# Climatic change: The future for Zimbabwe.


## Chris Nugent

*Department of Geography, University of Zimbabwe*



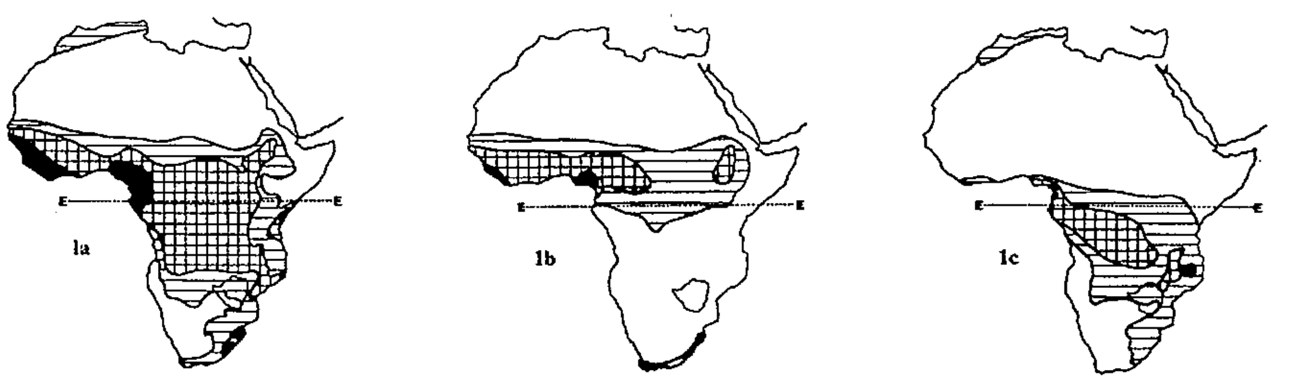
**The weather changes from day to day and through each year. The average weather conditions, measured over several tens of years, define climate and this too changes over longer periods of time. The last two million years or so, the Pleistocene epoch, marks probably the most turbulent climatic era in earth history. Global climates have continued to change in historical times but so slowly that it is very hard to notice and separate climatic changes from the natural variations of the weather. In the last couple of decades it has become clear that the activities of man have the capability to influence world climates. This paper examines natural climatic change and the influence of man. It considers how future global climatic warming can change the rainfall patterns of Africa and the effects on Zimbabwe.**


**Rainfall in Africa**

Before considering past African climates, it is necessary to understand the processes that currently bring rain to the continent and the resultant distribution of rainfall. Figure 1 shows the mean annual rainfall over Africa and seasonal rainfall for the northern and southern summers. Notice that the region with the highest annual rainfall is centred around equatorial latitudes. North and south of this lie drier areas that form the Sahara and Kalahari/Namib deserts. Rainfall increases polewards of the deserts, at around the north and south coasts of the continent.

This pattern arises because land near to the equator is heated the most by the sun, developing cells of convergent, rising air; the inter-tropical convergence zone (ITCZ). Air rising within the ITCZ cools with height and may cause convectional rainfall. This equatorial air diverges at heights of several kilometres and moves polewards, before descending over the deserts. The deserts are dry because air becomes warmer as it descends and can yield no rain. This general pattern is altered by the distribution of land and sea and the effects of altitude. Rainfall over southeastern Africa is increased by generally high relief and the proximity of th Indian Ocean. The lowlands of northeastern Africa are made more arid by dry air masses from the Middle East and Asia.

The climatic belts shift with the seasonal movement of the sun. During the northern summer the ITCZ moves northwards and Zimbabwe falls under the influence of the



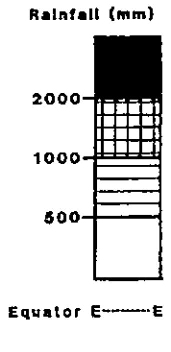




Figure 1. Mean rainfall conditions affecting Africa in historical times.
la = Mean annual rainfall.
1b = Mean rainfall May to October (northern summer)
1c = Mean rainfall November to April (southern summer)

descending air mass of the Kalahari (Fig. 1b). During the southern summer, the ITCZ moves southwards, creating conditions which may lead to convectional rainfall over Zimbabwe (Fig. 1c). The rainbelts that lie polewards of the deserts and affect the Mediterranean coast and southern coast of South Africa also move with the seasons. In the winter these regions come under the influence of cyclonic systems that characterise temperate latitudes, resulting in the winter rainfall of the Mediterranean climate.

