Estimation of climate change and adaptation strategies using water, soil and honey as sampling media: examples from Namibia

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ESTIMATION OF CLIMATE CHANGE AND ADAPTATION STRATEGIES USING WATER, SOIL AND HONEY AS SAMPLING MEDIA: EXAMPLES FROM NAMIBIA

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Abstract

The Intergovernmental Panel on Climate Change (IPCC) released the Assessment Report number 4 which crystallised scientific evidence documenting unequivocal climate change. Global average air temperatures are rising and this rise has of late become so alarming that the last 11 (1995-2006) years show the highest increase since 1906 when instrumental records begun. Evidence for rising sea levels shows that since 1961, the global sea level rise has averaged at a rate of 1.8 mm, whereas since 1993-2006, this value has increased at a much higher value of 3.1 mm, higher than the normal global rate observed over the geological history. The Sahara (Sahel region), the Mediterranean, Southern Africa and parts of southern Asia have all recorded decreases in the volume of precipitation. These changes in precipitation have led to the occurrence of extreme events in Southern Africa, such as floods and drought in a much more frequent manner. However the frequency of these events is yet to be properly understood. Soil samples reveal extreme event frequency and groundwater perturbations. Bee colonies are sensitive to small changes in environment. Surface and ground water samples help compare the changes obtained from honey samples with past events in the last 100 to 200 years. Identification of colony collapse disorder (CCD) could entail a complex of environmental and/or anthropogenic factors including climate change. All these facts have been used to gauge small scale changes in climate. The results are being slowly accumulated and will help us predict the rate of cultivated crop stability in the future, and hence address issues of food security and water scarcity, so as to enhance traditional methods of adaptation.

INTRODUCTION

While climate change is affecting communities, the rate with which it is taking place is not documented. The rate of climate change will determine largely how adaptation strategies must be implemented. Communities may find themselves unable to cope with extreme events caused by climate change. Accurate forecasting of and preparedness to climate change as it affects food security-crop reliability, water, and economic activities that depend on these variables will need to be quantitatively assessed. This work therefore combines questionnaires and collection of scientific data from communities to gauge and improve adaptation strategies.

The Intergovernmental Panel on Climate Change released the Assessment Report number 4 (IPCC, 2007) which crystallised scientific evidence documenting unequivocal climate change. Global average air temperatures are rising. This rise has of late become so alarming that the last 11 years of the past 12 (1994-2006) show the highest increase since 1906 when instrumental records begun. The period 1906-2005 had an average increase of 0.74°C, whereas the period 1901-2001 had an average increase of 0.6°C (IPCC, 2001). The increase in temperature is a global phenomenon, the largest index being the melting of polar ice at the North and South Poles, respectively. Evidence for rising sea levels shows that since 1961 the global sea level rise has averaged at a rate of 1.8mm per annum, whereas since 1993-2006, this value has increased at a much higher value of 3.1 mm, higher than the normal global rate observed over the geological history. The corollary to rising sea levels is its effect on air circulation and moisture generation in the oceans.

Regional data suggests that precipitation in the Southern African region is likely to decrease in the next fifty years (Figure 1). This implies that detailed studies need to be undertaken now to accurately measure this change and how it will affect rural communities and livelihoods.

The effects of climate change on precipitation are diverse and varied. They depend on the size of the land mass, and its location on the earth, i.e., how far away from the polar regions or equatorial regions. Eastern parts of north and south America, northern Europe and northern and central Asia have recorded significant increases, raising the risk of extreme events such as floods. On the other hand the Sahara (Sahel region), the Mediterranean, southern Africa and parts of southern Asia have all recorded decreases in precipitation volumes. These changes in precipitation have led to more frequent occurrence of extreme events in southern Africa, such as floods and droughts, whose periods are not well understood. The frequency of these events is yet to be properly understood as to the causes and timing. It is hoped that the use of fractal analysis of precipitation and ecosystem adaptation will yield some pertinent results.

