Understanding vulnerability, impacts and risks of climate change on ecosystems

C.H.D. Magadza
magadza.christopherhd@gmail.com

Observations

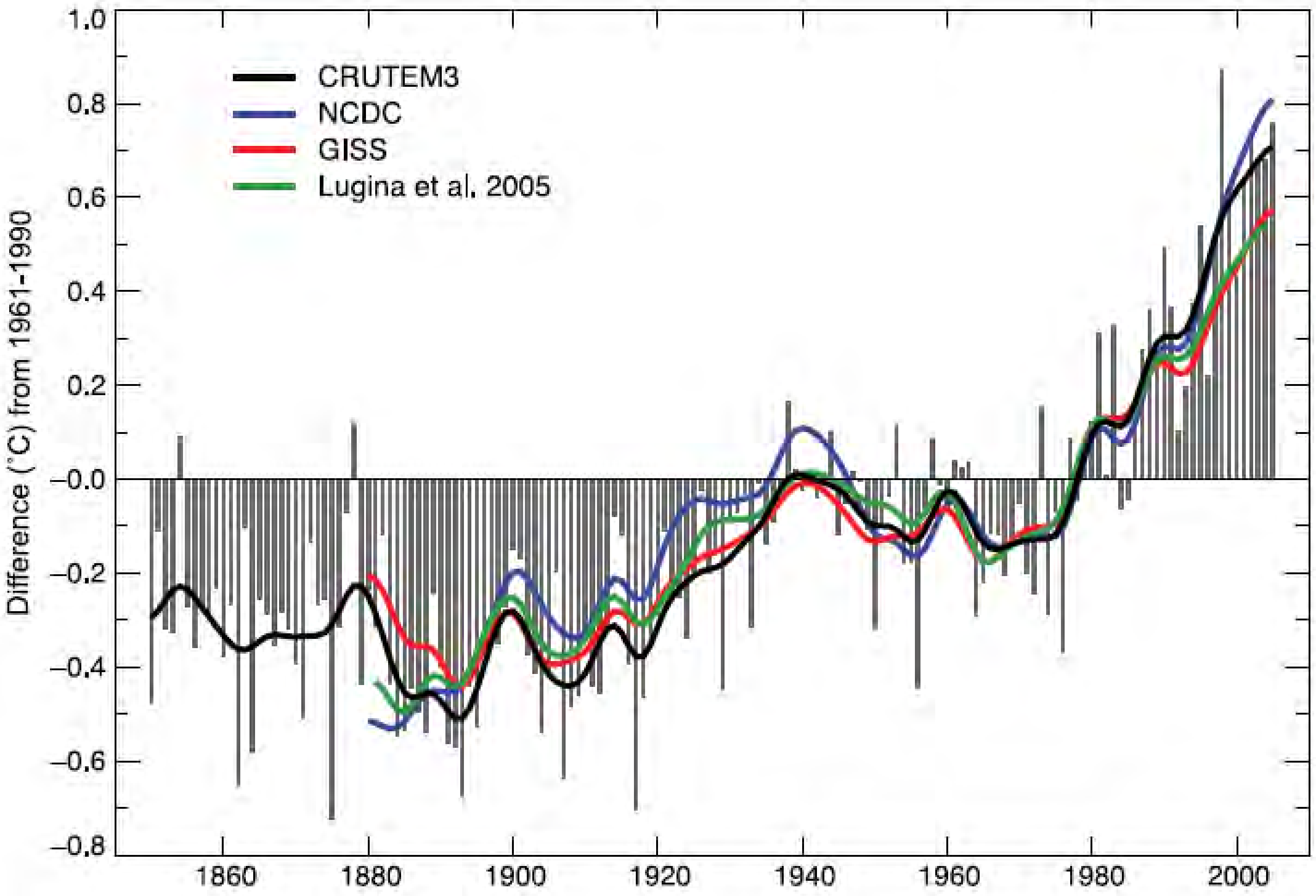


Figure 3.1. *Annual anomalies of global land-surface air temperature (°C), 1850 to 2005, relative to the 1961 to 1990 mean for CRUTEM3 updated from Brohan et al. (2006). The smooth curves show decadal variations (see Appendix 3.A). The black curve from CRUTEM3 is compared with those from NCDC (Smith and Reynolds, 2005; blue), GISS (Hansen et al., 2001; red) and Lugina et al. (2005; green).*