## Ice ages

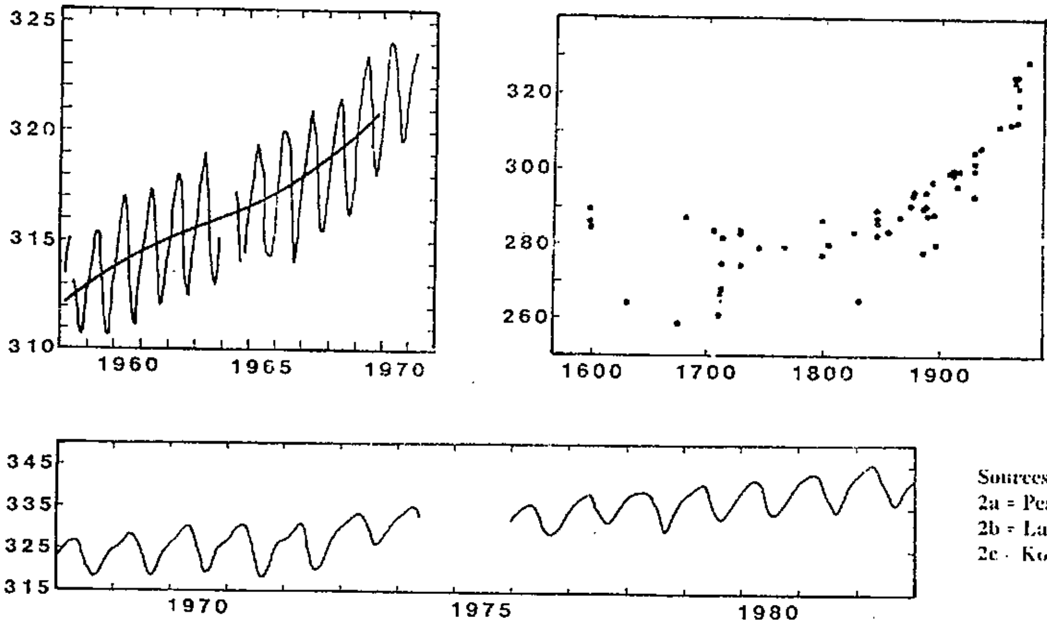
The climate of Africa has changed many times during the Pleistocene. Changes in the location and activity of Africa's rain belts can be seen as the consequence of climatic change at high latitudes. During globally cold intervals, areas at high latitudes that experienced sufficient snowfall developed ice sheets. These spread across North America and Northwest Europe, eroding the surface from upland areas and depositing a variety of glacial and periglacial sediments near the ice margins. At their maximum, ice sheets reached as far south as London and New York, pushing the northern hemisphere's temperate and tropical climatic belts into lower latitudes.

Sediment cores recovered from the deep sea have supplied relatively continuous and well dated records, going back millions of years. Ocean temperatures inferred from these sediments indicate repeated episodes of warm and cold conditions that appear to be related to long term variations in the earth's orbit. Changes in the angle of the earth on its axis and the obliquity of its orbit are known to occur over periods of tens or hundreds of thousands of years. By changing the amount and distribution of solar radiation reaching the earth's surface (Imbrie and Imbrie, 1980), these regular variations are believed to trigger changes in the energy balances of the atmosphere and oceans that lead to ice ages.

The amount of solar radiation absorbed by the earth is influenced by the nature of the surface, particularly the reflectivity or albedo, which governs the amount of energy reflected back into space. This is also affected by the composition of the atmosphere. Although air is transparent within the range of light emitted by the sun (the visible spectrum), the earth radiates heat at much longer wavelengths and certain gasses are opaque to this infra red radiation. This phenomenon is known as the greenhouse effect since, like a greenhouse, light enters freely but heat is prevented from leaving. One important gas with this property is carbon dioxide ($CO_2$). Studies of air bubbles trapped in ice (Neftel et al, 1982; Barnola et al, 1987) have shown that the last cold (glacial) period during the Pleistocene was characterised by atmospheric $CO_2$ concentrations about thirty percent lower than modern, pre-industrual levels.

## Climatic warming and man

The concentration of $CO_2$ in the atmosphere has increased since the Industrial Revolution by almost twenty five percent and by some ten percent




Sources:
2a = Pearman et al (1986)
2b = Lamb (1977)
2c - Komhyr et al (1985)

Figure 2. Three estimates of increasing atmospheric carbon dioxide. All graphs show $CO_2$ concentrations (parts per million by volume) plotted against time (years A.D.).

2a = $CO_2$ concentrations over the last 400 years, estimated from air bubbles in Antarctic ice. Notice that $CO_2$ concentrations start to increase at the Industrial Revolution, mid. 19th century.

