

IMPACTS OF PRESENT AND FUTURE CLIMATE VARIABILITY AND CHANGE ON AGRICULTURE AND FORESTRY IN THE ARID AND SEMI-ARID TROPICS

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PRESENTATION

- **Introduction**
- **Present variability and change in Asia, Africa and LA**
- **Future climate change scenarios in Asia, Africa & LA**
- **Impacts of climate variability and change**
- **Adaptation potential**
- **Conclusions**

INTRODUCTION

- **Arid Regions: R/PE between 0.05 - 0.20**
Semi-arid Regions: R/PE between 0.20 - 0.50
- **Arid and semi-arid regions**
 - **cover 30% of the total area in the world**
 - **inhabited by 1.10 billion people (20% of the world pop.)**
- **Arid and semi-arid regions are home to**
 - **24% of the population in Africa**
 - **23% in Asia**
 - **17% in the Americas and Caribbean**
 - **6% in Australia and Oceania**
 - **11% in Europe**

Why is climate variability so important to agriculture ?

Agriculture is the largest employer in the world and is probably the most weather-dependent of all human activities.

Climate variability has been, and continues to be, the principal source of fluctuations in global food production, particularly in the semi-arid tropics.

Throughout history, climatic extremes wreaked havoc on the agricultural systems.

In conjunction with other physical, social and political-economic factors, climate variability contribute to vulnerability to economic loss, hunger, famine and dislocation.

PRESENT CLIMATE VARIABILITY AND CHANGE - ASIA

Tropical Asia has a unique climatological distinction because of the pervasive influence of the monsoons.

- southwest monsoon (May-Sep)**
- northeast monsoon (Nov-Feb)**

The El Niño-Southern Oscillation (ENSO) phenomenon has an especially important influence on the weather and inter-annual variability of climate and sea level

Influence of Indian Ocean sea-surface temperature on the large-scale Asian summer monsoon and hydrological cycle and the relationship between Eurasian snow cover and the Asian summer-monsoon.

INCREASING SURFACE TEMPERATURE TRENDS - ASIA

India: Warming trend about 0.57°C per 100 years.

Vietnam: During 1895-1996 mean warming estimated at 0.32°C over the past 3 decades.

Sri Lanka: During 1869-1993, conspicuous increasing trend of about 0.30°C per 100 years.

Warming accompanied by increases in diurnality

RAINFALL TRENDS - ASIA

No definite trend in the long-term mean for precipitation for the region or in individual countries

Increase in extreme rainfall events over northwest India during the summer monsoon.

Decline in the number of rainy days during the monsoon along east coastal stations.

A long-term decreasing trend in rainfall in Thailand was reported.