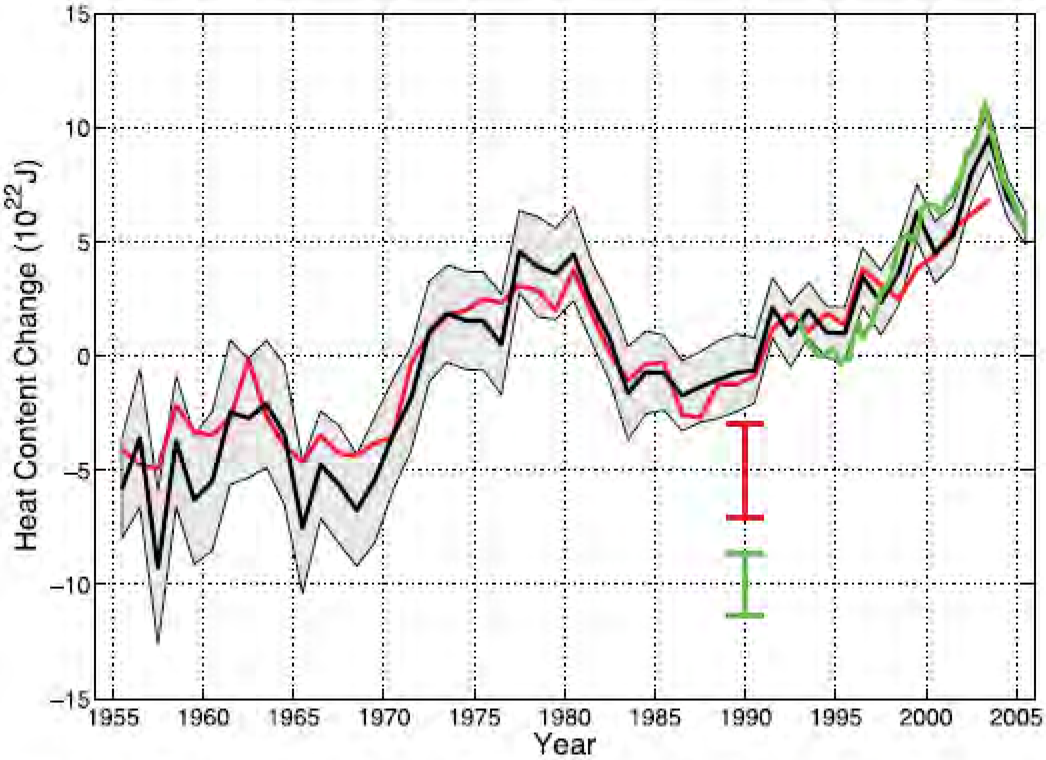


Figure 5.1. *Time series of global annual ocean heat content (10^{22} J) for the 0 to 700 m layer. The black curve is updated from Levitus et al. (2005a), with the shading representing the 90% confidence interval. The red and green curves are updates of the analyses by Ishii et al. (2006) and Willis et al. (2004, over 0 to 750 m) respectively, with the error bars denoting the 90% confidence interval. The black and red curves denote the deviation from the 1961 to 1990 average and the shorter green curve denotes the deviation from the average of the black curve for the period 1993 to 2003.*

