

# THE IMPACT OF GLOBAL CHANGE ON SOUTH AFRICA: FACTS AND FALLACIES

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## INTRODUCTION

The purpose of this brief paper is to summarise the current understanding of the key Global Change issues as they relate to South Africa. In doing so, much of the detailed argument must be glossed over. This is not a definitive account, since the science underpinning many of the topics is not fully mature, but an attempt will be made to indicate the degree of certainty associated with the conclusion given.

## TEMPERATURE RISE

The fundamental mechanism of the 'greenhouse effect' is not seriously in question. It is also indisputable that the concentration in the atmosphere of infra-red absorbing gases such as  $\text{CO}_2$ ,  $\text{CH}_4$ ,  $\text{N}_2\text{O}$  and tropospheric  $\text{O}_3$  has increased over the past 200 years. It follows therefore that the heat balance of the globe must have been disturbed, and will continue to be 'radiatively forced' in the future, leading to an increased global equilibrium temperature. What is not clear is how large an impact this will have on surface temperature, and how that impact will be distributed in time and space. The magnitude of change is influenced by both negative and positive feedbacks, the most important of which are those involving water vapour and clouds. There are also confounding effects, such as the radiation-shielding effect of atmospheric particles and dust, and inertial effects such as heat storage in the oceans. The tendency has been for the temperature change projections for the end of next century to decline as the models have incorporated more realistic processes, from around  $5^\circ\text{C}$ , to  $1\text{--}2^\circ\text{C}$ . There is consensus that this increase will be more pronounced with respect to the minimum (ie night time and winter) temperatures than the maximum temperatures. While the poles are likely to warm more than the tropics, this effect is not as strong as was previously thought.

The trend in the measured global surface temperature measured over the past 150 years is upward by about  $0.5^\circ\text{C}$ , even once biases and errors due to changing measurement technology and the encroachment of urban heat islands on formerly rural weather stations have been removed. Whether this trend is significant or not depends to some degree on the statistical techniques applied to it; the balance of opinions is that it is or soon will be. It is not possible to say unequivocally that it is due to 'anthropogenic' climate change, but this is the most likely contributing factor. The simulated temperature increase over the same period is comparable, but there is a degree of circular logic here.

The main contradictory evidence for temperature rise is the measurements of the atmospheric temperature taken by satellite since the 1970s. These show no consistent trend. These measurements are indirect, and of temperatures within the atmosphere at different altitude ranges. The record from weather balloons over the same period shows some increasing and decreasing trends, which are not predicted by the models.

Clearly, although the models capture the main global temperature trends quite well, they do not yet represent the details adequately, and the details can be quite important with respect to the feedback processes.

It is therefore reasonably certain that the mean surface temperature in South Africa will rise over the next century by  $1\text{--}2^\circ\text{C}$ . This is a biologically meaningful rise, over a period which is short relative to equivalent temperature changes in the past. It has the potential for leading to the extinction of species, especially those which are isolated on mountaintops. In the absence of adaptation, this level of temperature rise is sufficient to influence crop yields (mostly negatively in South Africa), but the change period is sufficiently long, and there is sufficient genotypic variability in most crop species, to have reasonable confidence that the agricultural sector will be able to adapt with little loss of yield.

## DROUGHT AND WATER SUPPLY

Water is the single most limiting factor for natural and human systems in South Africa, so the key global change issue is the degree to which the water balance will be disturbed. This is not yet predictable for southern Africa, even in direction, with an acceptable degree of confidence. Again, there are both positive and negative factors which could cancel each other out. On the positive side, an increase in the global mean temperature will increase evaporation, which will increase precipitation globally, but necessarily locally. The magnitude of this effect is unlikely to exceed about 15%. On the negative side, the models mostly agree that the precipitation in highly continental areas (such as the interior of southern Africa) tends to decrease in an 'enhanced greenhouse world'. Furthermore, it is predicted that the distribution of rainfall events will be shifted slightly towards more extremely large events, which are destructive and wasteful of the water resource.

On the water demand side, it is well established that plant water use efficiency (the water transpired per unit of carbon assimilated) will increase in an atmosphere with a higher concentration of  $\text{CO}_2$ . This will not necessarily lead to more water in the rivers or aquifers, or even a reduction in drought frequency — it may simply result in more growth, or for a longer season.

In South Africa, changes in rainfall and water supply remain a high risk factor associated with high uncertainty. The range of expected changes is enough to have important agricultural, conservation and water supply consequences, but not of sufficient magnitude to be beyond human adaptation with adequate investment in agricultural and water use technology.

It is unclear whether the rainfall seasonality in the southern Cape would change in an enhanced greenhouse world. If it were, for instance by a reduction in winter rainfall, the impact on ecosystems highly adapted to that climate pattern could be

severe. Preliminary indications are that the basic winter rainfall pattern will remain dominant, with perhaps the addition of slightly more summer rainfall.