CYCLONES, FLOODS, DROUGHTS AND WILD FIRES- ASIA

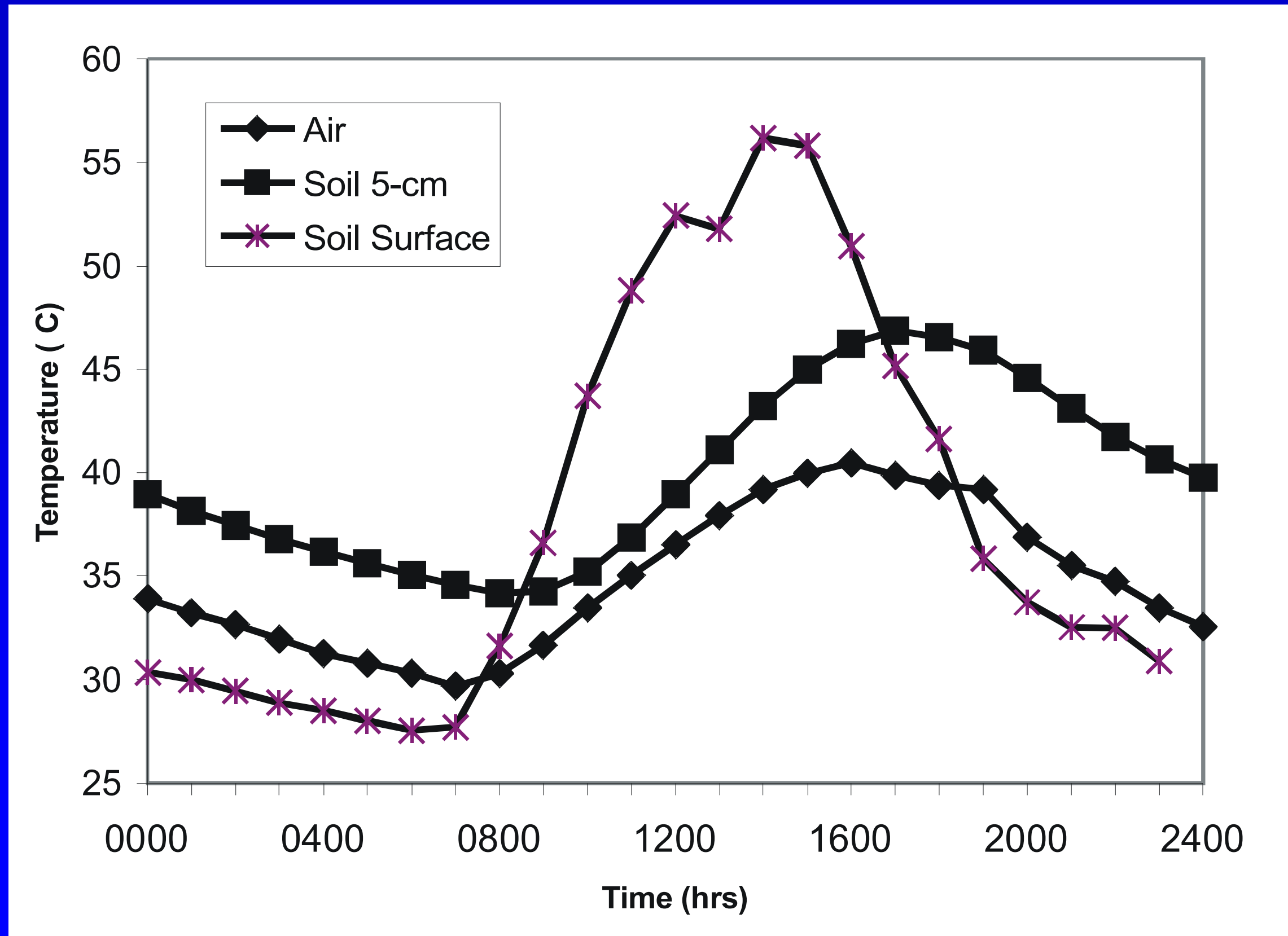
No identifiable variability in number, frequency, or intensity of tropical cyclones in northern Indian Ocean region over 100 yrs,

No conclusive increasing or decreasing trends in time series data of flooded areas in various river basins of India and Bangladesh.

India, Laos, Philippines, and Vietnam: drought more frequent following ENSO. 50% of Indian monsoon failures since 1871 during El Niño years.

Increase in frequency and severity of wild fires in grassland and rangelands in arid and semi-arid Asia in recent decades

Diurnal variation in the air temperature and soil temperatures at the surface and 5-cm depth before the onset of rains on 10 May 1992 at Sadore, Niger.



RAINFALL TRENDS - AFRICA

Rainfall is one of the most important natural resources for many of mainland Africa's 48 nations

African rainfall changed substantially over the last 60 years.

In the semiarid and subhumid zones of West Africa, 15% to 40% lower rainfall during last 30 years (1968-97) than during 1931-60.

A similar but smaller change in semiarid and subhumid regions of southern Africa.

In most of the Sahel, annual rainfall anomalies related primarily to rainfall in August and, to a lesser extent, September.

RAINFALL TRENDS - AFRICA (contd.)

Sahel: Between 1931-60 and 1961-90 rainfall dominated by reduction in June-August (0.4 mm day^{-1}).

Southern Hemisphere: December-February rainfall decline ($> 0.4 \text{ mm day}^{-1}$) over parts of Botswana and Zimbabwe.

Sahel: Striking persistence rainfall anomalies in contrast to East Africa and south-western Africa.

Southward shifts of JJA rainfall zones of 120 km between 1931-60 and 1961-90 and under 330 km between 1950-54 and 1983-87.

Significant increases in the intensity of extreme rainfall events over 70% of the country in South Africa (1931-60 and 1961-90).

