

GLOBAL WARMING AND THE EFFECT ON AGRICULTURE

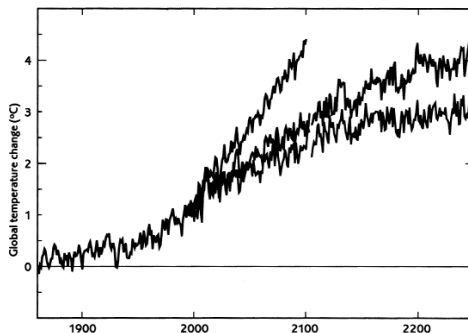
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Agriculture and the environment are closely and inextricably linked to each other. In this paper the changes to the global climate are examined, and the influence of global warming on agriculture are outlined. The use of animal power in agriculture may produce so much methane that it is not the best environmental option. Further work on this question is required.

The greenhouse effect is essential to life on Earth. The properties of the atmosphere allow solar energy, largely as ultra violet rays, to reach the Earth's surface but inhibit the escape of the lower energy infrared rays back into space. As a consequence the surface temperature of the Earth is much higher than it would be without an atmosphere. The problem facing us is that of the enhanced greenhouse effect; the composition of the upper atmosphere is changing, reducing the amount of infrared radiation to space with commensurate increase in the average surface temperature of the Earth. This is the so-called "Global Warming". Figure 1 details predicted temperature rises under three scenarios of managing emissions of carbon dioxide.

The major greenhouse gas is carbon dioxide (CO_2), the atmospheric concentration of which has been rising rapidly since the beginning of the 19th Century and is currently at a concentration of about 370 parts per million. The historical use of energy helps to link global climate to fossil fuel consumption since the burning of fossil fuels produces CO_2 . For thousands of years human power, animal power and biomass were the principal sources of energy. These sources of energy provided for a relatively small population and contributed little in the form of atmospheric release. This changed with the industrial revolution, which was very dependent on the burning of fossil fuels, and led to our heavy reliance on the combustion engine, for example. The long-term future of energy might be dominated by the limitation of coal, gas and oil reserves but in this paper we shall address the risk to the Global Climate from the burning of fossil fuels.

Figure 1 Global average temperature rise resulting from the unmitigated emissions scenario (top curve), an emission scenario which stabilises CO_2 concentrations at 750 parts per million (middle) and at 550 ppm (lower). Current concentration is about 370 ppm. Source: DETR (1999).



The developed countries are the major contributors of carbon dioxide emissions. In particular the USA, with only 3% World's population, has released 25% of all CO₂ since 1990. Amongst the developing countries, China, India and Brazil have the potential to increase global emissions quickly as their economies grow.

There are a number of greenhouse gases, each having a global warming potential (GWP) which is relative to carbon dioxide. Another important feature of these gases is the length of time that they reside in the atmosphere. Some typical values are given below. The global warming potentials of CFCs and HFCs are extremely high and their residence times are also long, so that the worldwide reduction (Montreal Protocol) in their use because of ozone depletion problems is to be welcomed in a Global Warming sense.

Agricultural processes both release and absorb greenhouse gases. The crop cycle itself is assumed to be neutral: emissions result from digestive processes in animals, animal wastes and fertiliser use. Increases in forest coverage or the amount of organic matter in the soil remove carbon from the atmosphere. Conversely, practices such as peat and fenland drainage, timber harvesting, or grassland to arable conversion lead to loss of soil carbon, and the use of fossil fuels and electricity leads to carbon dioxide greenhouse gas emission.

In the agricultural context methane (CH₄) is important. Agricultural activities release vast quantities of methane into the atmosphere. The global warming potential of methane is 35 times that of carbon dioxide, making it relatively much more damaging per kilogram than carbon dioxide. We should therefore address the methane release issue on a worldwide scale. In this paper we will examine the comparison between animal and mechanical power with these GWPs in mind.