2b & 2c = $CO_2$ concentrations since 1958 measured directly from the atmosphere in Hawaii (2b) and Colorado (2c). Notice seasonal variations are superimposed on a trend of increasing $CO_2$.

over the last thirty years (Fig. 2). This is due mainly to the large amounts of $CO_2$ added to the atmosphere by burning fossil fuels. Thermal power stations and internal combustion engines derive their power by oxidising carbon, forming a little carbon monoxide and a lot of carbon dioxide. Certain agricultural and industrial processes also generate $CO_2$ and a range of other "greenhouse gasses" that have a similar effect, including methane, nitrous oxide, chloroflorocarbons (CFCs) and ozone. These have accumulated since the Industrial Revolution to increase the greenhouse effect by the equivalent of 50 parts per million of $CO_2$ (Jones and Warrick, 1988). We know that levels of greenhouse gasses have increased and we know that this should cause the earth to warm but has the earth actually become warmer?

This question has proved surprisingly difficult to answer. It is necessary toseparate the short term variations of the weather from the longer term changes that we know as climate. Typically, measurements show so much variation that any apparent warming trend can be explained by this natural variability and the trend is said to be "not statistically significant". Recent syntheses of data from the southern hemisphere (Angell, 1986; Karoly, 1987) show that the lower atmosphere (troposphere) has been warming, at least since 1964, relative to the stratosphere. Computer models of increased $CO_2$ predict that the stratosphere should cool slightly as the troposphere warms. Thus the atmosphere is behaving as $CO_2$ models predict, although it still cannot be stated with any certainty that this temperature trend has resulted from an increase in levels of greenhouse gasses and not some other cause.

Future warming will obviously depend on the rate at which greenhouse gasses are released into the atmosphere. Projections of past trends suggest a doubling of the pre-industrial $CO_2$ concentrations by 2030 AD. Computer modelling predicts that this will eventually warm the earth by 1.6 °C to 4.9°C but, due to heat absorption by the oceans, the temperature at 2030 AD will be between 1.3°C and 3.1°C warmer (Jones and Warrick, 1988).

TABLE 1

World food crops and percentage of world food production, listed according to the biochemical pathways used during the process of photosynthesis. C3 crops will benefit considerably from increased atmospheric CO, C4 crops receive little benefit (see text). Data from Warrick (1988).

| C3 CROPS | % | C4 CROPS | % |
|---|---|---|---|
| Wheat | 17 | Maize | 15 |
| Rice | 15 | Sorghum | 2 |
| Potato | 9 | Cane sugar | 2 |
| Barley | 6 | Millet | 1 |
| Cassava | 5 | | |
| Sweet potato | 4 | | |
| Soyabean | 3 | | |
| Oats and Rye | 3 | | |
| Grapes | 2 | | |
| Bananas | 1 | | |
| Beet sugar | 1 | | |
| Other C3 | 13 | | |

Note that although C4 crops account for only 20% of world food production, they include species that are important in Zimbabwe. Increased CO coupled with climatic change could cause the advantage to shift to C3 species, encouraging, traditional agricultural patterns to change.

**Farming in the greenhouse**

Crop yields are expected to respond both to the direct effects of increasing levels of atmospheric $CO_2$ and to changing climates. In most food plants, biochemical reactions used in photosynthesis are limited by the availability of $CO_2$, so higher concentrations directly increase the rate at which carbon is fixed. These so called C3 species comprise some eighty percent by weight of the world's total food production. Other crops use the C4 photosynthetic pathways (Table 1) and do not benefit from increased $CO_2$ in the same way. Increased $CO_2$ causes the stomata on the surface of all leaves to close a little, thus reducing water loss during transpiration. The direct effect of increased $CO_2$ on agriculture are thus beneficial and Warrick (1988) estimates that a doubling of atmospheric $CO_2$ would increase yields of C3 crops by 10% to 50% and C4 crops by up to 10%.

The effects of climatic change are more complex. Climatic warming will be beneficial to areas whose growing season is short and constitutes the major limit to arable farming. Such marginal areas of the Canadian Prairies and Russian Steppes may develop a more secure agricultural base but these advantages are likely to be offset by changes in the distribution, amount and reliability of rainfall, that may not be predicted in advance. Climatic warming will not necessarily cause world agricultural belts to move, since there are a variety of ways that farmers can combat and ameliorate the effects of changing climate. By changing seed varieties, planting times or irrigation practises, traditional food crops may be grown even where the climate has become less advantageous.

**Previous warm intervals**

Why should we in Africa be so concerned about a global temperature increase of a few degrees centigrade? The answer is that the interactions on the earth's surface are complex; one change leads to several others and climatic warming could decrease ice volumes, raise sea level and shift global rain belts, with profound influences on man. In considering what a warmer earth would be like, it is instructive to examine what happened during former times when the earth was warmer than now.