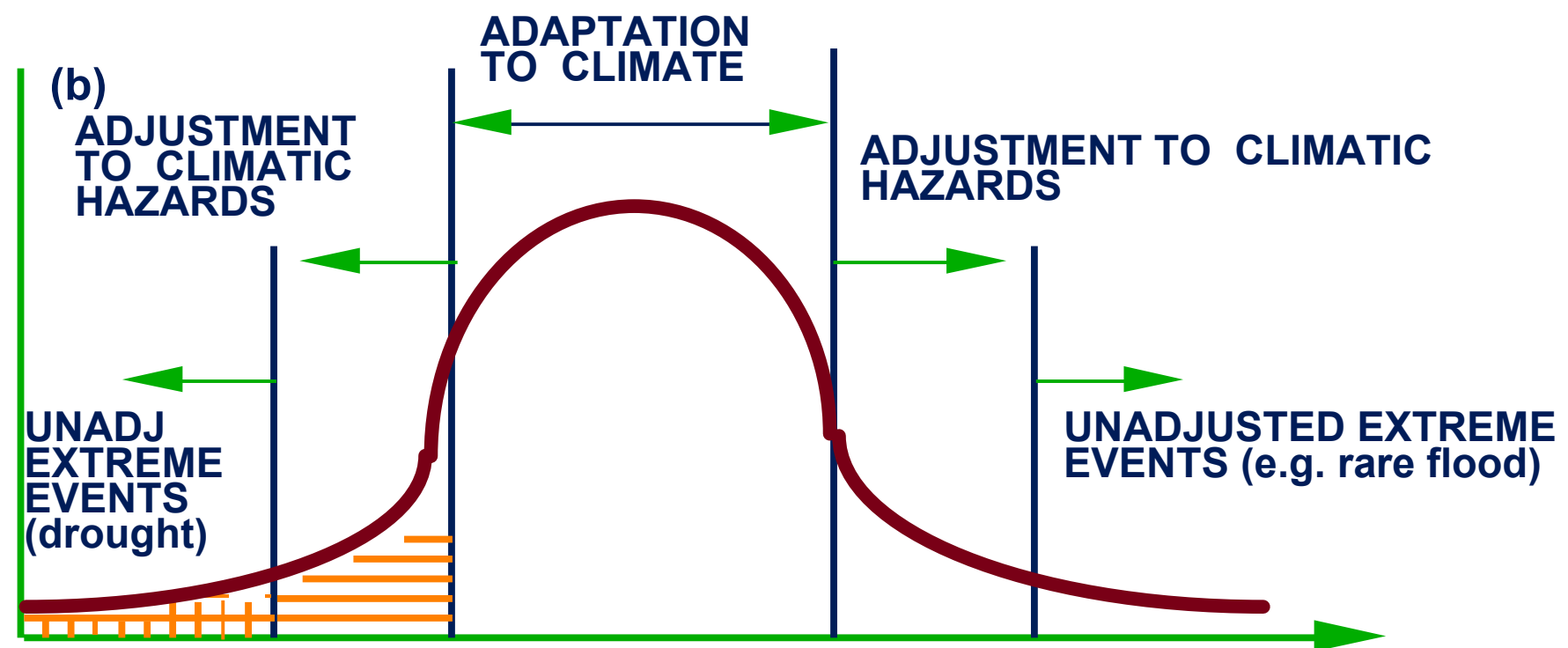
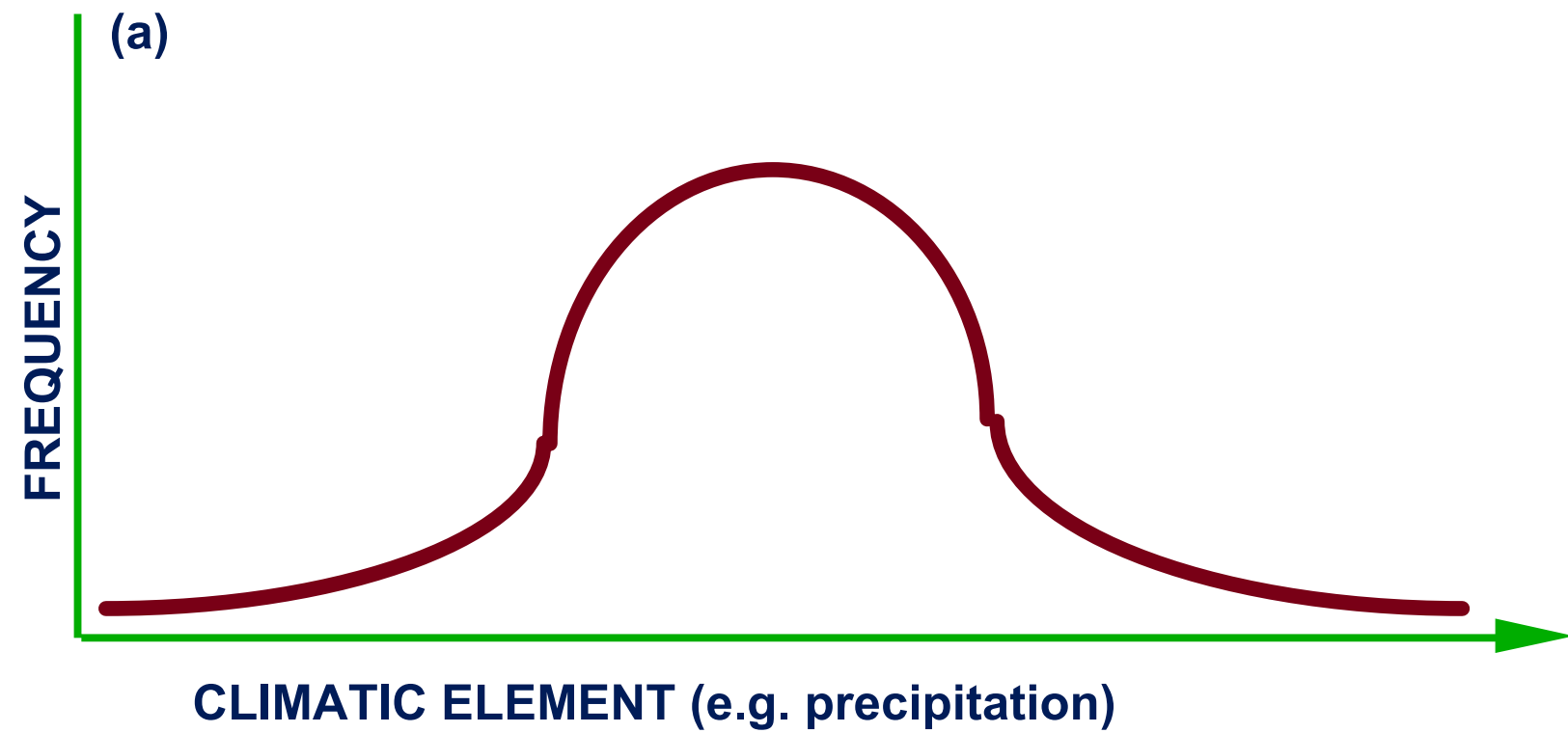
RAINFALL TRENDS, FORESTS - AFRICA

