Climate Change and Adaptation

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Definitions

• It is important to clarify the use of the terms climate variability and climate change.

• Climatic variability refers to observed year-to-year differences in values of specific climatic variables within an averaging period (typically 30 years).

• Climatic change relates to longer-term changes between averaging periods, either in the mean values of climatic variables or in their variability.

Hare (1985)
Annual Rainfall Variability at Banfora, Burkina Faso

<table>
<thead>
<tr>
<th>Year</th>
<th>Annual Rainfall (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1950</td>
<td>800</td>
</tr>
<tr>
<td>1955</td>
<td>1000</td>
</tr>
<tr>
<td>1960</td>
<td>1200</td>
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<tr>
<td>1965</td>
<td>1400</td>
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<tr>
<td>1970</td>
<td>1600</td>
</tr>
<tr>
<td>1975</td>
<td>Mean</td>
</tr>
<tr>
<td>1980</td>
<td></td>
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</tbody>
</table>

The graph shows the annual rainfall variability at Banfora, Burkina Faso from 1950 to 1980, with a mean line indicating the average rainfall over the period.
Global Average Temperature, 1880-to-date

Global Temperature (meteorological stations)

Temperature Anomaly (°C)

-6  -4.5  -3  -1.5  0  1.5  3  4.5  6

1880 1900 1920 1940 1960 1980 2000

- Annual Mean
- 5-year Running Mean
One affects the range and frequency of shocks that the society absorbs or to which it adjusts and the other alters the resource base.

Parry and Carter (1985)
Human activities have changed the composition of the atmosphere since the pre-industrial era.

The current concentrations of key greenhouse gases, and their rates of change, are unprecedented.

Carbon dioxide  Methane  Nitrous Oxide
Carbon dioxide

- Global atmospheric concentration of carbon dioxide has increased from a pre-industrial value of about 280 ppm to 379 ppm in 2005. This exceeds by far the natural range over the last 650,000 years (180 to 300 ppm) as determined from ice cores.

- The annual carbon dioxide concentration growth-rate of 1.9 ppm per year during the 10 year period 1995 – 2005 was larger than it has been since the beginning of continuous direct atmospheric measurements (1960 – 2005 average: 1.4 ppm per year).

- Annual fossil carbon dioxide emissions increased from an average of 6.4 GtC per year in the 1990s, to 7.2 GtC per year in 2000–2005.
Methane and Nitrous Oxide

• The global atmospheric concentration of methane has increased from a pre-industrial value of about 715 ppb to 1732 ppb in the early 1990s, and is 1774 ppb in 2005.

• The atmospheric concentration of methane in 2005 exceeds by far the natural range of the last 650,000 years (320 to 790 ppb) as determined from ice cores.

• The global atmospheric nitrous oxide concentration increased from a pre-industrial value of about 270 ppb to 319 ppb in 2005.
(Top) Patterns of linear global temperature trends over the period 1979 to 2005 estimated at the surface (left) and for the troposphere (Bottom) Annual global mean temperatures (black dots) with linear fits to the data.
Time series of global ocean heat content ($10^{22}$ J) for the 0 to 700 m layer.
Global and Continental Temperature Change

Maps show temperature anomaly (°C) data for different continents over the years 1900 to 2000. The data indicates a gradual increase in temperature anomalies across all regions with notable trends in Europe, North America, South America, Asia, and Australia.

Graphs display temperature anomaly trends for global, global land, and global ocean, illustrating the consistent rise in temperature anomalies over the century.
Precipitation patterns have changed

- More intense and longer droughts have been observed over wider areas since the 1970s, particularly in the tropics and subtropics.

- Increased drying linked with higher temperatures and decreased precipitation have contributed to changes in drought.

- Changes in sea surface temperatures, wind patterns, and decreased snow pack and snow cover have also been linked to droughts.

- Frequency of heavy precipitation events increased over most land areas, consistent with warming and observed increases of atmospheric water vapour.
Sea Levels have risen

Annual averages of the global mean sea level based on reconstructed sea level fields since 1870 (red), tide gauge measurements since 1950 (blue) and satellite altimetry since 1992 (black). Units are in mm relative to the average for 1961 to 1990.
Warming is Unequivocal

Rising atmospheric temperature
Rising sea level
Reductions in NH snow cover
And oceans...
And upper atmosphere....
The Chacaltaya glacier and Ski-lift, Bolivia

Skiing was no longer possible after 2004
Weather-related economic damages have increased.

Great Natural Disasters 1950 – 2005

Economic and insured losses

- Economic losses (2005 values)
- Insured losses (2005 values)
- Trend of economic losses
- Trend of insured losses

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Climate Change – Future Projections
What’s in the pipeline and what could come

Warming will increase if GHG increase. If GHG were kept fixed at current levels, a committed 0.6°C of further warming would be expected by 2100. More warming would accompany more emission.

1.8°C = 3.2°F
2.8°C = 5.0°F
3.4°C = 6.1°F

Global surface warming (°C)

Year

1900 2000 2100 2200 2300

A2 A1B B1 Constant composition commitment 20th century

CO2 Eq

850 600 400

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Future projections

- The globally averaged surface temperature is projected to increase by 1.8 to 4.0°C (2090-2099 relative to 1980-1999).