The Main greenhouse gases and agricultural contributions

➤ Carbon dioxide	10.6	land use change, energy use, liming of soils
➤ Methane	6.2	digestive processes in animals, animal wastes
➤ nitrous oxide	8.8	animal wastes, chemical fertilisers
➤ CFC		
➤ HFC		
➤ Ozone		

(Main CO₂ increase from fossil fuel burning and deforestation. The numbers represent the annual UK agricultural contribution in Mega tonnes of C equivalent. Overall the agricultural sector contributes about 12% of the UK greenhouse gas emissions, including 1/4 of UK methane and 1/2 of UK nitrous oxide.)

Global Warming Potential

	Atmospheric lifetime in years	GWP at 20 years	GWP at 100 years	GWP at 500 years
CO ₂	50-200	1	1	1
CH ₄	10.5	35	11	4
CFC	230	5500	5500	5500
HFC	20	2000	1200	800

(GWP of carbon dioxide is defined as 1)

The effects of Global Warming are difficult to predict accurately. The box below outlines some of the more significant areas, and some of the predicted impacts are given in the table based upon different scenarios: do nothing; implement Kyoto, 20% and 30% reductions.

Effects of Global Warming

- Sea level rise (around 50cm in 100 years)
- desertification
- generally reduced agricultural yields
- weather changes - less stable, UK colder

IMPACTS

• estimates for the year 2050

<i>Emissions Scenario</i>	<i>Glopal Warming wrt 1961- 1990 (oC)</i>	<i>Water shortage millions</i>	<i>Coastal flooding millions</i>	<i>Hunger millions</i>
Do nothing	1.39	1053	23	22
Kyoto	1.33	1053	22	20
20% reduction	1.22	909	21	17
30% reduction	1.19	891	20	16

In agriculture, crop yields are likely to be strongly affected by climate change. Figure 2 shows an example of the estimated changes in national grain yield (wheat, rice, coarse grains and protein feeds) for the UKMO change scenario for a doubling of CO₂ concentration. Note that these estimates, of the direct physiological effects, generally suggest very large yield reductions in Africa and significant reductions across most of the rest of the World. If agricultural systems are modified in attempts to mitigate the yield reductions the estimates are then represented, with adaptation 1 signifying minor changes and adaptation 2 major changes to existing agricultural systems.

Figure 3 gives estimates of crop yield by 2080 under scenarios of unmitigated emissions (top), stabilisation of carbon dioxide at 750 ppm (middle) and at 550 ppm (lower). In both models it is clear that agricultural yields will change dramatically and adaptations to farming practices may be necessary.

