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NPTEL ONLINE CERTIFICATION COURSES

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Organic Farming for Sustainable Agricultural Production

Dr. Dillip Kumar Swain, Associate Professor
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Lecture 09 : Organic Farming and Climate Change

What is Climate change ?

Climate change may refer to a change in average weather conditions, or in the time variation of weather within the context of longer-term average conditions.

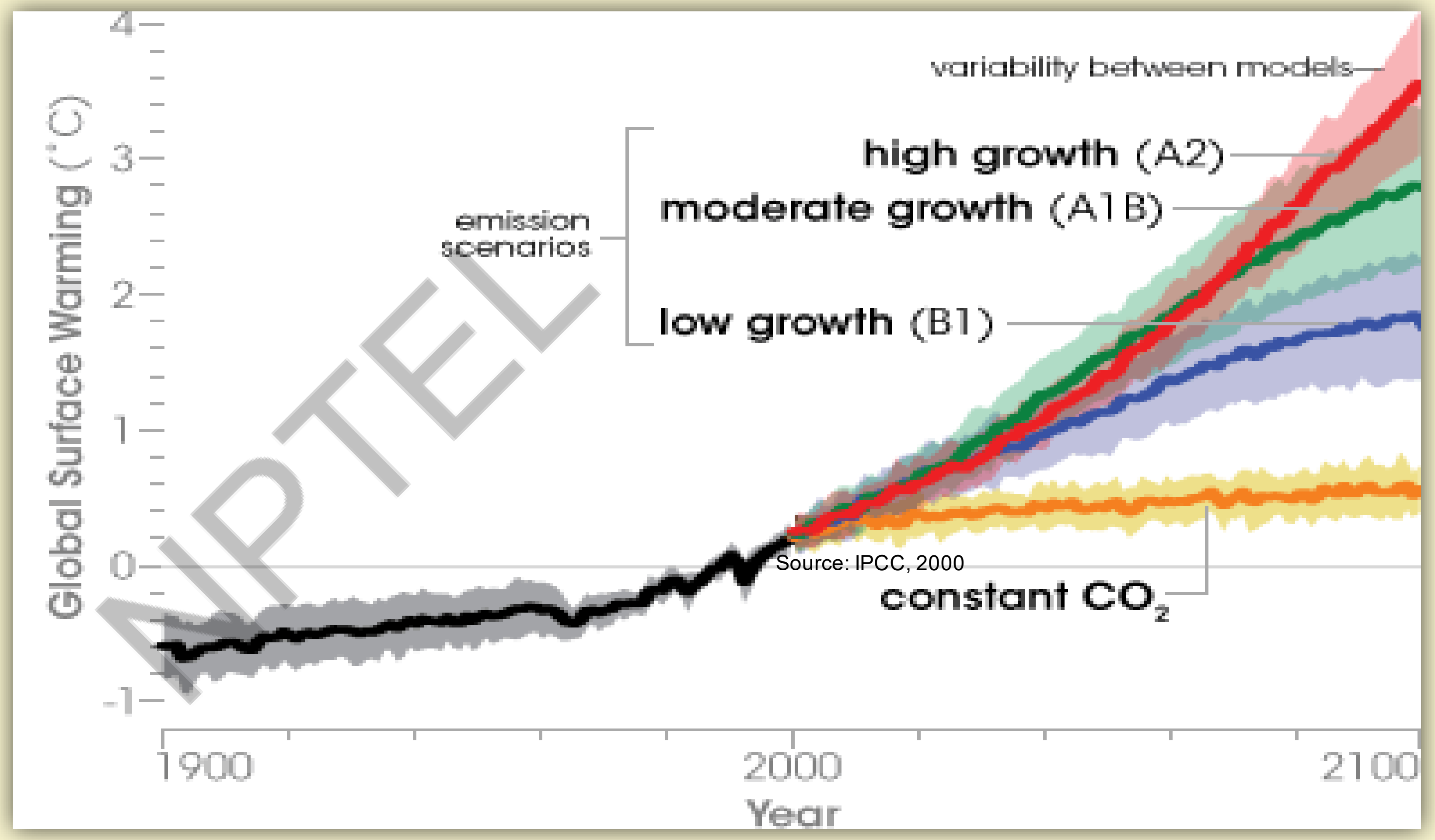
or

Climate change is a change in the usual weather found in a place. This could be a change in how much rain a place usually gets in a year. Or it could be a change in a place's usual temperature for a month or season.

NASA

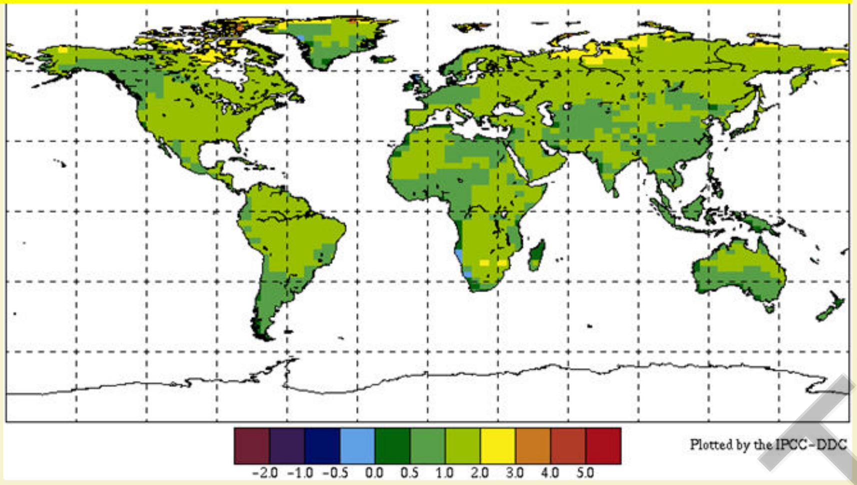
Future Climate Predictions

- Temperature is expected to increase by 1.1°C to 6.4°C by the year 2100, based on a range of emission scenarios.
- With sustainable development in effect from year 2000, CO_2 will increase by 45% to 110% by 2030 along with 0.2°C warming per decade.
- Increase in number of heavy precipitation events along with prevalence of droughts

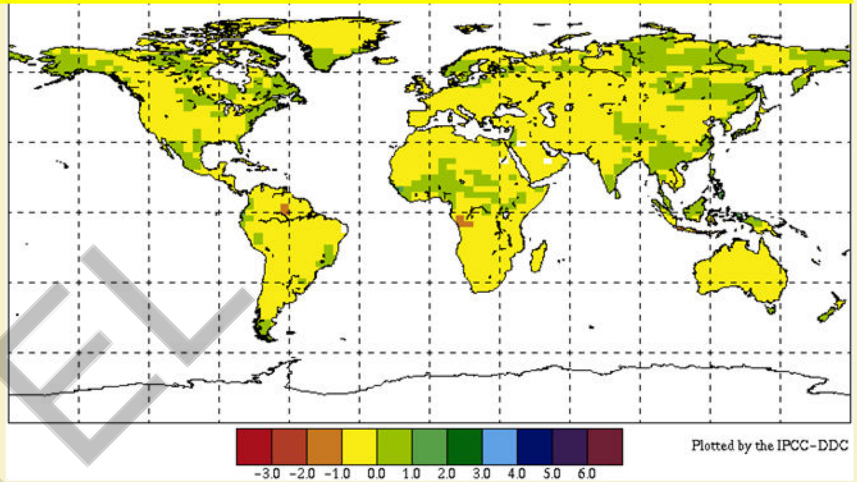


Future Climate Predictions

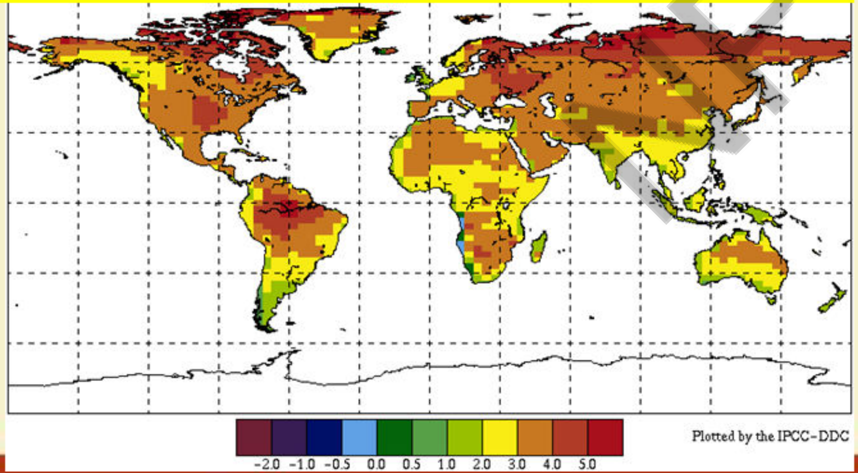
HadCM3/A1F Mean Temperature 2020 relative to 1961-90