- The projected rate of warming is much larger than the observed changes during the 20th century and is very likely to be without precedent during at least the last 10,000 years.

- Global mean sea level is projected to rise by 0.18 to 0.59 metres (2090-2099 relative to 1980-1999).
Future projections

• It is *very likely* that hot extremes, heat waves, and heavy precipitation events will continue to become more frequent.

• It is *likely* that future tropical cyclones (typhoons and hurricanes) will become more intense, with larger peak wind speeds and more heavy precipitation.
"Climate Change is a far greater threat to the world than international terrorism"

Sir David King, UK Chief Scientific Advisor

“I’m no longer skeptical...I no longer have doubts...I think climate change is the major challenge facing the earth”

Bill Clinton, Former US President
Impacts of Climate Change on Agriculture
Food production needs to double to meet the needs of an additional 3 billion people in the next 30 years.

Climate change is projected to decrease agricultural productivity in the tropics and sub-tropics for almost any amount of warming.
Wood fuel is the only source of fuel for one third of the world’s population.

Wood demand will double in the next 50 years.

Forest management will become more difficult due to an increase in pests and fires.
One third of the world’s population is now subject to water scarcity. Population facing water scarcity will more than double over the next 30 years. Climate change is projected to decrease water availability in many arid- and semi-arid regions.
Biodiversity underlies all ecological goods and services.

Climate change will exacerbate the loss of biodiversity.
Food and Fiber Production
Provision of Clean and Sufficient Water
Maintenance of Biodiversity
Maintenance of Human Health
Storage and cycling of Carbon, Nitrogen, Phosphorus

Climate change will affect the ability of ecological systems to provide a range of essential ecological goods and services
Within every society, there is a certain capacity to cope with drought.

Societal changes can increase or decrease this coping range.
How do we adapt to climate change in Agriculture?
What is Adaptation?

Adaptation

Adjustment in natural or human systems to a new or changing environment.

Adaptation to climate change

Adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities.
A fundamental change is required in the way weather and climate are viewed

• Traditionally, agricultural ministries and the research community viewed meteorological services as providers of data on weather and climate as and when they are needed.

• Many treat weather and climate as hazards that must be dealt with.

• Climate variability is referred to from the perspective of its negative impacts.

• Today agricultural research community’s challenge is to balance continuing need for increased productivity with the new and growing concerns about climate change, climate variability and associated environmental impacts.
A fundamental change is required in the way weather and climate are viewed

- There is a need for a greater understanding of weather and climate including the nature of inherent variability and methods of coping with the projected impacts of climate change.

- There is a lot to be gained from looking at climate not only as a hazard, but also as a “resource”.

- Resources must be known, assessed in quantitative terms and properly managed if they are to be used sustainably, and climate is no exception.

- Hence it is clear that a fundamental change is required in the way weather and climate are viewed.
Strategies for Adaptation in Agriculture

• Provision of the essential support services to make crucial tactical decisions during crop growing season

• Delivering relevant and appropriate early warnings of extreme events to reduce their impact on agriculture

• Developing adaptation strategies to cope with projected climate change impacts on agriculture and forestry
Adaptation Strategies to CC

• While AR4 focused on climate change, future impacts, and potential adaptation strategies, the main determinant of agricultural production is still the seasonal variation of temperature, precipitation, sunshine, etc.

• Droughts, floods, frost-freezes, and heatwaves stress both crops and livestock. It is the changing frequency of these events due to climate change that is the concern.
• 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.,
Vulnerability and Adaptation

- Some adaptation is occurring now, but it faces barriers, limits and costs

- Vulnerability can be exacerbated by other stresses (e.g. poverty, food insecurity, conflict, disease)

- Vulnerability depends not only on climate change but also on development paths; sustainable development can reduce vulnerability
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.
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 in Tropical Regions (3)

Develop innovative technologies:

Develop cultivars resistant to climate change:

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.
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 in the Temperate Regions (1)

- Earlier planting and sowing.
- Earlier planting of long season cultivars will increase yields (if adequate soil moisture and risk of heat stress is low).
- Earlier planting of short season cultivars will give best assurance of avoiding heat and water stress.
- Changes in land allocation may be used to stabilize production or for the conservation of soil moisture.
- Shorter rotations and regular thinning in areas to experience higher precipitation and reduce drought.
- Impacts of drought may be reduced by using larger spacing in plantation and later thinnings.
Adaptation Strategies in the Temperate Regions (2)

- Reduce erosion by planting shelterbelts of trees.

- Application of Integrated Pest Management techniques.

- Adoption of earlier seeding dates with conventional short-season crops results in water saving.

- Mitigation strategies for grasslands with focus on small to moderate improvement in soil carbon levels through the prevention of overgrazing.

- Summer fallow acreage will reduce N₂O emissions.

- Reduced tillage intensity; reduced summer fallow area; improved manure management, improved feeding rations, improved drainage/irrigation contribute GHGs reduction.

- Little progress in modeling agronomic adaptations.

- Agronomic adaptation found to be most effective in mid-latitude developed regions and least effective in low-latitude developing regions.
Adaptation Strategies - universal

Carbon Sequestration

- Adopting permanent cover.
- Conservation tillage.
- Reduction of summer fallow.
- Forage in Rotations.
- Nutrient management via fertilizers.
Conclusions

• 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