The geological record suggests that there have been only two times during and since the Pleistocene when the earth was warmer than it is today;

1) The Climatic Optimum was the most recent and occurred at around 5 000 years ago. It is believed to have been warmer because cer-

tain temperate plant species penetrated poleward of their present ranges. Sea level is thought to have been about the same as it is today.

2) The previous time was at the peak of the last interglacial, some 125 000 years ago. Most of the evidence on land was erased during the subsequent glaciation but it is clear that sea level was some 5m to 7m higher than now. It is inferred that this extra water was supplied to the oceans by the melting of ice. Various evidence suggests that mean global temperatures were then some 2°C warmer than now.

### Global temperatures and African rainfall

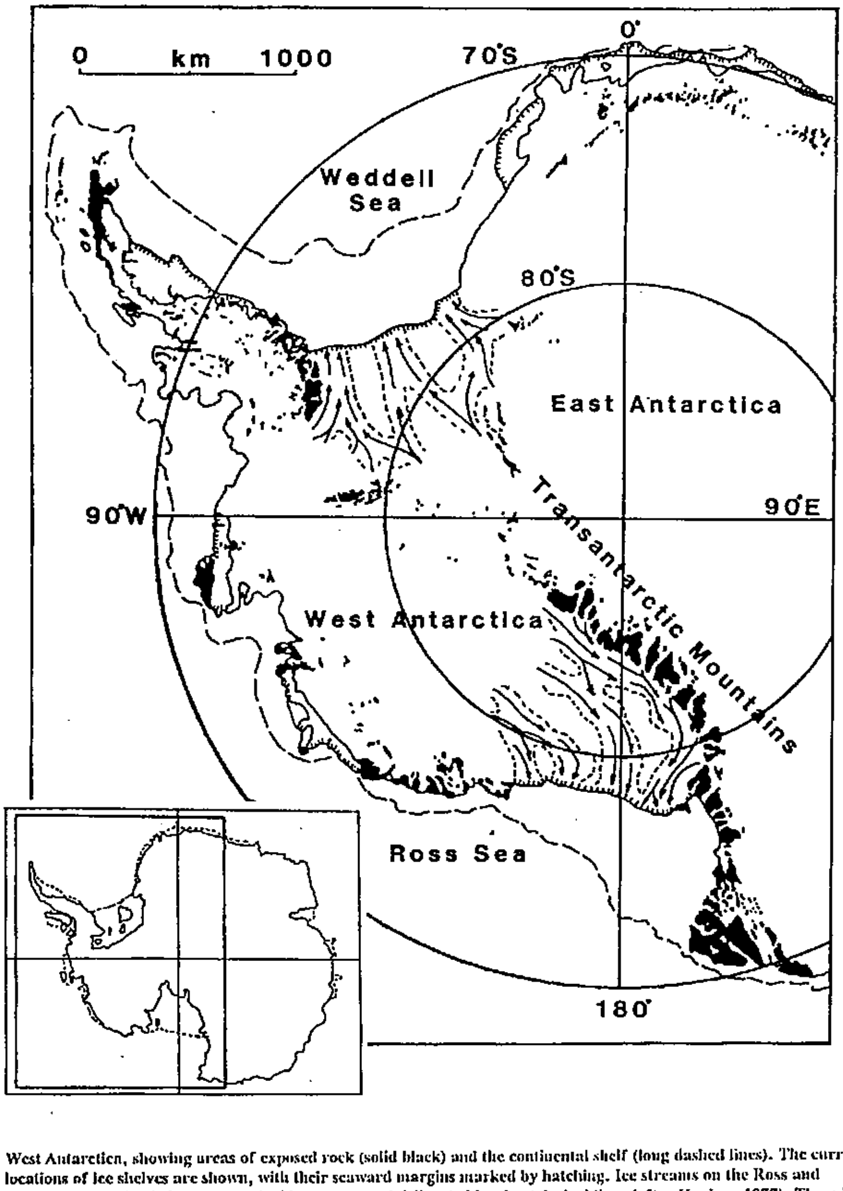
The chronology of Pleistocene climatic change in Africa has been pieced together largely from the records of lake levels around the continent. Where a lake forms the end point of an internal drainage basin, its level is a sensitive measure of the climate of its catchment. Former lake levels show that the glacial maximum at 18 000 years before present (18 000 BP) was a very dry time in the northern hemisphere tropics, which became wetter at around 12 000 BP (Street-Perrot et al, 1985). The southern hemisphere tropics show the opposite change, being comparatively wet during the glacial maximum and becoming dryer when the northern hemisphere tropics became wetter (Shaw and Cooke, 1986). These changes can be explained by movement of the equatorial rain belt, rather than changes in its activity. They suggest that the ITCZ was caused to move southwards during the last glacial and northwards during the present interglacial, the period known as the Holocene.