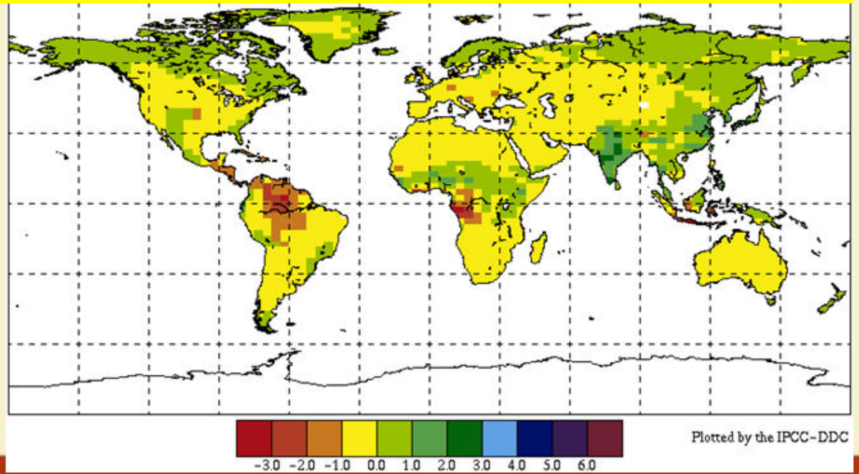
HadCM3/A1F Mean Precipitation 2020 relative to 1961-90



HadCM3/A1F Mean Temperature 2050 relative to 1961-90



HadCM3/A1F Mean Precipitation 2050 relative to 1961-90



Estimates of Future levels of CO_2

Year	CO_2, ppm
2000	369
2010-2015	388-398
2050-2060	463-623
2100	478-1099

GREENHOUSE GAS	CONCENTRATION (%)
Carbon dioxide	55
Methane	15
Chloroflorocarbons	24
Nitrous oxide	6

These GHG are necessary to maintain the temperature of the earth in other to be habitable by mankind, animals and plants.

IPCC, 2001

Internet sources

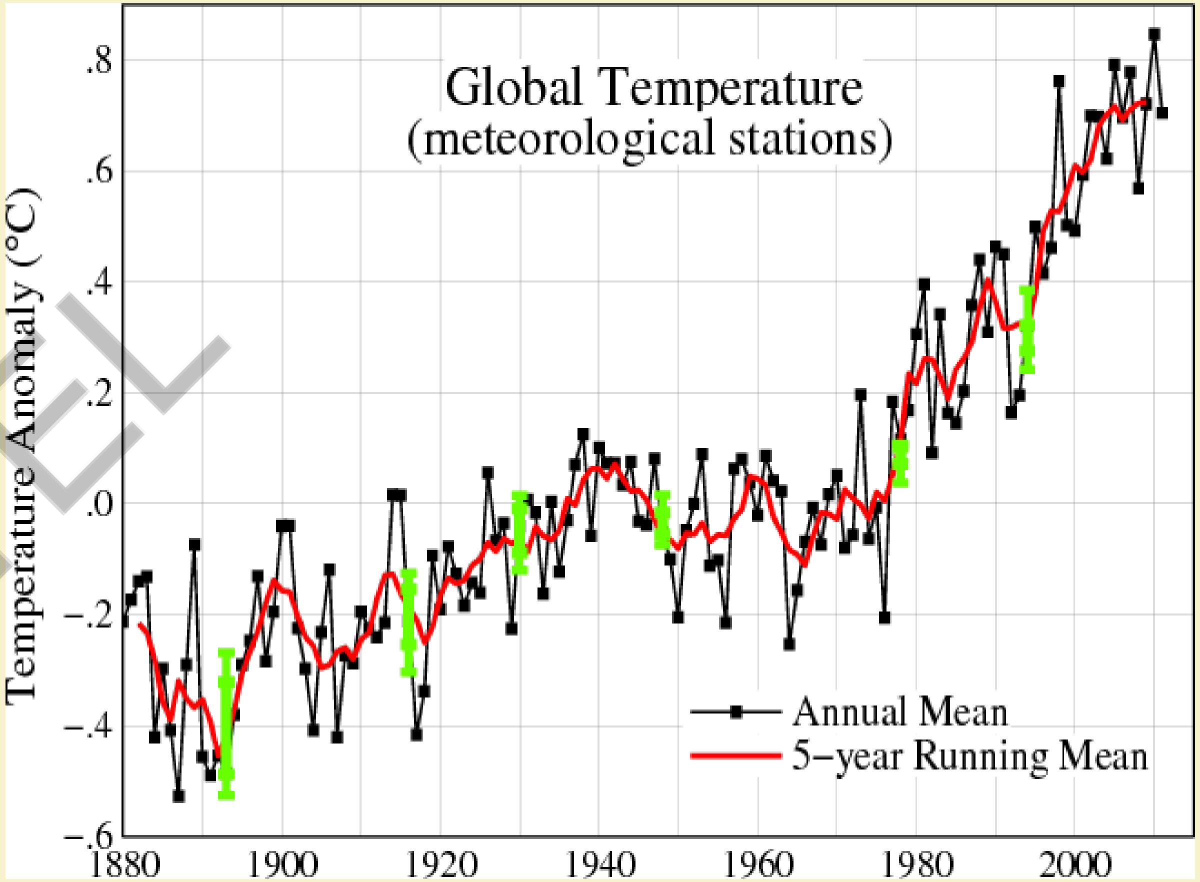
Impacts of Climate Change on Agriculture

Factors

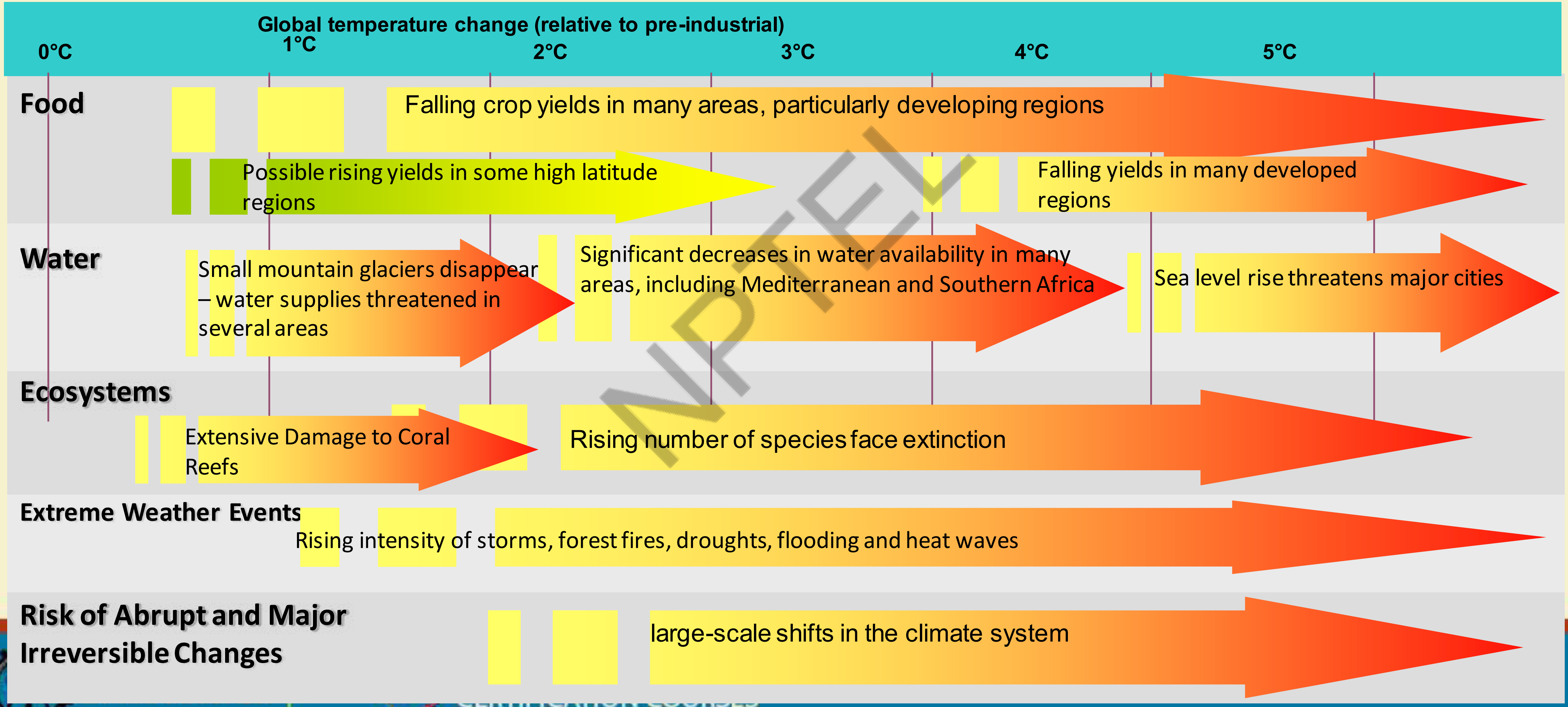
- Alterations in temperature and rainfall cycle
- Changes in soil quality
- Emergence of pests and diseases
- Increase in flood risks and hazards
- Increase heat and drought stress

FACE experiments (general rule):

- For every 75 ppm increase in CO_2 concentration, rice yield increases by 0.5 tons/ha
- For every 1°C increase in temperature, yield reduces by 0.6 tons/ha