Three possible causes for rainfall changes in Africa:

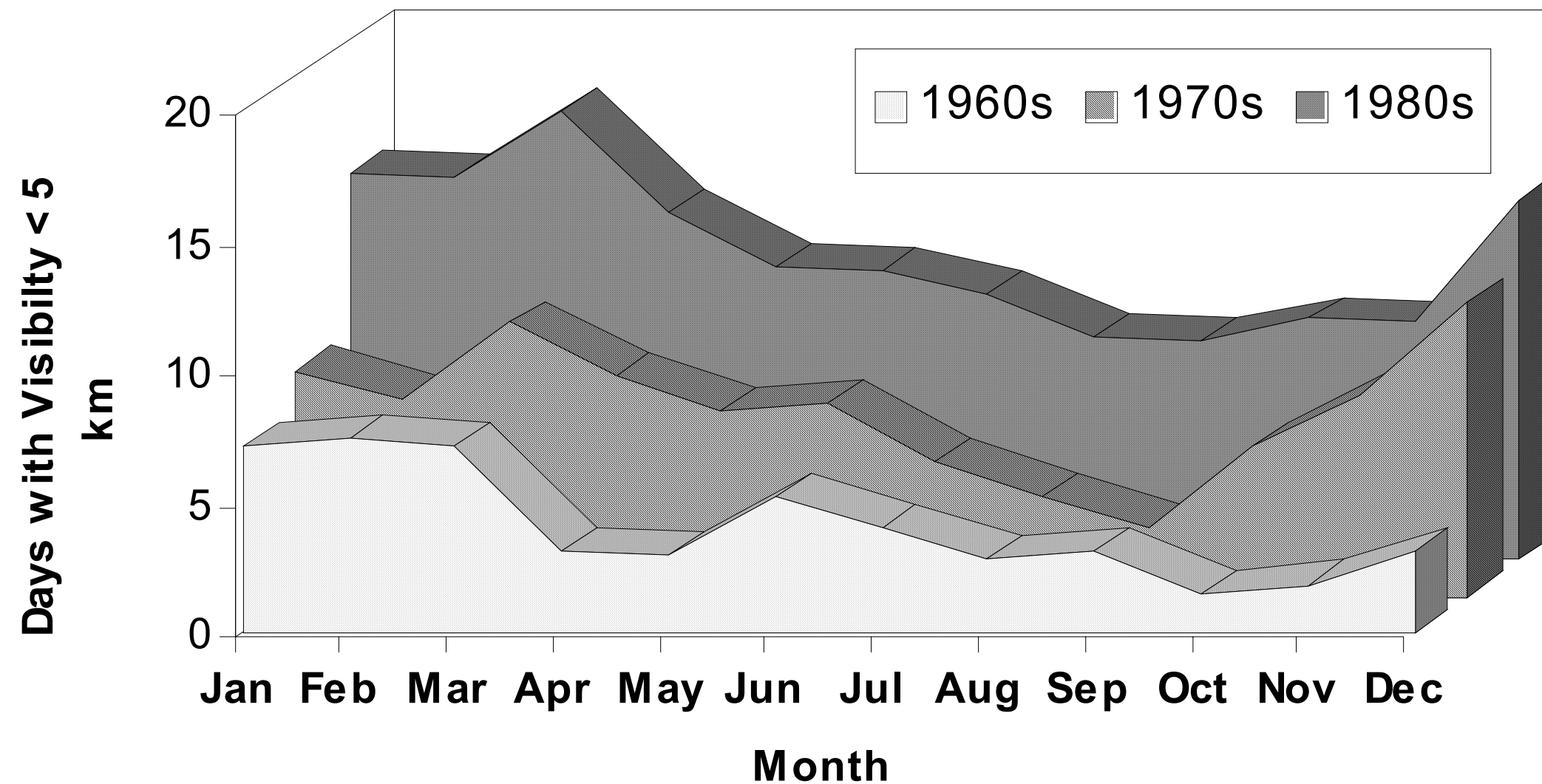
- land cover changes within the continent;**
- changes in global ocean circulation and patterns of SSTs**
- changing composition of the global atmosphere.**