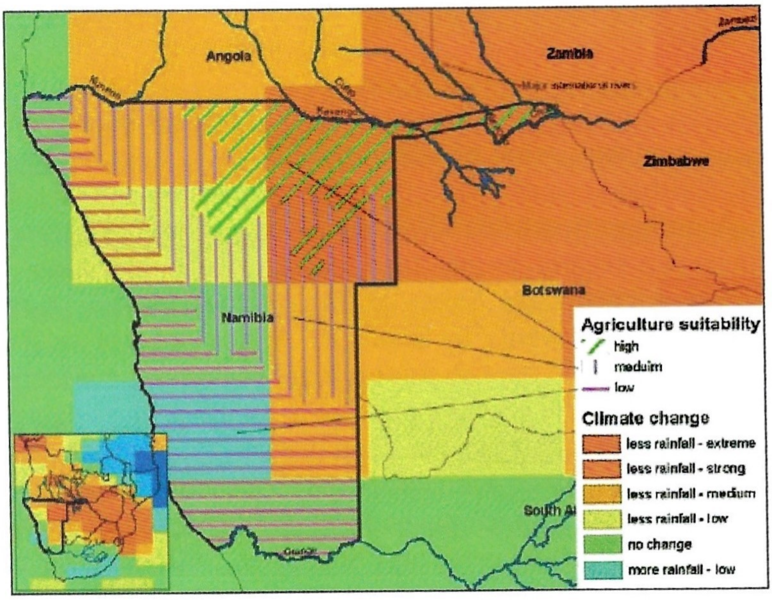


Figure 1: Climate Change Projected Map for the Years 1990-2020. After Mendlesohn *et al.*, 2002.

In the past eight years (2000-2008) more scientific data on Climate Change has been made available (IPCC, 2001, 2007). Models suggesting warming up of the globe have been constructed and show that though there are minor variations, the bulk of the data suggest increasing temperatures and a disturbed pattern of precipitation. Southern Africa is in a critical zone where rainfall and water availability are concerned. The region's climate is governed by the El Nino-Southern Oscillation and large scale atmospheric pressure system interactions that either enhance long periods of dryness or long rainfall. At present Southern Africa has a more or less well defined 30 year period variability in rainfall patterns which is beginning to change drastically (Christensen and Hewitson, 2007). Southern Africa is one of the areas on the globe which has been predicted to record a general rise in temperature in the 50 years (Murphy *et al.*, 2004).

From geological records we know that 3 million years ago when global temperatures were 3°C warmer than at present, sea level was 25 metres higher than current levels. Current observed rates of global warming of 1.2°C to 1.6°C over the last six decades (IPCC, 2007) indicate an imbalance in the global air and water circulation patterns. Diseases for both plant and animals also change with changes in climate. For instance a gradual drying up in Southern Africa would attract meningitis and unhygienic conditions; whereas if the opposite were to occur, such as very wet weather, then cholera would be widespread over the sub-region.

Literature on the impacts of climate change on food security has become relatively more available, some of which have delved into adaptation strategies (Klein, 2001; Leichenko and O'Brien, 2002; Misselhorn, 2005). In semi-arid tropics like Namibia, Botswana, Western Zambia and Western Zimbabwe, climate change can trigger events that lead to mass migration, hunger and famine, as East African and Sahel examples have shown (Konare, 2009). Extreme meteorological events in Southern Africa are not well understood, due to the lack of scientific data at sub-regional scale on the effects and rate of change. Such data would be very appropriate in synthesizing adaptive strategies based on a time series analysis. Furthermore, no data exists on how honey bees, forests, water scarcity or availability and soils can be used to estimate the rate of change at the micro and macro level. Clays in soils can retain certain anthropogenic cations (e.g. Mapani and Schreiber, 2008). These minerals can be used to determine pesticide or environmental contamination in a particular area. CCD, the effect of bee colonies dying at an accelerated rate has been well documented in North America (USDA, 2007; Lester, 2007), where causes have been tentatively attributed to biotic factors such as Varroa mites; Nosema apis and Israel acute paralysis virus. Other threats to bees that the USDA mentions are pesticides, genetically modified organisms (GMOs) and micro-changes in climate. In Europe CCD has been reported widely as well; e.g., Molga (2007) who connects climate change to bee losses; and in turn bee losses to food losses as the bees are the major pollinators of most cultivated crops. Mapani (2005) has shown that some pesticides have long life residence in water. We know that the quantity of precipitation decreases from east towards the west for Namibia. How this decrease will change with time it is not clear. What adaptive strategies are best suitable? Communities have their own methods of adaptation, some of which require refinement, while others are not useful in certain circumstances.