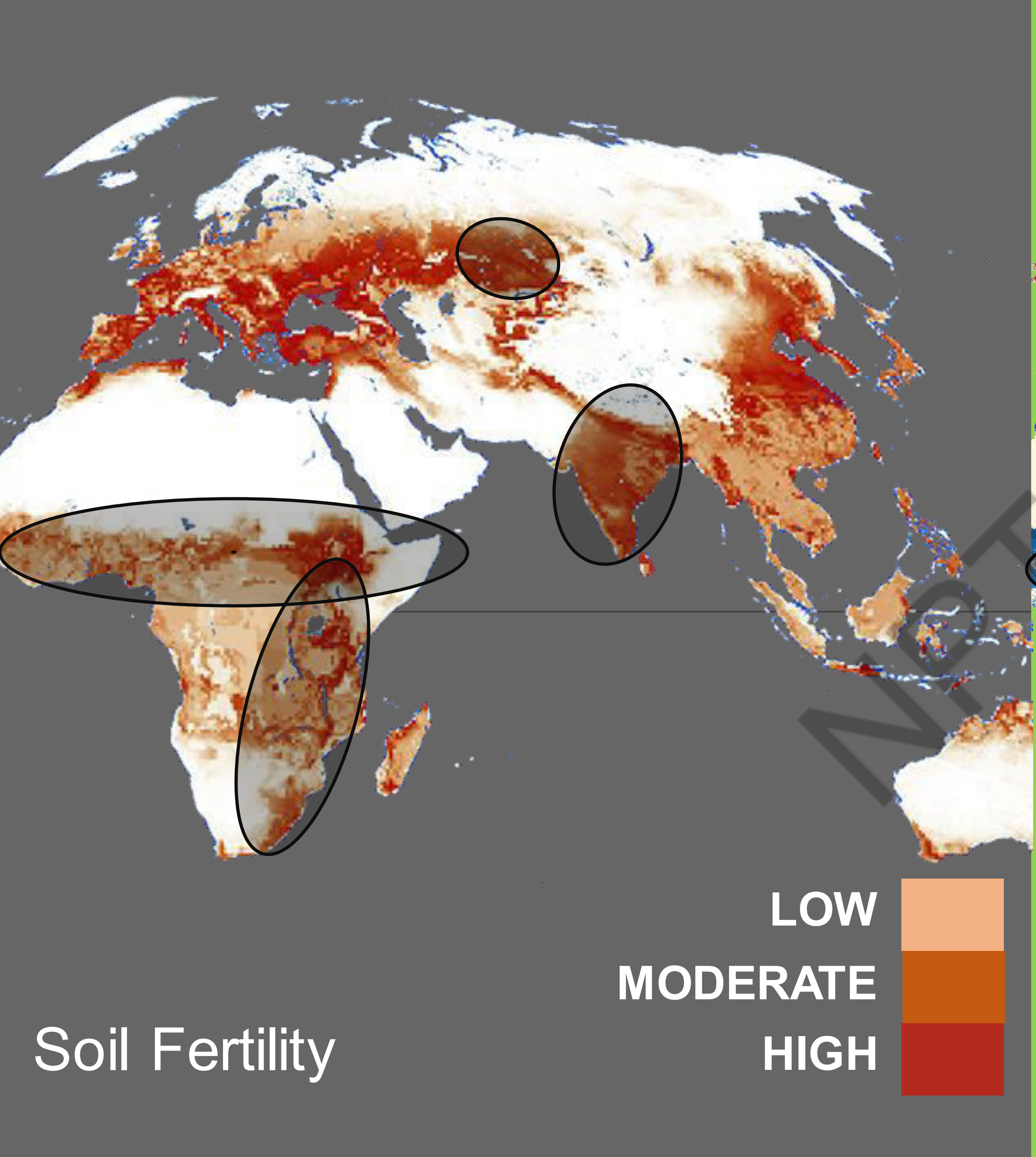
Projected impacts of global warming

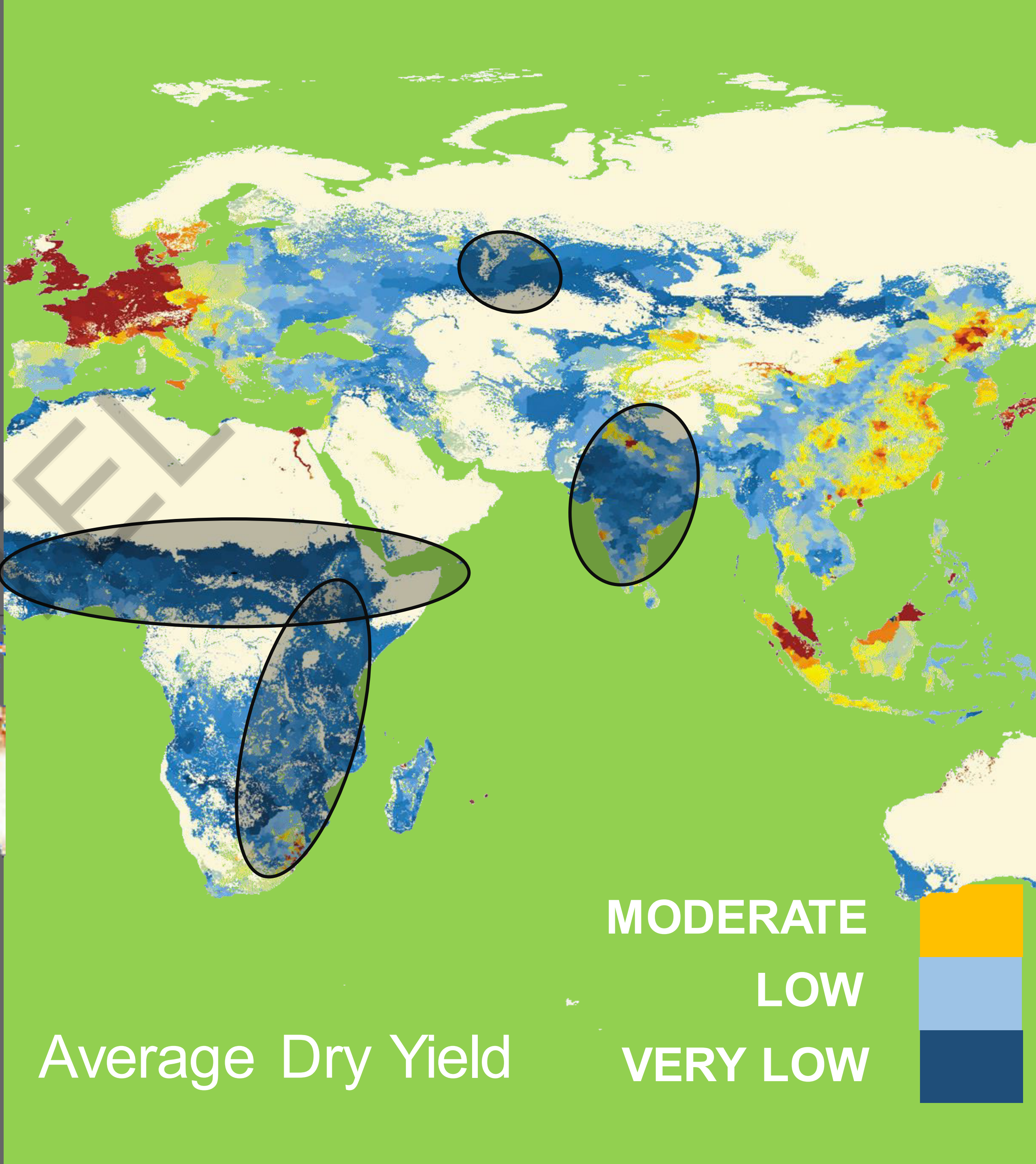


Effect of climate change on global food production (Percent change in yield) under various scenarios