### AGRICULTURAL PRODUCTION

The greatest uncertainty with respect to agricultural production in the future is connected to the uncertainty regarding rainfall. Most crop production in South Africa is rainfed, and the potential for increasing the area under irrigation is very small. In fact, it is likely that the amount of water available for irrigation will decrease in favour of domestic, environmental and industrial use. A major portion of the rainfed agriculture takes place in regions which are marginal with respect to water supply, by global standards. Agricultural production is therefore highly leveraged with respect to rainfall: a 10% change in effective moisture would translate into a substantially larger change in crop yield; perhaps as much as 50%. It is not yet possible to say if this change will be positive or negative on balance. Similar considerations apply to rangeland enterprises such as cattle, sheep and wildlife farming, except that the effect of forage quality becomes critical in addition to changes in forage quantity.

Plants grown under elevated CO<sub>2</sub> almost invariably show an increase in productivity. The maximum increase recorded in the laboratory for doubled contemporary CO<sub>2</sub> (ie 700 ppm relative to 360 ppm) average 30-40%, but in experiments carried out under field conditions, 10-15% is more generally observed. The higher yields are generally associated with water limited conditions such as prevail in South Africa, and are accompanied by a decline in quality (a lower protein content), which is particularly important to the pastoral industry. The difference between C<sub>3</sub> and C<sub>4</sub> crops has not proved to be as large as previously anticipated. One consequence is that it is not clear that bush encroachment will be enhanced by elevated CO<sub>2</sub>, although it may be by elevated temperatures. The most important effect on bush encroachment will continue to be the balance between fires and grazing.

The increase in minimum temperatures will expand the frost-free area of the country. Since subtropical fruit and horticulture crops currently earn more per hectare than other land uses, including forestry, this is highly likely to drive land use changes in areas of sufficient rainfall (or irrigation potential) for high value crops, but which were previously exposed to frost.

### SEA LEVEL RISE

The sea level is highly likely to continue to rise at about 5 cm a decade, reaching a level 50 cm above the present mean by the end of next century. The range of uncertainty is between 20 and 100 cm. This rise is due to expansion of the water column in the oceans, and is advanced as indirect evidence of global warming. This rise will continue for decades after the atmospheric composition has been stabilised, due to the long time lag in the oceans and ice caps. There is great uncertainty regarding the long-term stability of ice caps and sea ice under a markedly different future climate. If substantial areas of ice shelf were to melt, the sea level rise over a few centuries could be ten times higher than the modest rises currently predicted.

A sea level rise of 0,5 m over a century will lead to an increase in damage to coastal structures in South Africa, but since most

of the coastline is relatively steep, the land lost will not be very large. The economic implications are significant but not devastating. The extreme case of melting icecaps would be catastrophic for coastal infrastructure.

### HUMAN AND ANIMAL HEALTH

Tropical diseases which are carried by insect vectors are highly likely to be favoured by climate change, due to the extension of the range and breeding season of the vectors. This includes malaria, trypanosomiasis and bilhazia, and a range of animal diseases. The degree to which this results in increased human and animal deaths will depend on the success of disease control efforts, which depend in turn on the level of investment in preventive medicine in South Africa and neighbouring countries.

Deaths associated with heat stress will increase marginally, while those associated with cold exposure will decrease. Since neither of these are well documented in South Africa (typically, the climate is only one of several contributing factors leading to death in the aged and infirm), it is unclear what the balance would be. Relative to mortality factors such as AIDS it will be small.

### AVOIDANCE OR ADAPTATION?

The above analysis, and those from other parts of the world, indicates that climate change of the magnitude anticipated in the next century is survivable, and in some cases even beneficial. The question therefore arises, how strenuously should it be avoided? Some economic models have suggested that the cost of adapting to the changes is not very different from the cost of preventing them (both being of the order of 1% of GDP). The assumptions embedded in these models are still strenuously debated. The confidence of our predictions regarding impact declines sharply at long time scales, and for changes well beyond existing climates. The global climate system (and closely linked systems such as the global carbon cycle) are known to be non-linear; if incremental changes exceed some critical but currently unknown threshold, all the present models are invalid, and the changes in the climate could be catastrophic and irreversible. Examples of such thresholds would be the reversal of the thermohaline circulation system of the oceans, the collapse of the Ross Ice Shelf, or runaway thawing of the permafrost. Such uncertainties would argue for a precautionary stance, where the nations of the world seek to avoid excessive climate forcing through collaborative efforts. It is clear, however, that a certain amount of climate change is already inevitable, so adaptation measures will be required as well.

### INTERNATIONAL POLITICS AND TRADE

Because the United Nations Framework Convention on Climate Change is mostly to do with limiting the future use of fossil fuel energy, and energy use is so highly correlated with economic activity, climate change has become a high profile international issue. In many senses the debate is only ostensibly about climate; the real issues are north - south relationships, development and intellectual property rights. South Africa has to pay attention to the process, since as both a developing country and a major exporter and consumer of coal, it has a lot at stake. The option of ignoring the international treaties is not available, since non-conforming countries will come under trade-based pressures anyway.