OBJECTIVES OF THE STUDY

The main objective of this paper is to disseminate new techniques and current knowledge on the rate of Climate Change in the Omusati, Ohangwena, Kavango, Otjozondjupa and Caprivi regions and assess whether current adaptation strategies are sufficient for the near future.

METHODOLOGY

The research focussed on sampling unprocessed honey from honey combs, soil in the vicinity of the honey samples, and groundwater where possible in the Omusati, Ohangwena, Kavango, Otjozondjupa and Caprivi regions of Namibia. Honey samples were analysed for pollen density. Species will be identified and pollen of cultivated and wild species will be recorded. Since pollen grains do not degrade over time, and retain their integrity; and are known to be resilient natural products, we will have accurate data of pollen both from honey and soils as described below.

Soil samples were sampled over a 0.5m to 1m soil horizon in a few locations, and sampling is ongoing, from which profiles will be obtained, and grain mounts made to study extreme event frequency and groundwater perturbations. Crops that are pollinated by wind will be investigated from soil samples collected from several locations. The soil profiles will also be dated using Pb^{210} to obtain exact dates and time frames reflecting flooding events in the past few hundred years to present. A questionnaire was also employed to assess community adaptation.

This combined pool of information is yielding three main lines of evidence: bee colony stability, pollen health and environmental change. This will give us an idea of the changes taking place on a very short time scale over the next five years. Identification of CCD could entail a complex of environmental and/or anthropogenic factors including climate change. Water and soil samples will help compare the changes obtained from honey samples with past events in the last 100 to 200 years using data of ^{18}O ratios of water and in honey to ^{18}O ratios from boreholes so as to establish how the food security is related to water adequacy in the area. The bee sourced information will yield data on a scale of months to a few years, which will be supplemented by questionnaire information.

The data obtained will be treated on a fractal dimension of both time and space. Soil samples will be geostatistically treated to observe covariance between sites and moisture shifts. The results so obtained will help predict crop stability in the future, and hence address issues of food security and water scarcity, so as to enhance traditional methods of adaptation in the study areas.

RESULTS

As the study is still ongoing, only partial results are available for comment. First is the diminishing number of beehives within communities. This is especially so in the Ohangwena region, followed by the Omusati region. The Otjozonjupa region has not been well documented in the past, hence a comparison is not possible to current beehive levels.

Precipitation levels have also been obtained, together with studies on river flow volumes for the Okavango, Kunene and Zambezi rivers from Mendlesohn *et al.*, (2002) (Figures 2, 3 and 4). These rivers are major indicators of moisture shifts in the subregion. In contrast to the Zambezi river in the same period, both the Kunene and Okavango show marked decreases in annual river flows. The Zambezi river on the other hand shows a see-saw pattern, suggesting extreme event behaviour, where the total moisture remains more or less constant. The Zambezi river also shows this patterns as a result of its large catchment in the Democratic Republic of Congo and Angola.