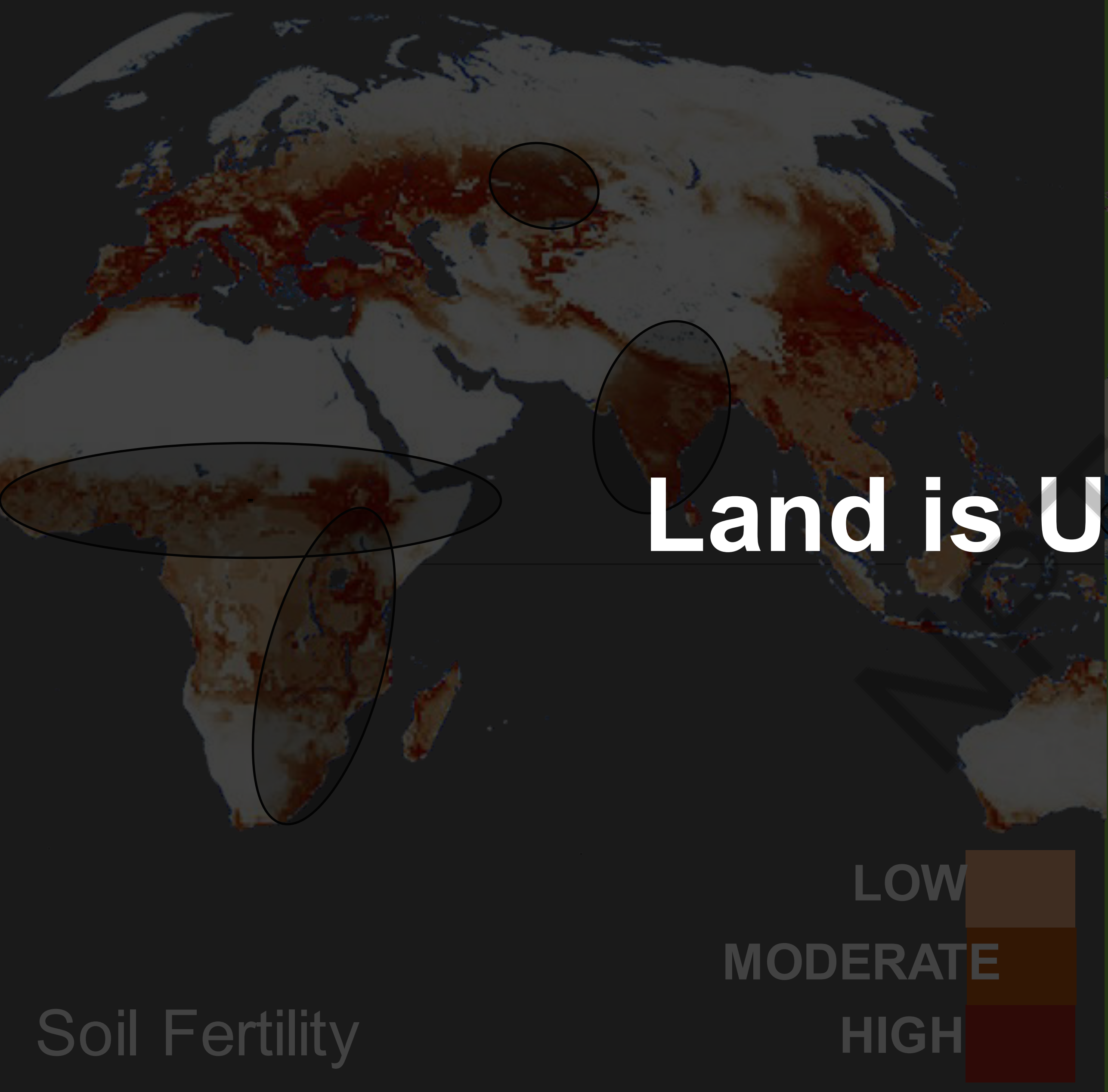
	HadCM3 2080s							HadCM2 2080s	
	A1F1	A2a	A2b	A2c	B1a	B2a	B2b	S550	S750
CO_2, ppm	810	709	709	709	527	561	561	498	577
World	-5	0	0	-1	-3	-1	-2	-1	1
Developed Countries	3	8	6	7	3	6	5	5	7
Developing Countries	-7	-2	-2	-3	-4	-3	-5	-2	-1
Difference in Developed and Developing Countries	10.4	9.8	8.4	10.2	7.0	8.7	9.3	6.6	7.7

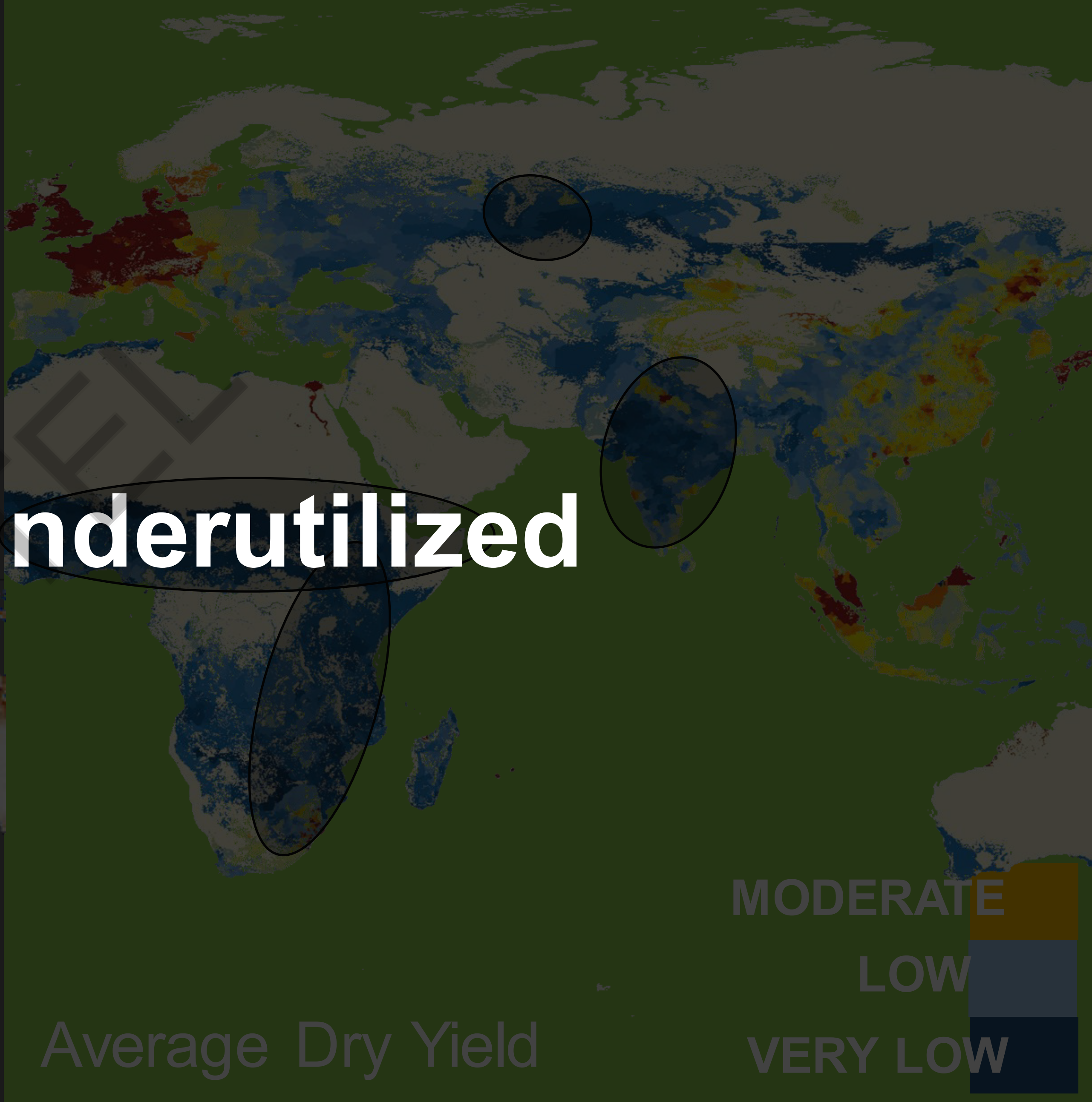
Source: Rosenzweig and Hillel (2005) Climate change, Agriculture and Sustainability. In Lal et al. (Ed): Climate Change and Global Food Security


LOW
MODERATE
HIGH
Soil Fertility


MODERATE
LOW
VERY LOW
Average Dry Yield

Land is Underutilized





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Climate change and Food Security

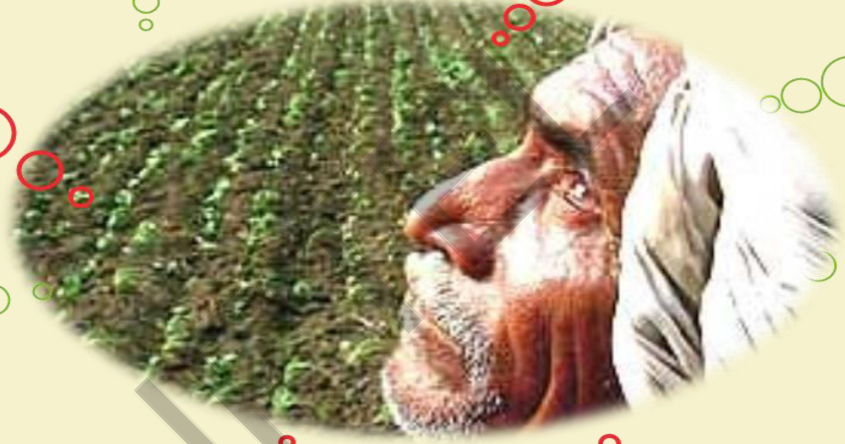
- Food security has four major components:
  - Food availability through production and trade;
  - stability of food supplies;
  - access to food; and
  - actual food utilization.
- Besides climate change, the factor that may cause food security problems are
  - Regional conflicts,
  - changes in international trade agreements and policies,
  - infectious diseases, and
  - other societal factors

Internet sources

Climate change and Food Security

- Projections of undernourishment depend on climate impacts and also on economic development, technical conditions, and population growth
- At the beginning of the millennium, between 800 and 900 million people were at risk of hunger. Most of them lived in Asia and sub-Sahuran Africa
- Economic growth and slowing population growth can significantly reduce the number of people at risk of hunger.
- In a pessimistic scenario with strong global warming, high population growth, and no CO_2-fertilization effects, the number of additional people at risk of hunger may be as high as 500-600 million by 2080