**Africa contributes to 56% of total forest destruction worldwide
(annual net loss 5.3 m ha)**

**Because the open forests are mainly an unmanaged ecosystem,
their regeneration may pose problems.**



Changes in the visibility from the 1960s to 1980s at Niamey, Niger



RAINFALL TRENDS - LATIN AMERICA

Pampa Province (Argentina): 1921- 2000 trends show drought cycle with a peak in 1940 and lasting until 1960

Cuba: frequent climatic abnormalities in the last decades had a noticeable negative impact on all socio-economic activities.

Brazil: During the positive phase of ENSO, increase in the intensity of drought in the northeastern region while in the south an increase in precipitation is observed.

RAINFALL TRENDS - LATIN AMERICA

Argentina: close relationship between the increase or decrease of rainfall and the warm or cold phase of ENSO.

Brazil, Argentina and Uruguay: Evaluation of El-Niño and La-Niña (1938 to 1998) on barley showed that in most cases La-Niña had a positive impact and El-Niño a negative one.

FUTURE CLIMATE CHANGE - TEMPERATURE IN ASIA

Projected area-averaged annual mean warming over land regions of Asia is likely to be:

$1.6 \pm 0.2^{\circ}\text{C}$ in the 2020s

$3.1 \pm 0.3^{\circ}\text{C}$ in the 2050s

$4.6 \pm 0.4^{\circ}\text{C}$ in the 2080s

Indonesia, the Philippines and coastal south Asia and Indo-China: least warming in the islands and coastal areas

South Asia and Indo-China: greatest warming in inland continental areas except from June to August in south Asia

FUTURE CLIMATE CHANGE - RAINFALL IN ASIA

Projected area-averaged annual mean increase in precipitation

$3 \pm 1\%$ in the 2020s

$7 \pm 2\%$ in the 2050s

$11 \pm 3\%$ in the 2080s

South Asia: High uncertainty in future winter and summer precipitation

Small climate changes cause large water resource problems in many areas, especially in the semi-arid regions

Extremes associated with a given ENSO event likely to be more intense in the tropical Indian Ocean region and intensity of extreme rainfall events higher in a warmer atmosphere

FUTURE CLIMATE CHANGE - TEMPERATURE IN AFRICA

Future annual warming: 0.2 - 0.5 °C per decade.

Warming in land areas: 1.6°C over the Sahara and semi-arid parts of southern Africa. 1.4°C in equatorial countries

Rise in SSTs: less than the global average (about 0.6–0.8°C)

Coastal regions of the continent therefore will warm more slowly than the continental interior.

FUTURE CLIMATE CHANGE - RAINFALL IN AFRICA

Changes in mean seasonal rainfall less well defined. Different patterns with different models, or different simulations with the same model

North Africa and southern Africa: 10 to 20% decreases during March-November, 5 to 15% during November-May.