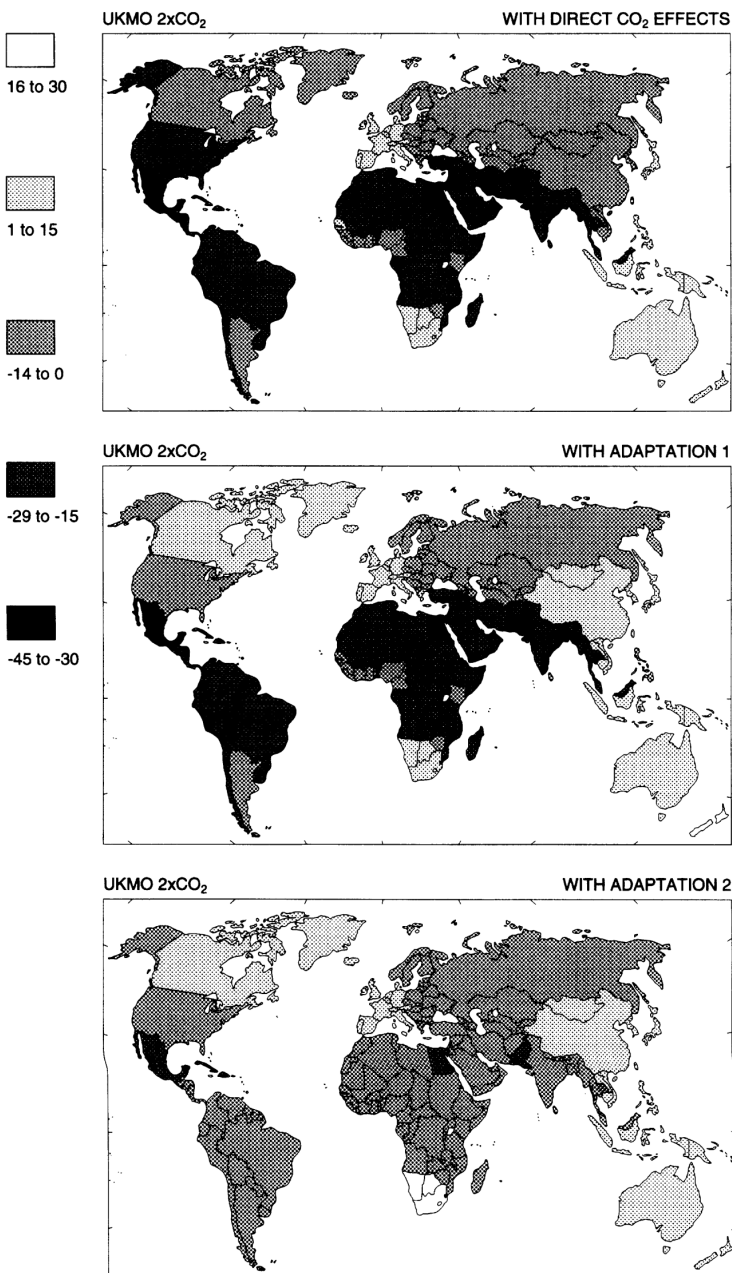


Figure 2 Estimated changes to crop yields according to the UKMO model and considering adaptations. Source: Rosenzweig and Parry.