Challenges to the Farmer

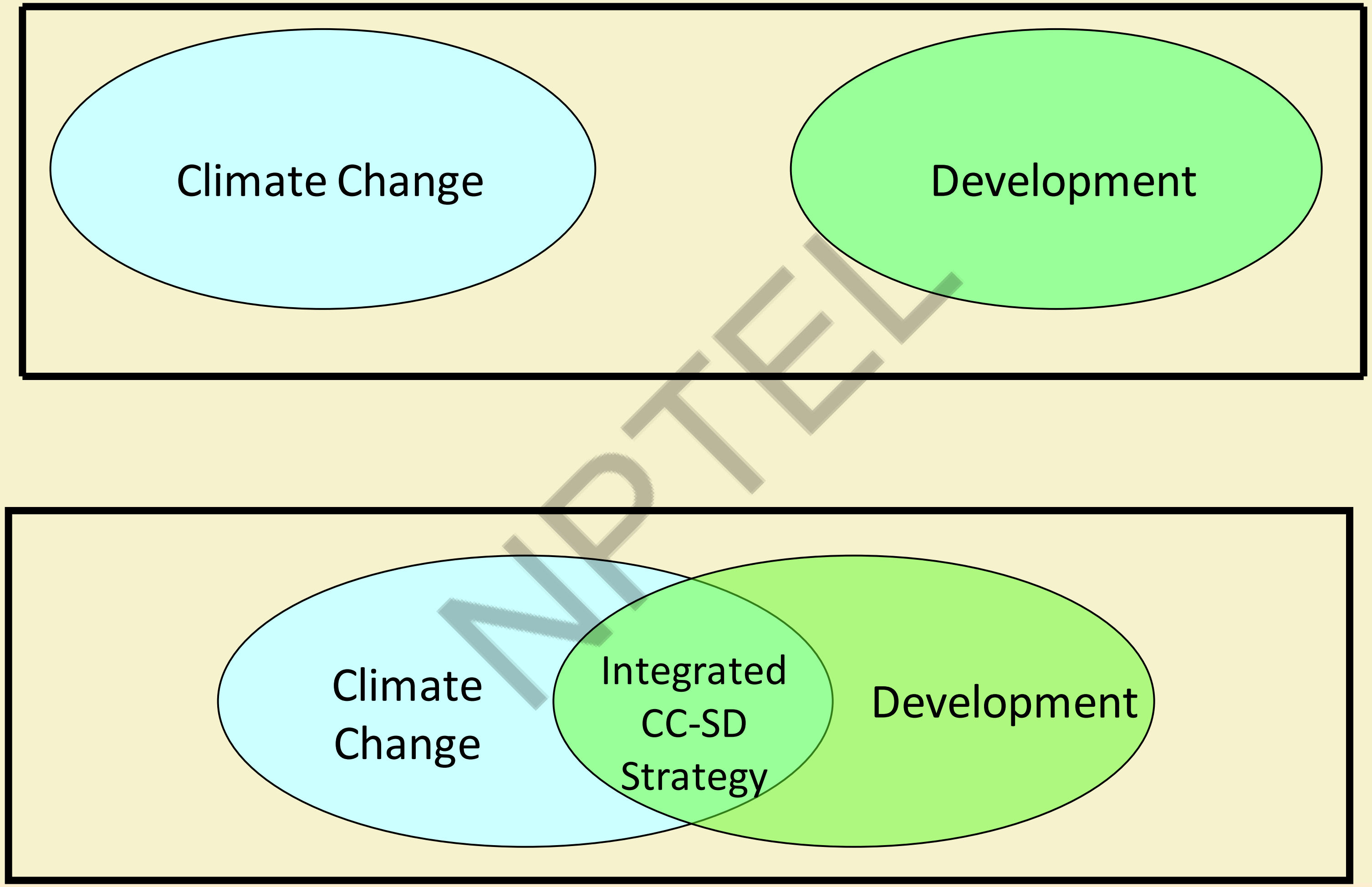


- Unpredictable rainfall, natur al calamities
- Input Availability
- Climate Change
- Shrinking Farm Land
- Soil erosion and degradation
- Pest & Disease Attack
- Droughts Floods, Frost
- Debts, Loans Mortgages

An integrated climate change-sustainable development strategy is essential

Former Viewpoint

Emerging Viewpoint



Source: Adapted from Munasinghe, 2005

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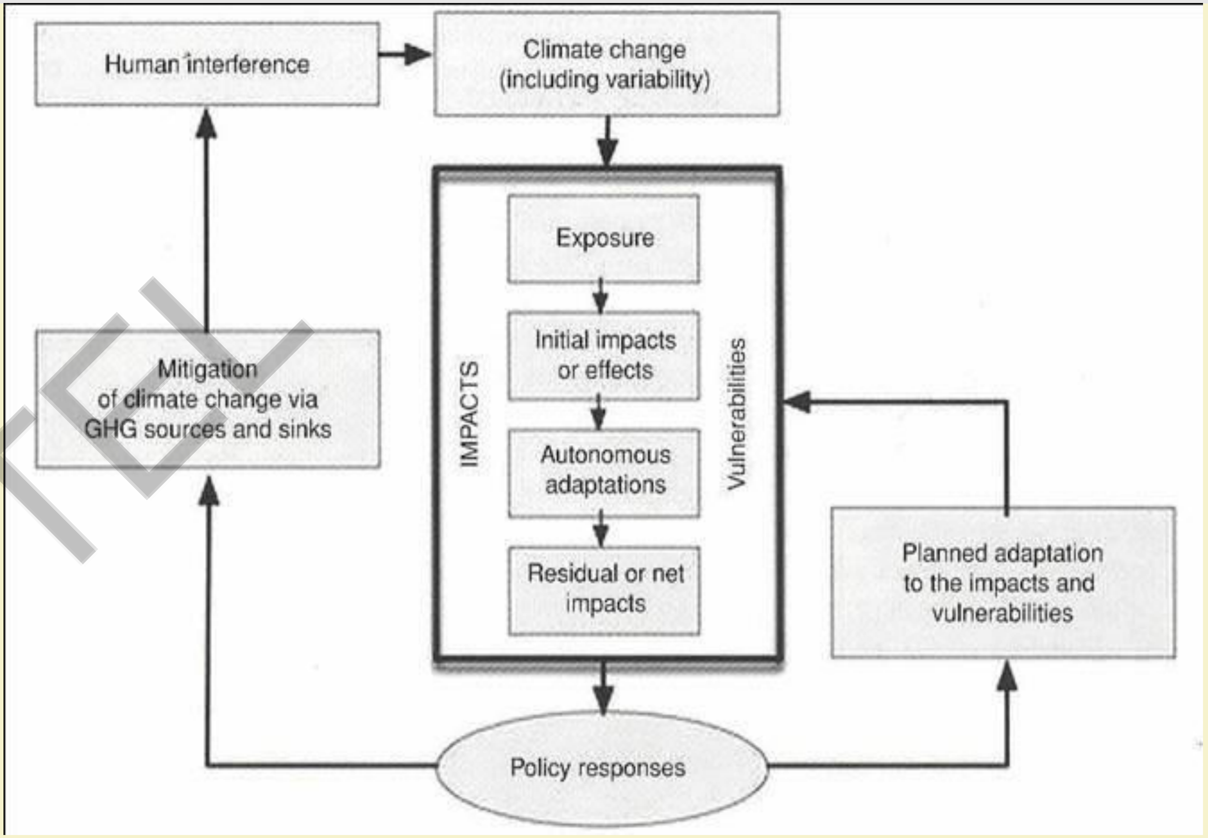
Lecture 10 : Organic Farming and Climate Change (Contd.)

Adaptations/Mitigations

- Concerns about the issues of climate change resulted in highlighting two fundamental response strategies; Mitigations and adaptations by the UNFCC
- The adaptation responses aim to alleviate the adverse impact through a wide range of system-specific action.
- The mitigation response seeks to limit the emission of GHG and enhance sink opportunities so that climate does not change fast