Sahel: 15% increases over the 1961–90 average.

Equatorial Africa: smaller increase (5%).

Rainfall results not consistent: problems with climate change signal under large natural variability and use of imperfect climate models.

FUTURE CLIMATE CHANGE - EXTREME EVENTS IN AFRICA

Little can be said yet about changes in extreme events.

Rainfall may become more intense, but speculation regarding tropical cyclones or changed frequency of El Niño events.

Greater drought risks due to higher evapotranspiration and decrease in precipitation

An increase in precipitation variability would compound temperature effects.

FUTURE CLIMATE CHANGE - SEA LEVEL AND ENSO IN AFRICA

Changes in sea level and climate expected by 2050. A sea-level rise of about 25 cm is projected.

The temperature-precipitation-CO₂ forcing of seasonal drought less significant than large-scale circulation changes driving continental droughts.

Changes in the frequency and duration of atmosphere-ocean anomalies (ENSO) could force large-scale changes in rainfall climatology.

However, such scenarios of climate change are not well developed at the global level, much less for Africa.

FUTURE CLIMATE CHANGE - LATIN AMERICA

Amazonia: greater than average warming in June-August, inconsistent projections for December-February.

Southern South America: less than global average warming in June-August, greater warming in December-February

Amazonia: increase or little change in precipitation, signals inconsistent for Southern South America.

Tendency for simulated rainfall to decrease in northern Amazonia and increase in southern parts of the region.

IMPACTS OF CLIMATE VARIABILITY AND CHANGE - ASIA

Mid- and high- latitudes: increases in crop yield

Lower latitudes: decreases in yields.

Water shortage + thermal stress: adverse affect on wheat and, more severely, on rice even under the positive effects of CO₂

India, Bangladesh and Philippines: wheat, maize and sorghum vulnerable to climate change.

Decline in tea yields: due to frequency of droughts and extreme rainfall events

IMPACTS OF CLIMATE VARIABILITY AND CHANGE - ASIA (2)

Thailand: profound effects of climate change on the future distribution, productivity, and health of forests.

A northward shift of tropical wet forests into areas currently occupied by tropical dry forests also is projected.

Semi-arid regions of Tropical Asia: forests sensitive to changes in temperature and rainfall

All productivity indicators of forests (NPP, NEP and NBP) and their ability to supply goods and services will be affected.

More frequent forest fire in arid and semi-arid regions of Asia.

IMPACTS OF CLIMATE VARIABILITY AND CHANGE - ASIA (3)

Mountain regions: impact on soil erosion and sedimentation

Coastal regions: combined effects of subsidence and sea level rise on drainage and sedimentation problems

Rangelands and drylands: environmental and social stress

Desert zones: negative impacts of temperature increases on natural vegetation

Plants with surface root systems, which utilize mostly precipitation moisture will be vulnerable.

Sheep breeding and lamb wool: negative impacts of climate change

IMPACTS OF CLIMATE VARIABILITY AND CHANGE - ASIA (4)

Higher temperatures in winter: higher pathogen survival rates, more host plants for pathogens (extension of cropping area)

Weakening of disease resistance due to heat-stress and more favourable growth conditions for pathogenic bacteria.

Warmer and wetter climate: widespread incidence of wheat scab, rice blast, and sheath and culm blight of rice growth, reproduction, and spread of disease bacteria

IMPACTS OF CLIMATE VARIABILITY AND CHANGE - AFRICA (1)

Arid and semi-arid regions: vulnerable especially in West Africa

Impacts of climate variability and change related to:

- projected temperature increases,**
- consequences to water balance of enhanced temperatures
+ changes in precipitation**
- sensitivity of different crops/cropping systems to projected changes.**

IMPACTS OF PROJECTED TEMPERATURE - AFRICA

Highlands: more suitable for annual cropping (increased temperatures, reduced frost hazards).

20% increase in agroecological suitability in the highlands of Kenya

Lowlands: growth of crops hindered by high temperatures and break down of plant metabolism above 40°C.

Reduced yields of wheat, rice, maize, and potatoes. Impeded vernalization in plants that require chilling (apples, peaches, and nectarines) due to warmer night temperatures

Enzyme degradation could limit photosynthesis and growth.

CONSEQUENCES TO WATER BALANCE - AFRICA

Serious implications for water resources and regional development.

Decreased soil fertility and agricultural, livestock, forest and rangeland production.