The movement of the rain belt can be explained in terms of the extent of high latitude ice sheets in each hemisphere, which affect the strength of the atmospheric circulation (Harrison et al, 1984). During glacials, when ice sheets advanced over northern temperate regions, the extent of southern hemisphere ice increased very little. This was due to there being very little land at temperate latitudes in the southern hemisphere. Ice over the Antarctic probably advanced a small distance to the edge of the continental shelf (Fig. 3). In contrast, ice sheets developed over millions of square kilometres of the northern hemisphere, increasing the strength of the atmospheric circulation and pushing the ITCZ south of the equator.

During deglaciation, ice sheets over Canada and Northwest Europe melted completely, causing the equatorial rain belt to move northwards. At the Climatic Optimum the vegetation belts of north east Africa lay some 4 north of their current latitudes (Ritchie and Haynes, 1987) and Savannah vegetation with big game penetrated north into what is now the Sahara Desert (Munson, 1981). If this is what we can expect from climatic warming then it is a bleak outlook for Zimbabwe. If the mean positions of the rain belts move further northwards, then the frequency with which they migrate southwards over Zimbabwe during the southern summer will be reduced, lowering our annual rainfall. Can we expect this pattern to repeat itself and what will be the effect of further climatic warming on the world's ice sheets and hence on the rainfall of Africa?

### Remaining ice sheets

There are currently two places on earth where climatic conditions are still able to maintain ice sheets:




West Antarctica, showing areas of exposed rock (solid black) and the continental shelf (long dashed lines). The current locations of ice shelves are shown, with their seaward margins marked by hatching. Ice streams on the Ross and Ronne-Filchner iceshelves are marked by arrows and delineated by short dashed lines (after Hughes, 1977). These ice shelves are believed to buttress the ice sheet over West Antarctica such that their removal could cause this ice sheet to collapse and melt (see text).

Greenland and Antarctica. The North Pole lies in an ocean, the Arctic ocean, covered by a floating ice cap that is tens or hundreds of metres thick. The high snowfall areas of North America, Northwest Europe and New Zealand are too warm to support ice throughout the year, except at high altitudes, where valley glaciers form. Under conditions of a cooler earth these places become the nucleii of ice sheets, under conditions of a warmer earth these nucleii contract below their present limits. Higher sea level during the last interglacial, by about 5m to 7m, implies that the world's ice sheets were then smaller by about two million cubic kilometres. In assessing the effects on the rainfall of Africa, it is vitally important whether this ice was removed from the ice sheets of Greenland or Antarctica or both.

Antarctica in fact supports two ice sheets, over East and West Antarctica, separated by the Transantarctic Mountains (Fig. 3). The East Antarctic ice sheet lies on land that is mainly above sea level. Ice moves outwards towards the coasts, where it either joins small ice shelves or calves directly into the sea as icebergs. The ice over most of West Antarctica is channelled via ice streams into the Ross and Ronne-Filchner ice shelves, where it begins to float. These ice shelves are several hundred metres thick and each covers an area of sea roughly equivalent to the land area of Zimbabwe. The ice moves towards the open sea, passing over numerous rocky protrusions beneath the shelves, which slow down ice flow from West Antarctica and buttress the ice sheet.

These properties are believed to make the West Antarctic ice sheet inherently unstable (Hughes, 1973). If climatic warming were to cause the calving front at the seaward margin of the ice shelves to recede, the buttressing effect would be diminished. Ice streams would channel ice more rapidly into the Ross and Weddell Seas, causing the ice sheet to thin. More of it would then float, increasing the rate of melting. Such a process would probably lead to the deglaciation of large areas of West Antarctica, much of which lies well below sea level. The North American and NorthwestEuropean ice sheets have already melted away completely, could the West Antarctic ice sheet be the next one to go?

**Evidence from Africa**

Unfortunately, the record of the last interglacial has been largely removed from high latitudes by the erosive work of the succeeding glaciation. The record from Africa has been preserved in several places but evidence is not always easy to interpret or to date. Sediment cores taken from the Nile Delta shows comparatively wet conditions in the Nile catchment at that time (Rossignol-Strick, 1983), consistent with the presence of large lakes in Southern Libya (Gaven et al, 1981). This evidence suggests a situation similar to that at the Climatic Optimum, with the ITCZ pushed north of its current mean latitude.