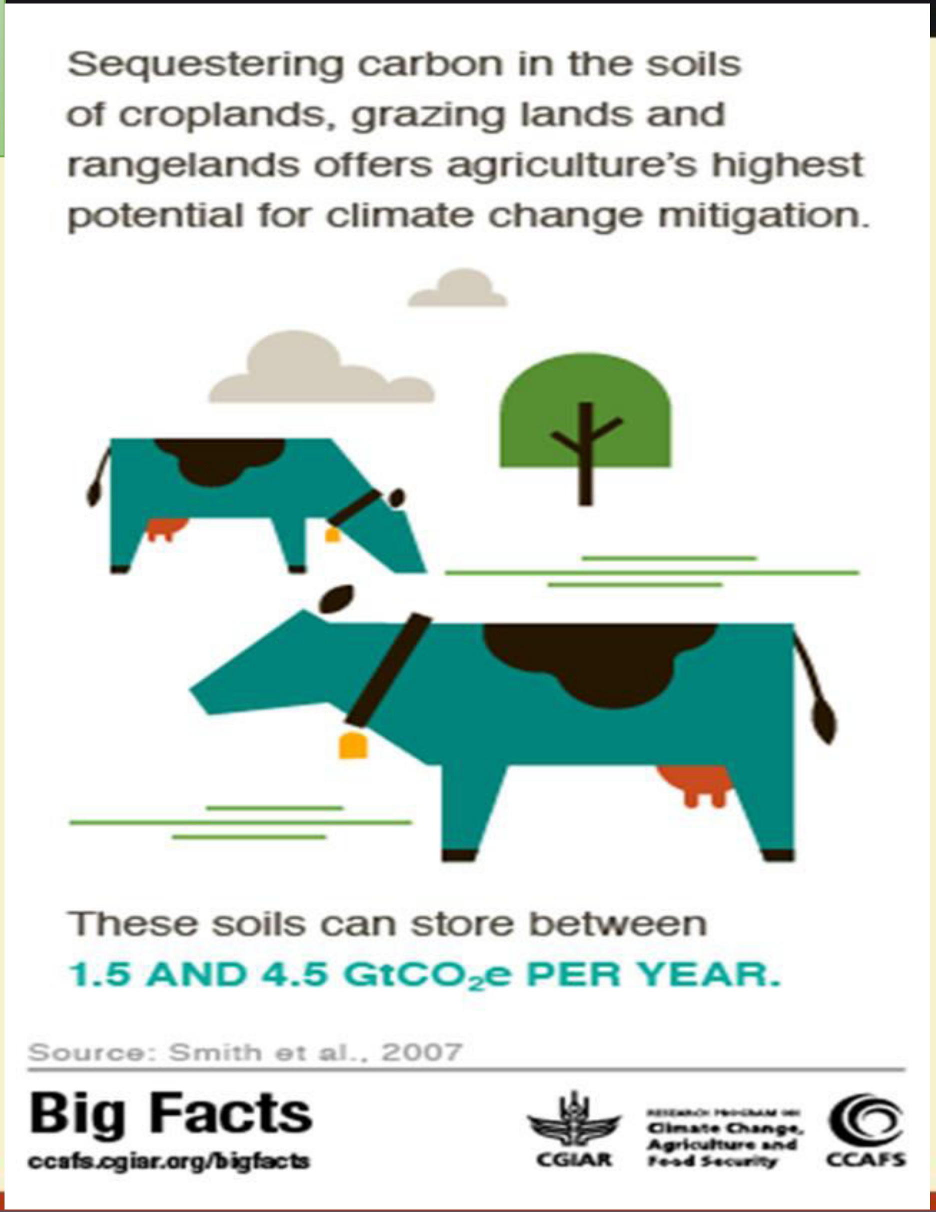
Link between climate change adaptation and mitigation

Source: Adapted from Munasinghe, 2005

Organic Farming: Climate change mitigation

- Carbon sequestration, lower-input of fossil fuel dependent resources, and use of renewable energy all present opportunities for organic agriculture to lead the way in reducing energy consumption and mitigating the negative affects of energy emissions.

- Organic agriculture provides management practices that can help farmers adapt to climate change through strengthening agro-ecosystems, diversifying crop and livestock production, and building farmers' knowledge base to best prevent and confront changes in climate.



Climate change and Soil Organic Matter

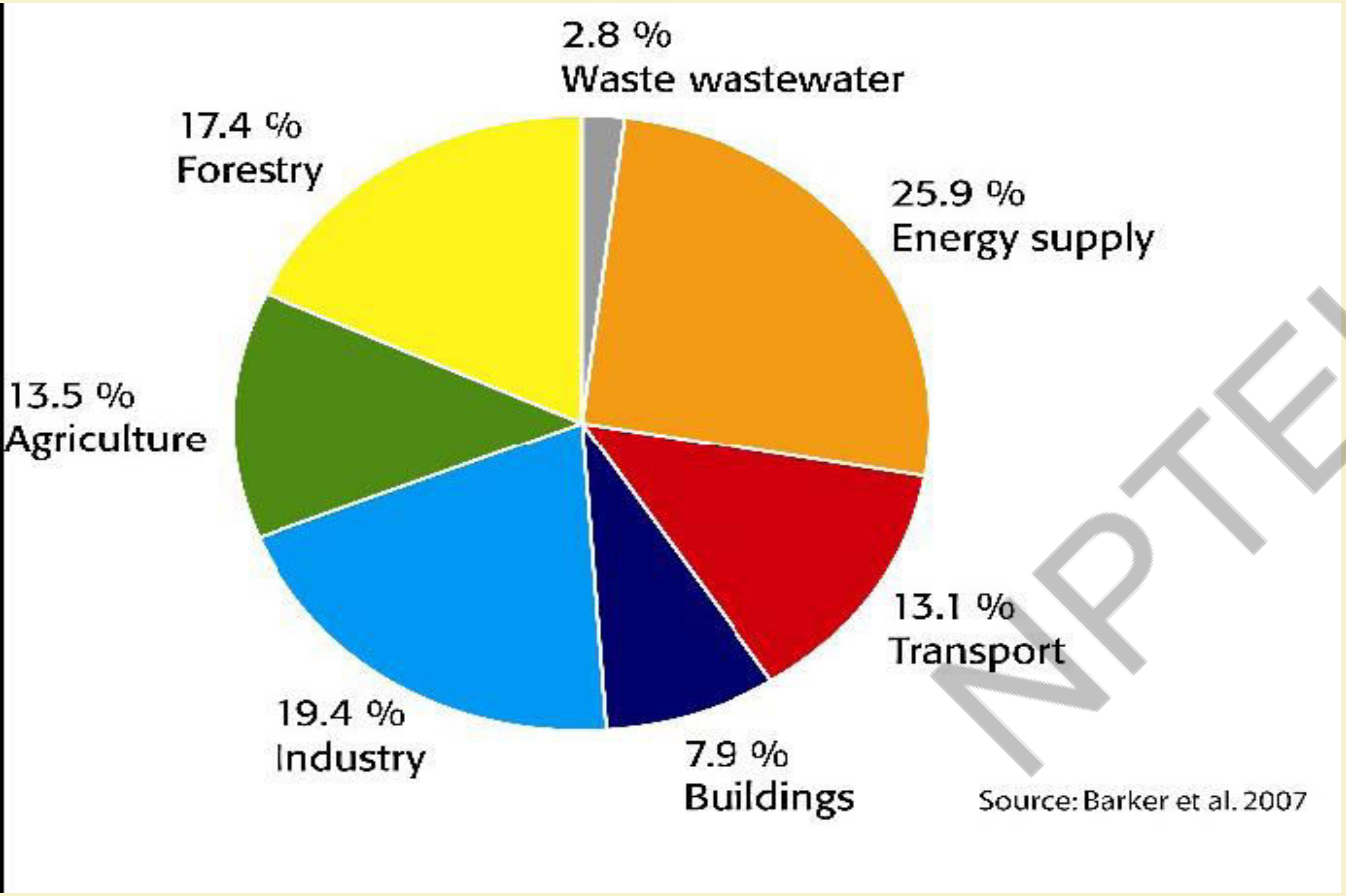
- Two schools of thought exist with regard to the effects of climate change on soil quality, which is mainly governed by the organic matter content.
- The first school of thought argues that the climate change will cause soil erosion and degradation, especially in developing countries of tropics and subtropics.
- The soil erosion rate is controlled by erosive power of rainfall because of more extreme precipitation events under climate change scenarios. One percent increase in precipitation is expected to lead to 1.5-2% increase in erosion rates
- The accelerated erosion will cause depletion of soil organic matter. Further increased temperature and precipitation will accelerate the loss of soil organic matter, which is great concern for low-input agricultural system.

