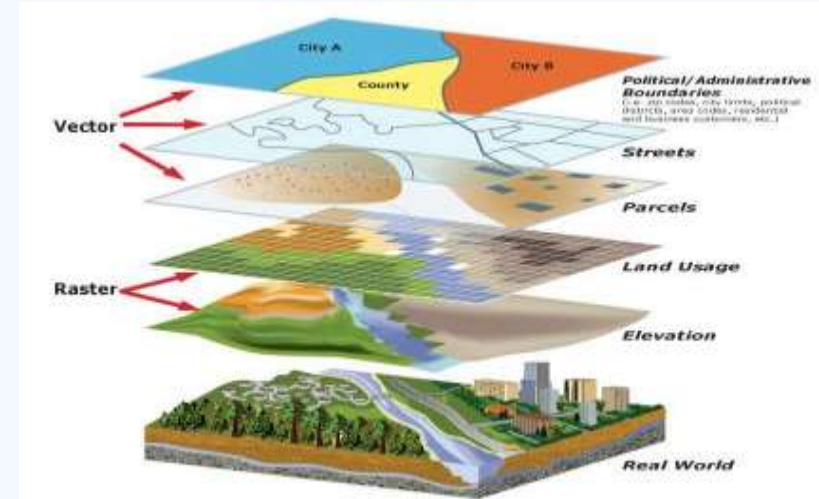


# Climate Change Adaptation in Agriculture

## Integrated Farming System in Himalaya

Scientific, Economic and institutional interventions are Pre-requisite for development of Integrated Farming System in Himalaya

- Development of comprehensive agricultural resources information system at watershed level
- Development of value chain system, and strengthening local institutions
- Improvement of marketing facilities based on locational planning of agricultural facilities and services
- Linking integrated farming system with other sectors of mountain economy, particularly tourism
- Incorporating new knowledge, experiences, and best practices, to face the current challenges of food insecurity, resources depletion in face of climate change and natural disasters





# Climate Change Adaptation in Agriculture

## Summary

- Increasing temperature, altered precipitation pattern, and increasing frequency, severity and intensity of extreme weather events are having serious impacts on agricultural resources and productivity
- Climate change adaptation in agricultural sector involves reducing the vulnerability to its impacts. This can be done by altering exposure to climate change, reducing sensitivity, and improving adaptive capacity of agricultural system to climate change