Increased open water and soil/plant evaporation due to a 5-10% increase in PET

Dominant impact of the lowest conversion factor of precipitation to runoff (averaging 15%) leads to a reduction in soil moisture in subhumid zones.

SENSITIVITY OF DIFFERENT CROPS/CROPPING SYSTEMS - AFRICA

Advantage of the CO₂ enhancement negated by low nutrient availability in many African landscapes

Decreased yields of maize in semi-arid west South Africa and increased potential yields in most of the country

Increased droughts could seriously impact the availability of food and water.

Climate change affects on agricultural pests, diseases, and weeds. Little quantitative research in Africa

IMPACTS OF CLIMATE VARIABILITY AND CHANGE - LATIN AMERICA (1)

Incisive socio-economic impacts on the populations

Agriculture and water resources most affected (excessive heat, frost, drought, flooding).

Dry periods and droughts have a long-lasting effect and bring the most damage to society

IMPACTS OF CLIMATE VARIABILITY AND CHANGE

- LATIN AMERICA (2)

Severe decline in the culture of pre-Colombian civilizations due to excessive drought or flooding

Such large variations associated with the El Niño and La Niña phenomena.

In many cases however there is a joint effect between these and the variations in the SSTs of the North Atlantic Ocean.

IMPACTS OF CLIMATE VARIABILITY AND CHANGE

- LATIN AMERICA (3)

Peru - typical example of El-Niño impacts and its distinct phases (cold and warm), with damaging effects on agriculture.

1997-98: droughts, frosts and flooding with losses in over 2 million hectares and > 50% reduction in crop yields

Impossible to establish a general rule (different ecosystems, wide variety of impacts)

Substantial contribution of human actions to the fragility of ecosystems (deforestation in Amazon, fires in central western Brazil, poor irrigation management in southeast Brazil etc.)

ADAPTATION POTENTIAL IN THE ARID AND SEMI-ARID TROPICS (1)

Whether or not there will be a significant climatic change, the inherent climatic variability makes adaptation unavoidable.

The importance of the rate of climate change must be assessed by comparing the rate at which the systems that might be affected change and adapt.

Adaptation depends on the cost of adaptive measures, existence of appropriate institutions, access to technology, and biophysical constraints eg., land and water resource availability, soil characteristics, genetic diversity, topography etc.,

ADAPTATION STRATEGIES FOR THE ARID AND SEMI-ARID TROPICS (1)

Improve monitoring:

To assess carefully the impact of future climate change on the managed and unmanaged ecosystems, it is crucial to monitor local climate, and natural changes in species adaptation, if any.

Use Strategies for Efficient Conservation of Water

Important step in coping with the climate change. Strategies include: soil and water conservation; better runoff management; improved rainwater harvesting; improved management of irrigation systems; and recycling wastewater.

ADAPTATION STRATEGIES FOR THE ARID AND SEMI-ARID TROPICS (2)

Implement Sustainable Agricultural Practices:

Development and adoption of technologies consistent with the principles of sustainable development:

**Minimum/no till systems,
Crop livestock integration (agro-silvi-pastoral systems)
Changing crop varieties in cropping patterns
Inter cropping/relay cropping
Mixed tree/grass/crop systems,
Rotations
Use of crop residues**

ADAPTATION STRATEGIES FOR THE ARID AND SEMI-ARID TROPICS (3)

Develop innovative technologies:

Develop cultivars resistant to climate change: susceptible core population versus surviving resistant types in peripheral populations to rehabilitate and restore affected ecosystems

Adoption of new farm techniques for management of crops under stressful conditions, plant pests and disease

Design and develop efficient farm implements

Improve post-harvest technologies: use and processing of farm products, by-products and agricultural waste.

ADAPTATION STRATEGIES FOR THE ARID AND SEMI-ARID TROPICS (5)

Seek active participation of local communities:

Quick adoption by local communities of innovative and productive technologies depends on their participation in the process of developmental activity

Community perceptions of soil and water management can be a powerful agent for sustainable management of natural resources.

Natural resource management must be sensitive to social and even cultural perceptions as well as traditional resource management practices.

ADAPTATION STRATEGIES FOR THE ARID AND SEMI-ARID TROPICS (6)

Enforce Effective Intervention Policies:

Intervention by governments to manipulate the circumstances of choices:

Amount of time needed to carry out the adaption is so long that we must act now.

Action is profitable even when climate does not change.

Penalty for waiting a decade or two is great.

CONCLUSIONS

The projected climate change and its impacts add additional risk and uncertainty to an ecosystem that is already impacted by land degradation and growing population pressures.