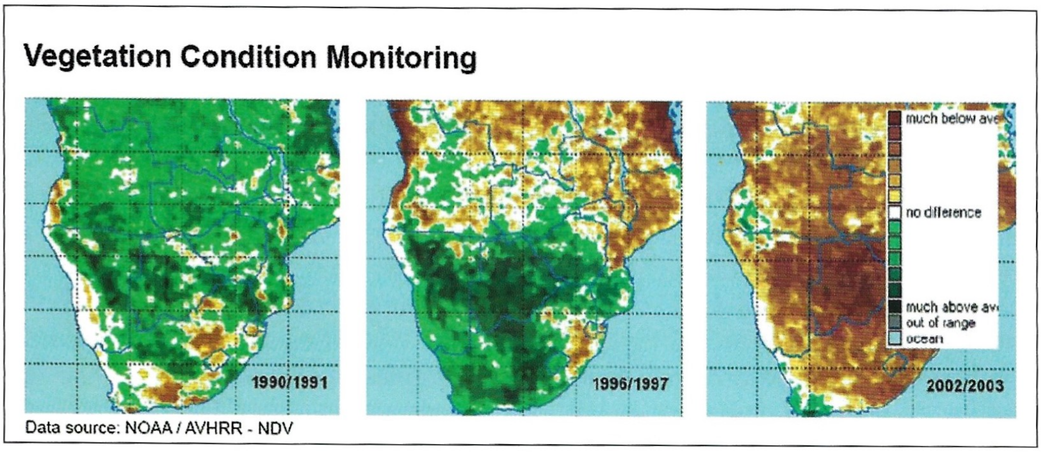


Figure 2: Vegetation Conditions of Vigour as Established by Satellite Imagery NDV from NOAA and AVHRR.

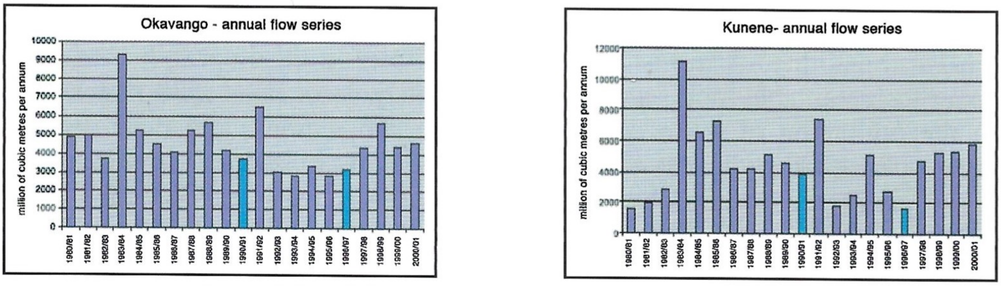


Figure 3: Annual River Flows for the Okavango and Kunene Rivers for the period 1990-2000 respectively (after Mendlesohn *et al.*,2002).

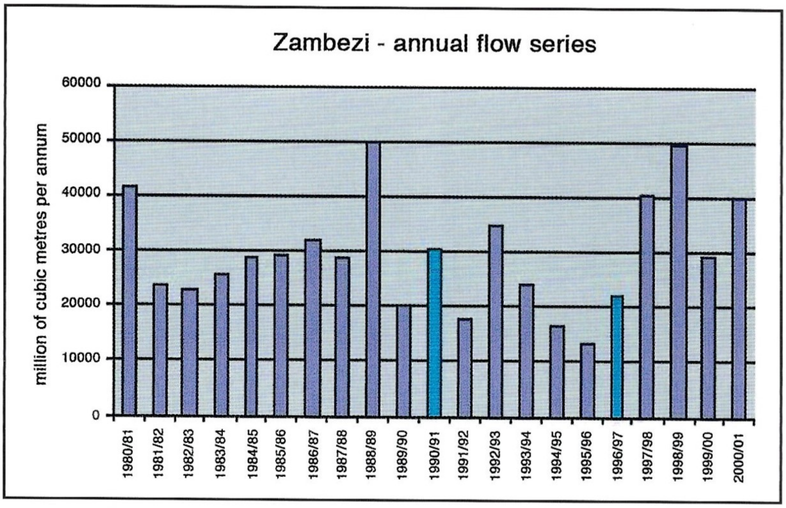
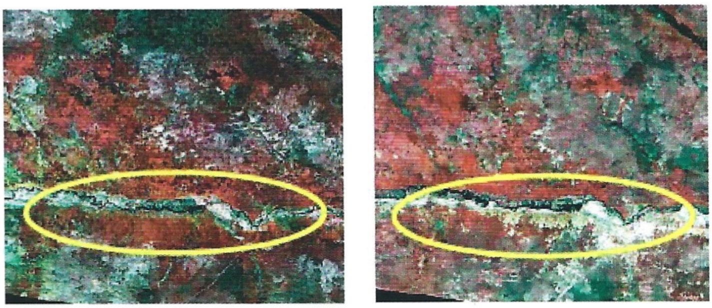