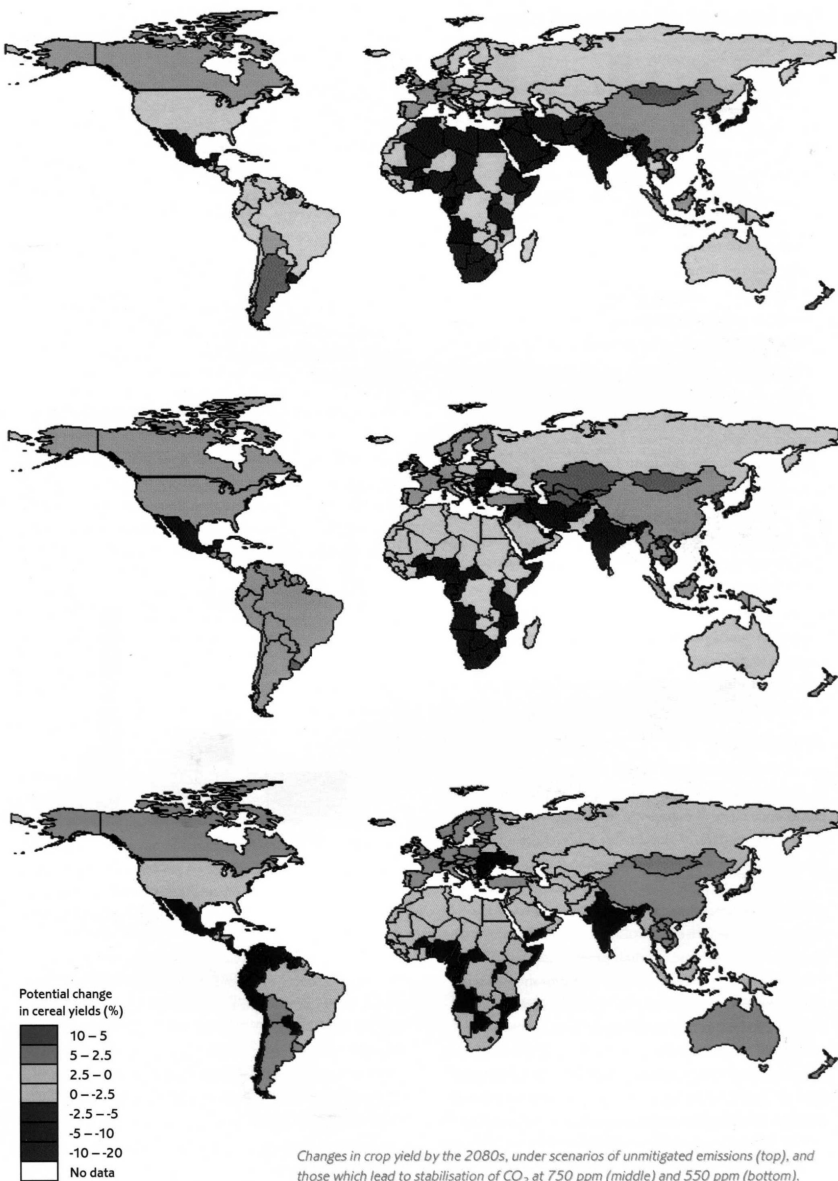


Figure 3 Estimated changes to crop yield by 2080. Source: DETR (1999).

What can be done?

A number of international treaties and conventions have been proposed, agreed and ratified. On climate change Kyoto is important, although it is still to be ratified by many countries. The overall annual reduction in climate change gases by implementing Kyoto would only be 5.2%.

Kyoto

- Scientists say 60% cuts in CO₂ emissions are needed to stabilise the climate at levels which will adapt to increasing temperatures.
- EU has the best offer of the industrialised world: 15% cuts by 2010
- UK has promised 20%
- Australia wants exemption
- USA will stabilise to 1990 levels by 2013, followed by 5% reduction
- Alliance of Small Island States want 20% cut by 2005
- Developing countries exempt to permit economic growth

Methane

Carbon dioxide emissions, mostly due to burning fossil fuels, are usually considered to be the culprit in global warming. In agricultural systems methane is also a major problem. Methane emissions are from many sources, including about 30% from rice paddies, enteric fermentation and animal wastes. As we have seen, it has a large global warming potential compared to carbon dioxide. Ironically then, growing rice is contributing to the global warming which is predicted to reduce its yield.

If crops are evaluated in terms of their energy content then evidence suggests that human power gives the best energy return (ie energy out/energy in).

Human	10.4
Animal	3.5
Mechanical	3.4

The human/oxen example from Mexico for maize shows an energy ratio of 10.74 for manpower compared to 4.34 for oxen. There may be other considerations, for example bullocks may give valuable service to India for example when social and financial issues are included.

An estimate of the energy consumption of the horse and mechanical systems suggests that they produce similar amounts of CH₄ and CO₂ respectively per unit yield. The energy ratios are nearly identical. Applying the global warming potentials, this indicates that since CH₄ has the more significant potential, animal power should be employed carefully. We

are actually stating here that burning fossil fuel in a tractor might be less environmentally damaging than using draught animals. More detailed analysis is required.

Renewable energy schemes offer some options for agriculture. Some of the renewables are already economically competitive for remote applications; indeed some can compete with fossil fuels in grid connection supply. Large-scale hydro and wind schemes are being exploited in the UK. Wind pumps for water and PV for battery charging/lighting/water pumping are examples of remote applications. Short rotation coppicing provides a valuable wood source which can be burned to produce heat and/or electricity. As with most crops it is regarded as carbon neutral. Digestion of crop and animal waste and burning the resulting methane gas produces carbon dioxide but on balance this is better than allowing the methane to reach the atmosphere and it displaces the burning of fossil fuel, saving the fossil fuel resource. Charging the batteries of electric vehicles from a renewable source means that transport and traction power could be obtained without contributing to global warming. At the present time batteries are still expensive and have limited capacity. The longer term fuel-cell technologies may overcome these drawbacks.

Conclusions

To retain our standard of living and provide for future generations agriculture should:

- reduce fossil fuel use dramatically
- minimise methane emissions from all possible agricultural sources
- use renewable sources of energy
- assess the overall economic contribution of animals
- assess the overall environmental impact of animal power
- cooperate internationally, with agricultural technology and adaptations to mitigate the global warming and it's effects.

References

- DETR (1999). Climate change and its impacts. The Met Office.
- Rosenzweig, C and Parry, M.L. (1994). Potential impact of climate change on world food supply. *Nature* **367**, 133-138