Farmers in these regions have over centuries adopted cropping strategies that minimize the risk and ensure some degree of productivity even in poor years.

Such strategies are based on their understanding of natural climatic variability

But the projected climate change is not factored into this understanding.

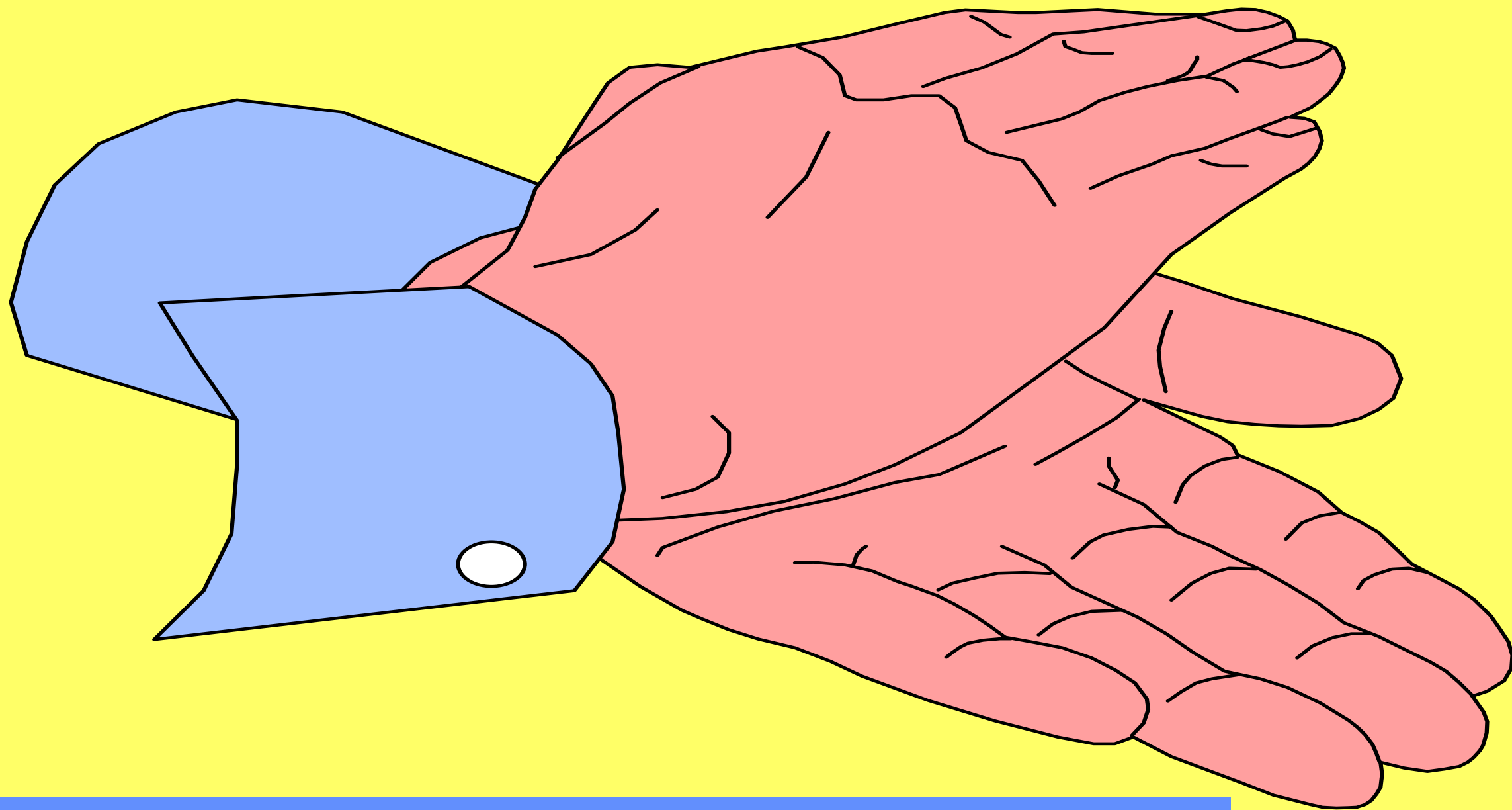
CONCLUSIONS (contd.)

Important to examine crop responses to a range of possible changes, especially in the nature, frequencies and sequences of extreme climatic changes.

Issues such as sustainability or land productivity, changes in erosion, degradation and environmental quality also need careful consideration.

Improved management strategies are necessary for coping with the projected global climatic change in the arid and semi-arid tropical regions of the world.

**Thank you very much for your
attention**



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