South of the equator, particularly high rainfall is indicated over the catchment of the Upper Zambezi, when it joined with the Middle Zambezi to form a single river. The Upper Zambezi previously formed part of an internal drainage system that ended in a lake in the Kalahari. Record of the lake is preserved as alluvial and lacustrine sediments that underlie and extend beyond the modern Okavango and Chobe swamps and the Makgadikgadi Pans (Fig. 4). The joining together or capture of its upper catchment by the Middle Zambezi is believed to have occured at Katombora, upstream of the Victorial Falls, and resulted in severe degradation of the channel downstream. Before this downcutting began, the river left behind a flood deposit which now forms the Stoney Ridge at Mana (Nugent, 1988). This flood indicates that river capture resulted not from headwards erosion and backcutting of the Middle Zambezi, but rather from overtopping of Palaeo-lake Greater Makgadikgadi (Nugent, 1989).

Downcutting can be dated from Stone Age artifacts found on terraces that formed on the Middle Zambezi as the river cut down to its modern level. The Stone Age sequence described by Bond and Clark (1954) shows that degradation was occurring as the first cultures of the Middle Stone Age appeared in the Zambezi Valley. Although the Middle Stone Age is not well dated in the African interior, the record from caves on the South African coast (Singer and Wymer, 1982) shows that these cultures began to evolve during the lowering of sea level that followed the last interglacial. Early Middle Stone Age cultures thus link degradation of the Zambezi River with lowering of sea level and strongly suggest that river capture occurred

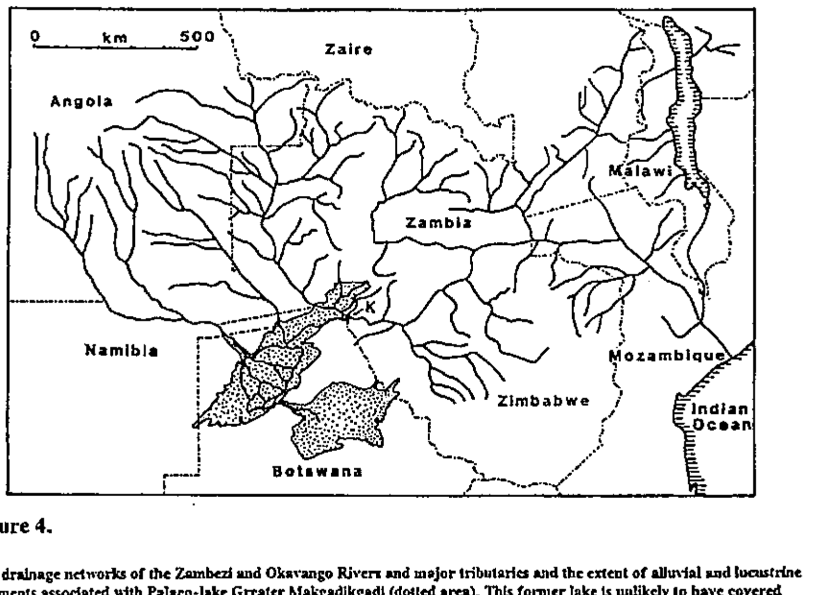



Figure 4.

The drainage networks of the Zambezi and Okavango Rivers and major tributaries and the extent of alluvial and lacustrine sediments associated with Palaeo-lake Greater Makgadikgadi (dotted area). This former lake is unlikely to have covered the entire area of lacustrine sediments at any one time and the highest shorelines (at 945m a.s.l.) enclose about half this area. The letter "K" marks the Katombora rapids, believed to have been the point where the palaeo-lake overtopped its margin, spilling on to the basalt plateau upstream of the Victoria Falls.

at around the time of highest sea level, at the peak of the interglacial.

Overtopping of Palaeo-lake Greater Makgadikgadi into the Middle Zambezi River system is believed to indicate a period of high rainfall over the lake's catchment, in Eastern Angola and Western Zambia. Overtopping does not seem to have occurred during any of the previous glacials and interglacials of the Pleistocene. To move the ITCZ from north of its modern position to the catchment of the Zambezi would have required either a northern polar cooling or a southern polar warming. Since capture is believed to have coincided with high sea level at the peak of the interglacial, the latter cause seems the more probable. The most obvious candidate is the melting of the West Antarctic ice sheet.

**Implications for the future**

Can we expect the future pattern of climatic warming to mimic that of the past? One important difference is that the events that led to the Climatic Optimum started at the peak of the glacial maximum, at around 18 000 BP. The movement of the ITCZ was then determined by the sequence of deglaciation in both hemispheres. A global warming starting now (or rather at the Industrial Revolution) cannot be expected to reproduce this sequence. Thus the fact that the ITCZ lay north of its mean modern position at the last interglacial and at the Climatic Optimum does not mean that future warming will lead to this situation.