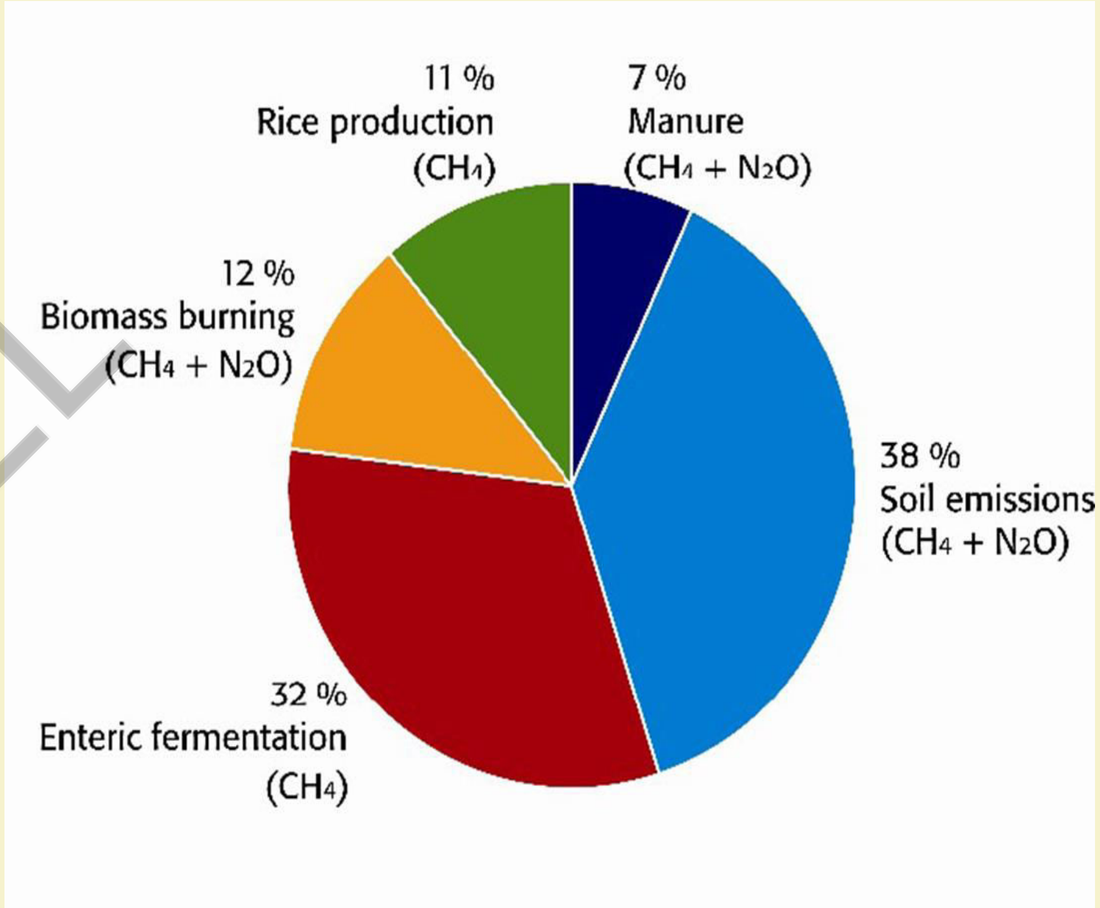
Internet sources

Climate change and Soil Organic Matter

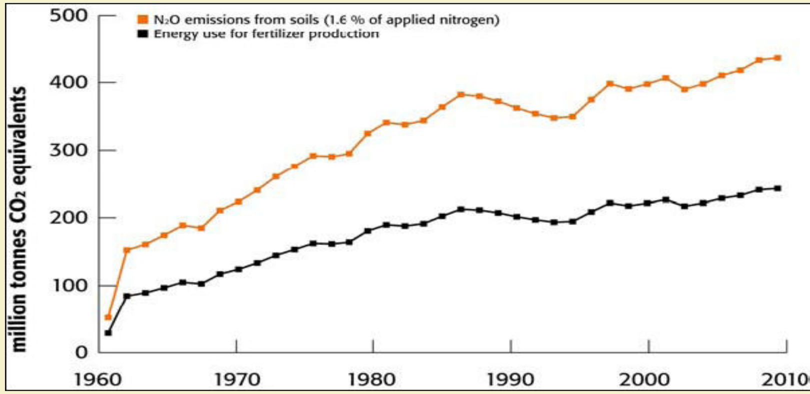
- The second school of thought argues that the CO_2 fertilization effect with increased atmospheric CO_2 concentration would increase biomass productivity with more litter and crop residues returned into the soil and higher root mass and greater root exudation.
- This would result in a gradual increase in soil organic matter status.
- However the net effect of climate change would depend on adaptive options or use of recommended management practices.

Greenhouse gas emission by sectors (CO2, CH4 and N20 converted to CO2 equivalents)





Agricultural Practices: Greenhouse Gas Emission



N_2O emission:

- High soluble nitrogen levels in the soil from synthetic nitrogenous fertilizers (http://www.fertilizer.org/)
- Animal housing and manure management

CH_4 emission :

- Enteric fermentation by ruminants (e.g. cows, sheep, goats).
- Anaerobic turnover in rice paddies
- Manure handling
- biomass burning, e.g. from slash-and-burn agriculture, emits both methane and nitrous oxide.

CO_2 emission :

- Vegetation – together with the soil ecosystem as the place for decomposition – generates large fluxes of carbon dioxide
- According to the Intergovernmental Panel on Climate Change (IPPC), this flux is nearly balanced in agriculture.
- By sequestering carbon dioxide in the soil, agriculture may contribute to the carbon cycle in a positive way.

Potential agricultural options

- Improved cropland management
  - nutrient management,
  - tillage/residue management and
  - water management
- Restoration of degraded soils
- Agriculture can help to mitigate climate change by
  - reducing emissions of greenhouse gases and
  - sequestering CO2 from the atmosphere in the soil.

- **The potential of "Organic Farming" for both effects is high**

Organic farming as climate change mitigation

Reducing emission of N_2O

- Inclusion of leguminous crops
  - the potential nitrogen production by leguminous plants via intercropping and off-season cropping to be 154 million tonnes, a potential which exceeds the nitrogen production from fossil fuel by far and which is not fully exploited by conventional farming techniques.
- Diversified crop rotation with green manure
- Organic managed soil are more aerated and have significantly lower mobile nitrogen

Reducing emission of CH_4

- Avoiding continuous flooding in rice
- Choosing low methane emitting varieties

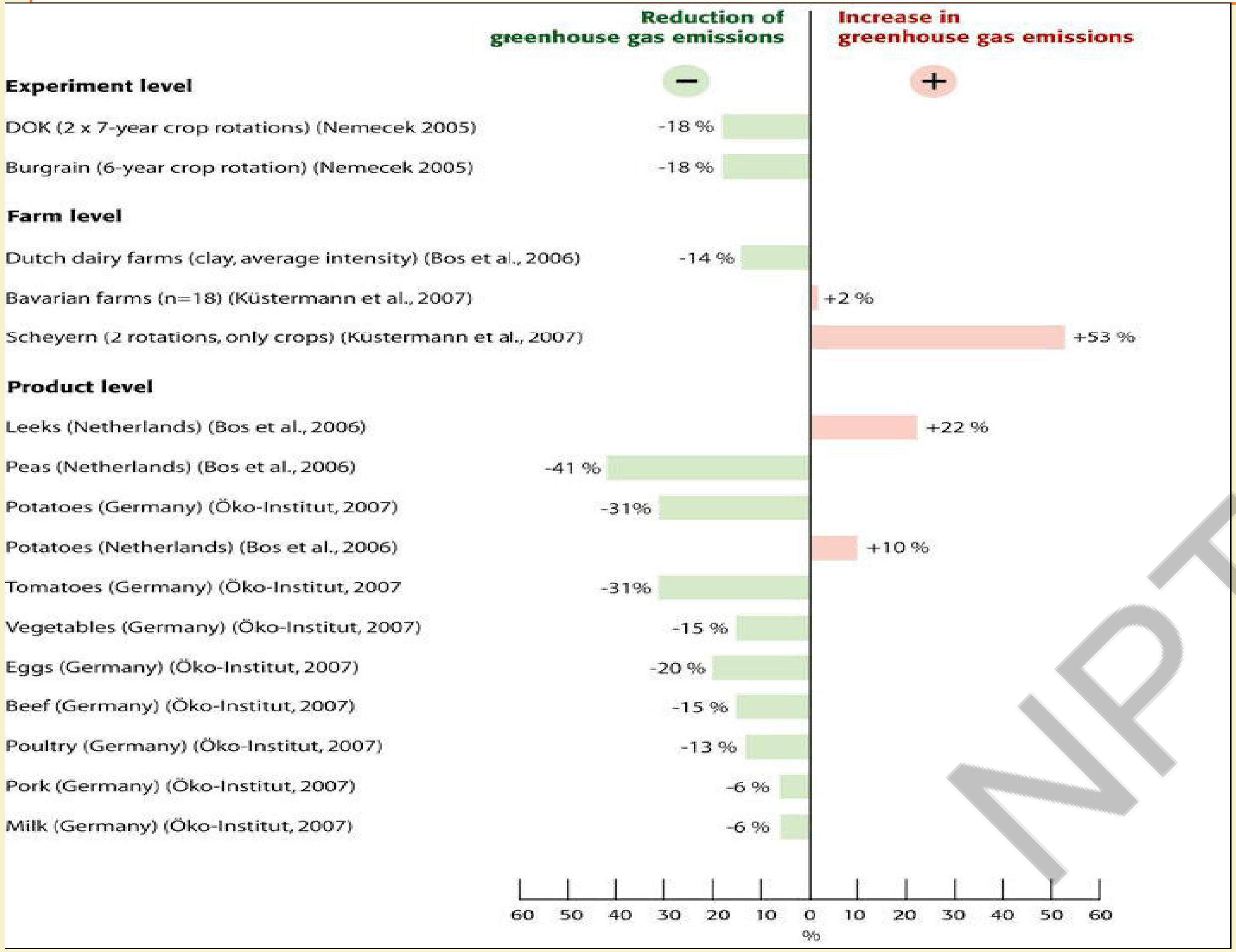
Organic farming as climate change mitigation