Changes in dissolved ocean CO_2 & pH

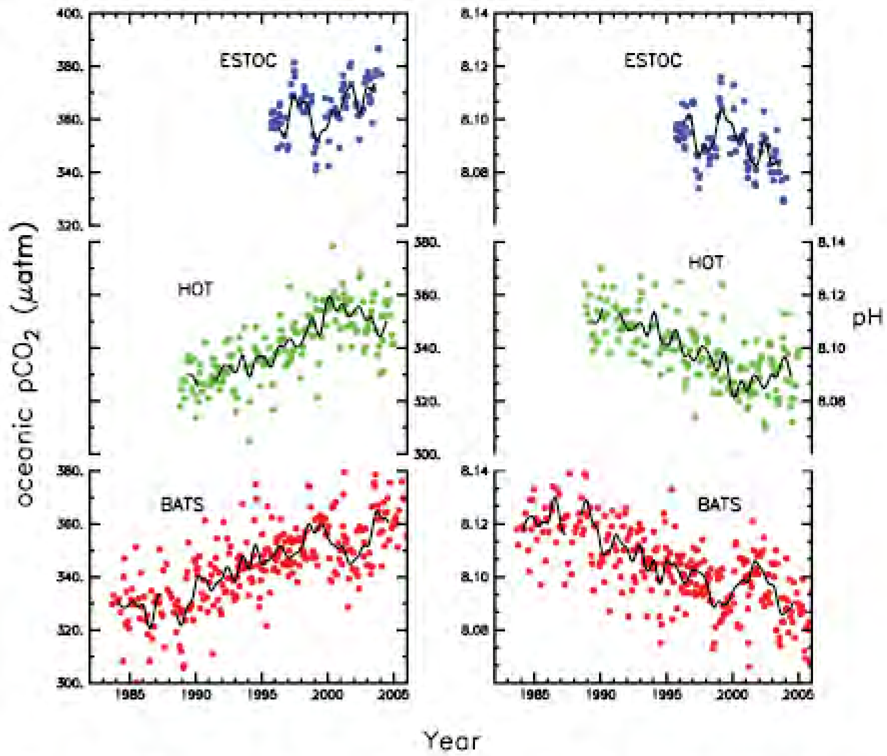


Figure 5.9. *Changes in surface oceanic pCO_2 (left; in μatm) and pH (right) from three time series stations: Blue: European Station for Time-series in the Ocean (ESTOC, 29°N, 15°W; Gonzalez-Dávila et al., 2003); green: Hawaii Ocean Time-Series (HOT, 23°N, 158°W; Dore et al., 2003); red: Bermuda Atlantic Time-series Study (BATS, 31/32°N, 64°W; Bates et al., 2002; Gruber et al., 2002). Values of pCO_2 and pH were calculated from DIC and alkalinity at HOT and BATS; pH was directly measured at ESTOC and pCO_2 was calculated from pH and alkalinity. The mean seasonal cycle was removed from all data. The thick black line is smoothed and does not contain variability less than 0.5 years period.*

Projections of the climate system (AR4 WGI)

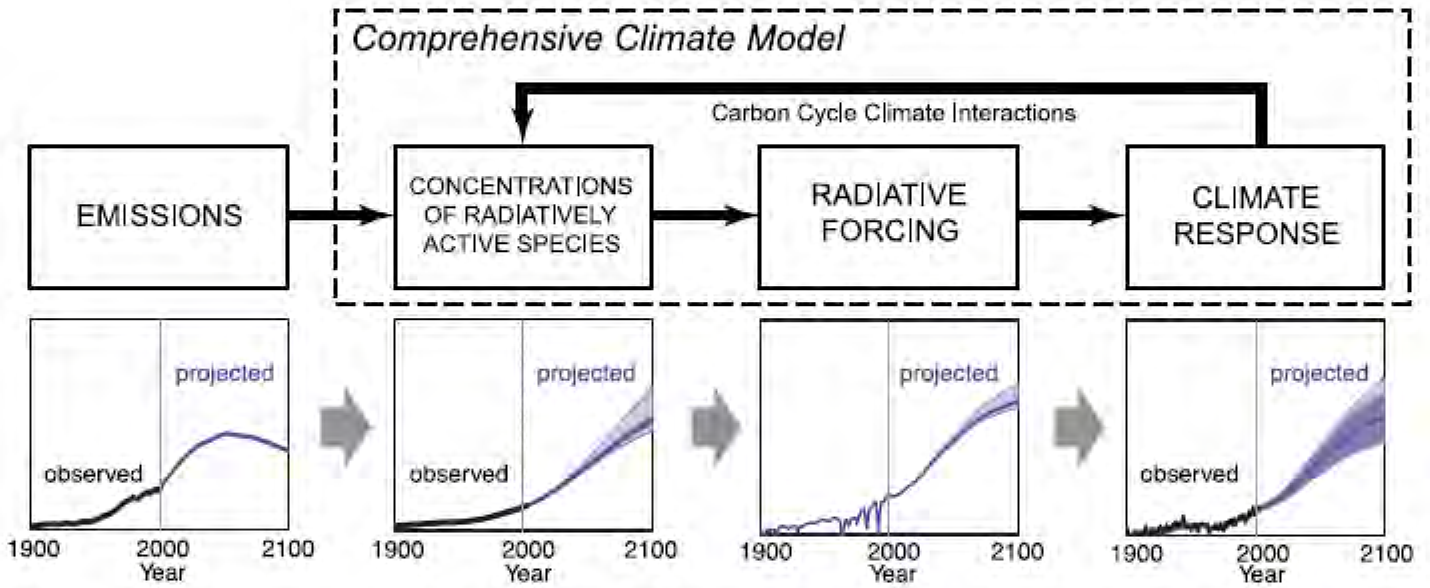


Figure 10.1. *Several steps from emissions to climate response contribute to the overall uncertainty of a climate model projection. These uncertainties can be quantified through a combined effort of observation, process understanding, a hierarchy of climate models, and ensemble simulations. In a comprehensive climate model, physical and chemical representations of processes permit a consistent quantification of uncertainty. Note that the uncertainty associated with the future emission path is of an entirely different nature and not addressed in Chapter 10. Bottom row adapted from Figure 10.26, A1B scenario, for illustration only.*