An aspect of future climatic change that is perhaps more clear is the next stage in the remaining process of deglaciation. Evidence from the Zambezi and consideration of the unstable nature of the West Antarctic ice sheet suggest that as the earth continues to become warmer, it is this ice that will be the next to melt. Predicted warming of $1.3^0$ C to $3.1^o$C, associated with a doubling of $CO_2$ by 2030 AD, suggests that the earth will by then have achieved a temperature regime similar to that of the last interglacial. Melting of polar ice will lag behind this atmospheric warming and the rate of deglaciation will depend on whether ice shelves remain to buttress ice flow. If the ice shelves were removed by rapid iceberg calving, then the whole ice sheet would be able to surge, melting or floating away relatively rapidly (Stuiver et al, 1981).

**The outlook for Zimbabwe**

In the broadest terms, the very long range weather forecast for Zimbabwe seems to be quite promising. On the assumption that the concentration of atmospheric $CO_2$ will continue to increase and that this will continue to cause global warming, the volume of world ice sheets will be reduced. Theoretical considerations of ice sheet stability and the record of the last interglacial suggest that the ice sheet over West Antarctica will be hardest hit and may melt away completely. The last interglacial capture of the Upper Zambezi River suggests that this was the wettest time in the catchment of the Upper Zambezi during the whole Pleistocene. There is every reason to believe that future climatic warming will eventually recreate these conditions. Zimbabwean agriculture will be encouraged to change as the changing environment favours high rainfall and $CO_2$ loving crops over the traditional C4 species.

Before we rush off to buy land in the Kalahari, it would be wise to consider some other implications of climatic change. The whole process of deglaciation of West Antarctica will probably be so slow that our children and even our grandchildren are unlikely to witness the effects. In the mean time, the Southern African climate may even become dryer, as the equatorial rain belt is pushed further north. Mankind is only now awakening to the possibility of global climatic change. If and when change occurs, disruption of agriculture and sea level rise will be particularly damaging to the densely populated, maritime nations of the developed world and may thus help to precipatate a new economic order. It is encouraging that we, or rather our descendents in Central Southern Africa, will live in one of the few places on earth likely to benefit from future climatic changes.

**Acknowledgements**

I am very grateful to the Zimbabwe Hunters' Association for providing me with a postgraduate scholarship, without which this work would not have been possible.

**References**

**Angell, J.K.** (1986). Annual and seasonal global temperature changes in the troposphere and low stratosphere, 1960-85. *Monthly weather review*, 114, 1922-1930.

**Barnola, J.M., Raynaud, D., Korotkevich, Y.S. and Lorius, C.** (1987). Vostok ice core provides 160 000 year record of atmospheric $CO_2$. *Nature*, 329, 408-409.

**Bond, G. and Clark, J.D.** (1954). The Quaternary sequence in the Middle Zambezi Valley. *South African Archaeological Bulletin*, 9, 115-130.

**Gaven, C., Hillaire-Marcel, C. and Petit-Maire, N.** (1981). A Pleistocene lacturine episode in southeastern Libya. *Nature*, 290, 131-133.

**Harrison, S.P., Metcalfe, S.E., Street-Perrott, F.A., Pittock, A.B., Roberts, C.N. and Salinger, M.J.** (1984). *A climatic model of the last Glacial/Interglacial transition based on palaeotemperature and palaeohydrological evidence.* In: Vogel, J.C. (Ed.), *Late Cainozoic palaeoclimates of the southern hemisphere.*, Proceedings of the SASQUA symposium, Swaziland. pp. 21-34.

**Hughes, T.J.** (1973). Is the Antarctic ice sheet disintergating? *Journal of Geophysical Research*, 78, 7884-7910.

**Hughes, T.J.** (1977). West Antarctic ice streams. *Reviews of Geophysics and Space Physics*, 15, 1-46.

**Imbrie, J. and Imbrie, K.P.** (1980). Modeling the climatic response to orbital variations. *Science,* 207, 943-953.

**Jones, P.D. and Warrick, R.A.** (1988). Greenhouse effect and the climate. *Atom*, 381, 13-15.

**Karoly, D.J.** (1987). Southern hemisphere temperature trends: A possible greenhouse gas effect? *Geophysical Research Letters,* 14, 1139-1141.

**Komhyr, W.D., Gammon, R.H., Harris, T.B., Waterman, L.S., Conway, T.J., Taylor, W.R. and Thoning, K.W.** (1985). Global atmospheric $CO_2$ distribution and variations from 1968-1962, NOAA/GMCC $CO_2$ flask sample data. *Journal of Geophysical Research,* 90, 5567-5596.

**Lamb, H.H.** (1977). *Climate present, past and future,* Vol. 11. Methuen and Co. Ltd., London, 835 pp.

*Munson, P.J.* (1981). A Late Holocene (c. 4500-2300 BP) climatic chronology for the southwestern Sahara. *Palaeoecology of Africa,* 13, 53-60.