Reducing emission of CO_2

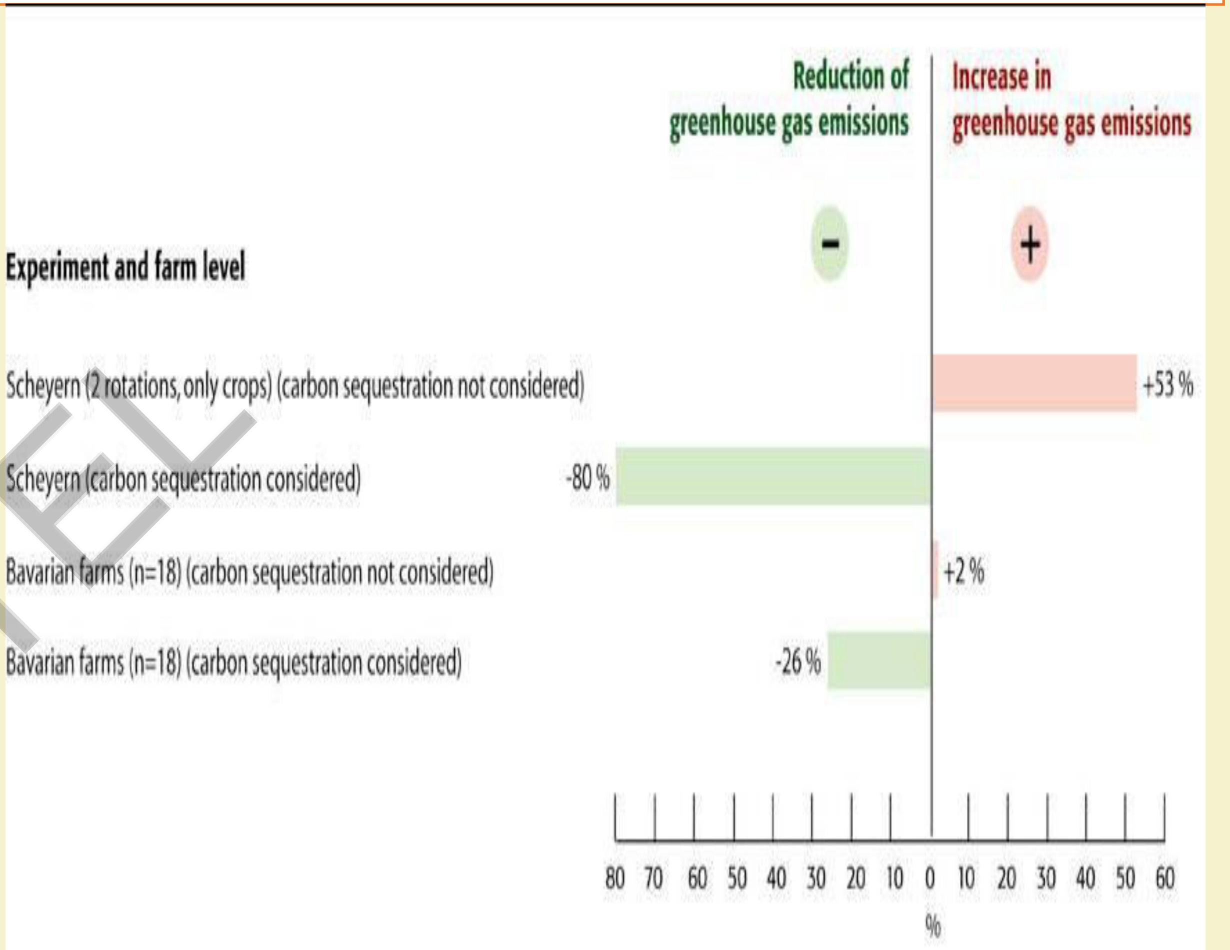
- Control of soil erosion: The application of improved agricultural techniques
  - organic farming,
  - conservation tillage,
  - agroforestry
- The improved practices stops soil erosion and converts carbon losses into gains.

GWP components	Kg C_{equiv}/ha/year	
	Conventional Till	Conservation Till
Soil C sequestration	0	-337
CO_2 emission		
Agril inputs	+156	+202
Machinery	+72	+23
Net C flux	+228	-112
Relative C flux	0	-340

Organic Farming

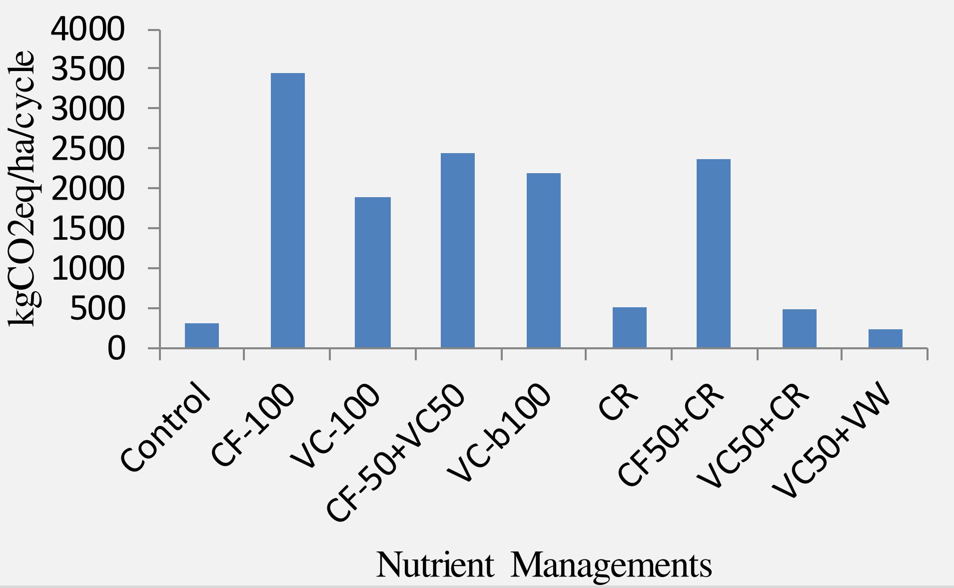


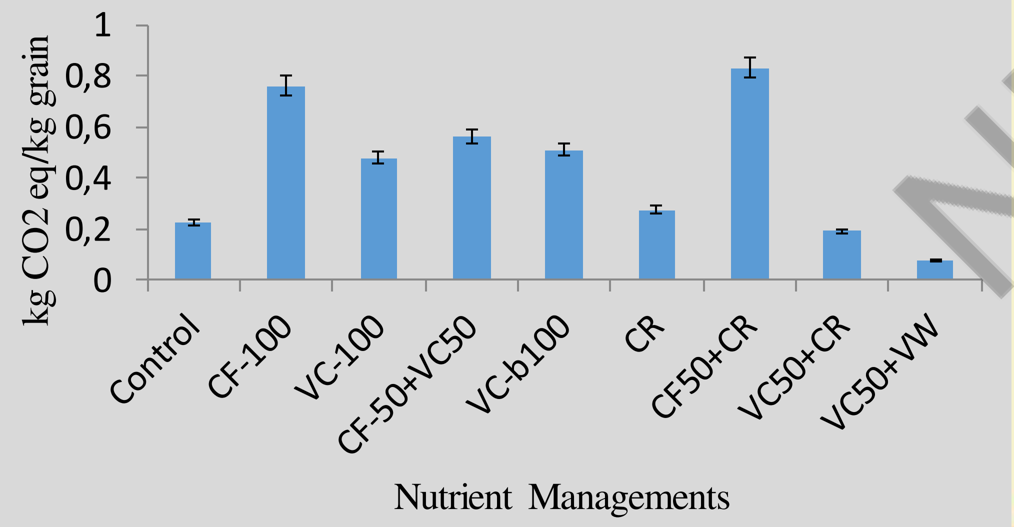
Relative global warming potential of organic agriculture compared to conventional agriculture (basis: grams CO2 equivalents per kg product).



Relative global warming potential of organic agriculture compared to conventional agriculture with and without consideration of CO2 sequestration (basis: grams CO2 equivalents per kg product; (Küstermann et al., 2007).

Global warming potential of organic nutrient management in rice





Assessment of nutrient management as compared to Chemical Fertilizer

Treatment comparisons	Yield loss, %	GWP reduction, %
VC-100	0.09	41
VC-50+CF-50	0.04	29
CF-50+CR	15	31
VC-50+CR	22	85
CR	58	85
Control(Native fertility)	69	90

Organic farming as climate change mitigation

➢ Changing consumer behavior and diet

- Production of meat requires inputs that are seven times as high as the inputs needed to produce the same quantity of non-meat calories.
- GHG emission is highest in beef production (CO_2 equivalents per kg meat are higher than 10,000 g), followed by pork, poultry and egg production (2,000 to 3,000 g CO_2 equivalents per kg) and milk (approximately 1000 g CO_2 equivalents per kg). Emission from production of plant foods are generally below 500 g CO_2 equivalents per kg (Bos et al. 2007;Nemecek 2006, Ökoinstitut 2007, Küstermann et al. 2007).
- Organic agriculture aims at precisely this goal: consumption of less-processed products and increased consumption of products like cereals, potatoes, pulses and oils.

➢ Stopping deforestation

Performance of organic farming as compared to conventional farming in the context of climate change

Adaptivness to climate change (unpredictable weather extremes, longer drought periods, floods etc.)	+ +
Global warming potential of production (Emission of CO_2 equivalents per ton.)	+
Productivity (Land area needed for global food supply)	–
Soil erosion and degradation (through farming and grazing)	+ + +
Carbon sequestration (into soil carbon stock)	+ +
Various ecological impacts (biodiversity, nature conservation, water use efficiency, environment)	+ + +
Further potential for improving the system to climate change (by research, technology transfer)	+

Organic farming is…
- slightly inferior
+ slightly better
++ clearly better
+++ definitively better


Thank you