Figure 4: Annual River Flows for the Zambezi River, 1990-2000 (after Mendlesohn *et al.*, 2002).

Crops such as melons, pumpkins, which are entomorphilously pollinated crops are in danger of being affected by adverse effects of climate change accelerated by human agents of deforestation. The main cause in the study regions is the diminishing forest cover (Figures 2 and 5). In figure 2, we observe that the main changes in forest cover occurred between 1997 and 2003. The changes in forest cover are more complex to study as it is both anthropogenic and climate changes due to reduction in moisture levels reaching the Ohangwena and Kavango areas. In figure 5, we see the reduced forest cover due primarily to anthropogenic causes. As more and more people settle and clear large tracts of land for cropping, a lot of forest cover is lost. In such areas, it is essential that we educate the local populace on how to protect and keep forest cover for community adaptation and sustainability of subsistence agriculture. Hence the importance of forest cover to sustainable food security is immediately seen. Bees are a major factor in the polination of some cash crops in the sub regions, and their decrease means pollination will only be dependent on few insect species and wind. Wind speed also is determined by the amount of forest cover. A sustainable forest cover achieves a number of things: Firstly, it ensures favourable microclimates for bee activity and, consequently, plant pollination. Secondly it improves plant root activity and organic matter structure in the soil, increasing hydraulic conductivity and reducing runoff. These parameters increase soil moisture and soil fertility. Forest cover also blocks winds that would carry dust bowls, which are detrimental to crop pollination, as in desertified areas. Lastly, forest cover increases precipitation.



Satellite imagery (Landsat MSS, ETM+) of 100 km of the Namibia - Angola border. Dark indicates forests, white areas bare soils. The forest along the Cubango river is clearly seen in the 1973 image and little remails by the year 2000

Figure 5. Satellite Imagery from Landsat MSS, ETM Showing Deforestation between 1973 and 2000.

Supplementary information to the other parameters employed in the study have come from tree-trunk rings, that can be correlated with isotope data. Tree rings in moist years are thicker, whereas in drought years are thinner.

LESSONS

There is a subtle but noticeable change in climate in the subregion. Indicators of changes in precipitation show that we are currently receiving less moisture than in the past four decades. It is therefore a big lesson for us to begin implementing strategies that will mitigate these changes in climate for mostly rural communities. Working with communities is an important factor in issues relating to arresting climate change. Communities have to be made aware of the impact of deforestation. Rainforests once covered 14% of the earth's land surface; now they cover a mere 6%.

Estimates show that the last remaining rainforests could be consumed in less than 40 years (HYPERLINK "http://www.rain-tree.com/facts.htm" http://www.rain-tree.com/facts.htm). The ensuring of beehive survival is crucial for ecosystems in these regions, as bees are important in pollination of several wild species. These trees make up forests, which in turn help in moisture distribution over periods of years and decades. Bees are also agents of pollination for some crops such as melons and pumpkins in the studied areas.

CONCLUSIONS AND RECOMMENDATIONS

The main conclusions at present are that ecosystems appear to be under stress in these regions. The Ohangwena region has recorded a major decrease in forest cover. This is partly due to growing populations and need of grazing and farm land for communities. This then requires a reforestation programme to help trap lower level atmospheric moisture. However, it is important to ensure that populations co-exist with large forests. The management of wild bees requires an understanding of managing forests. These two taken hand in hand would help communities mitigate some effects of climate change in their areas. The main recommendation is a region wide education programme on how communities can mitigate climate change impacts and adapt to current situations.

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