**Neftel, A., Oeschger, H., Schwander, J., Stauffer, B. and Zumbrunn, R.** (1982). Ice core sample measurements give atmospheric $CO_2$ content during the past 40 000 yr. *Nature,* 295, 220-223.

**Nugent, C.** (1988). The Zambezi River at Mana. *Zimbabwe Science News,* 22, 14-18.

**Nugent, C.** (1989). The Zambezi River: Tectonism, climatic change and drainage evolution. *Palaeogeography, Palaeoclimatology, Palaeoecology.* In press.

**Pearman, G.I., Etheridge, D., de Silva, F. and Fraser, P.J.** (1986). Evidence of changing concentrations of atmospheric $CO_2$, $N_2O$ and $CH_4$ from air bubbles in Antarctic ice. *Nature,* 320, 248-250.

**Ritchie, J.C. and Haynes, C.V.** (1987). Holocene vegetation zonation in the eastern Sahara. *Nature,* 330, 645-647.

**Rossignol-Strick, M.** (1983). African monsoon, an immediate climate response to orbital insolation. *Nature,* 304, 46-49.

**Shaw, P.A. and Cooke, H.J.** (1986). Geomorphic evidence for the Late Quaternary palaeoclimates of the Middle Kalahari of Northern Botswana. *Catena*, 13, 349-359.

**Singer, R. and Wymer, J.** (1982). *The Middle Stone Age at Klasies River Mouth in South Africa.* University of Chicago Press, 234 pp.

**Street-Perrott, F.A., Roberts, N. and Metcalfe, S.** (1985). *Geomorphic implications of Late Quaternary hydrological and climatic changes in the northern hemisphere tropics.* In: Douglas, I. and Spencer, T. (Eds), *Environmental change and tropical geomorphology,* Allen and Unwin, London, pp. 165- 183.

**Stuiver, M., Denton, G.H., Hughes, T.J. and Fastook, J.L.** (1981). *History of the marine ice sheet in West Antarctica during the last glaciation: a working hypothesis.* In: Denton, G.H. and Hughes, T.J. (Eds.) *The last great ice sheets.* John Wiley and Sons, USA, pp. 319-436.

**Warrick, R.A.** (1988). Carbon dioxide, climatic change and agriculture. *Geographical Journal,* 154, 221-233.

**The study of ice cores reveals much of past climates** **Photo: U.S. Information Agency**

# EDITORIAL

## Charting Our Course

According to our lead article, 'Climatic Change, the future for Zimbabwe' our decendants in Central Southern Africa, will live in one of the few places on Earth likely to benefit from future climatic change. Much of the world's population, living in the maritime nations, will not be so fortunate. It is thought that increased carbon dioxide concentrations in the atmosphere, leading to global warming and extensive melting of the ice sheets will raise the level of the sea and flood these low lying and densly populated lands.

There seems little doubt that climatic changes will have an influence, even in Zimbabwe. The available evidence suggests that we are entering a period of dryer weather, resulting from northerly movements of the equatorial rain belt, but that in the more distant future increased rainfall can be expected. In combination with elevated levels of carbon dioxide, such conditions favour crops like wheat and rice, rather than maize, our current staple food. Thus a greater use of drought resistant crops may become essential in the near future, with more emphasis being placed on crops like rice, for instance, in the more distant future.

We, in Zimbabwe are becoming more familiar with a changing world. Our precious wildlife, fast dissappearing, our precious land eroding away, with the threat of acid rain on our doorstep, and the AIDS epidemic looming like a black cloud in front of us.

And yet in almost every case, man is in a position to make "course corrections" for the better - if he so chooses.

In charting the course which Zimbabwe must take, it is essential that a scientific approach must be taken, and that practical use is made of the accumulated wealth of knowledge that is currently available to us. By so doing, it is possible for the nation as a whole to make "course corections" and adapt to make the best of new circumstances.

In a thought provoking view, written by the editors of World Development Forum, our Senior Citizens were here before the pill, penicillin, and plastic; before television, xerox and ballpoint pens. Unless we, of today, begin to make certain "course corrections" the Senior Citizens of 2089 will find themselves in a much more daunting and unfamiliar world. Will they be the ones who were here before the seas rose, before the headwaters of the Nile became a trickle, before the AIDS epidemic decimated cities on three continents. Will they be the ones who could, in past years, still see rhinos, elephant and cheetah in the wild and freshwater lakes teamed with life?

It is up to our scientists to chart a course into the future, using the great wealth of knowledge that is already available to us, for the benefit of our children and their children, after them.

PETER MORGAN

**What will the future bring for our children - and their children.**