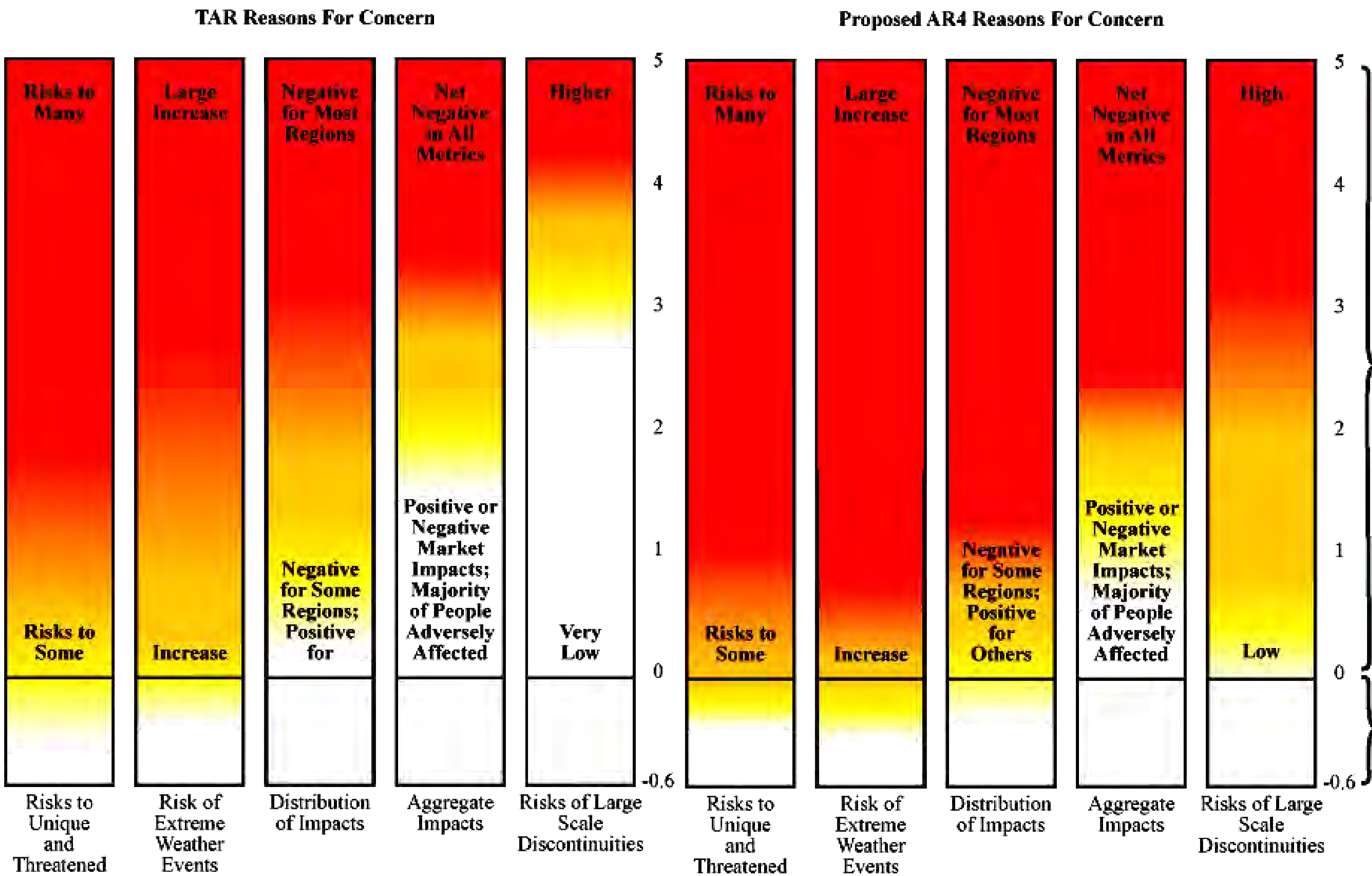
ARTICLE 2
OBJECTIVE

The ultimate objective of this Convention and any related legal instruments that the Conference of the Parties may adopt is to achieve, in accordance with the relevant provisions of the Convention, **stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system.** Such a level should be achieved within a time-frame sufficient to allow ecosystems to adapt naturally to climate change, to ensure that food production is not threatened and to enable economic development to proceed in a sustainable manner.

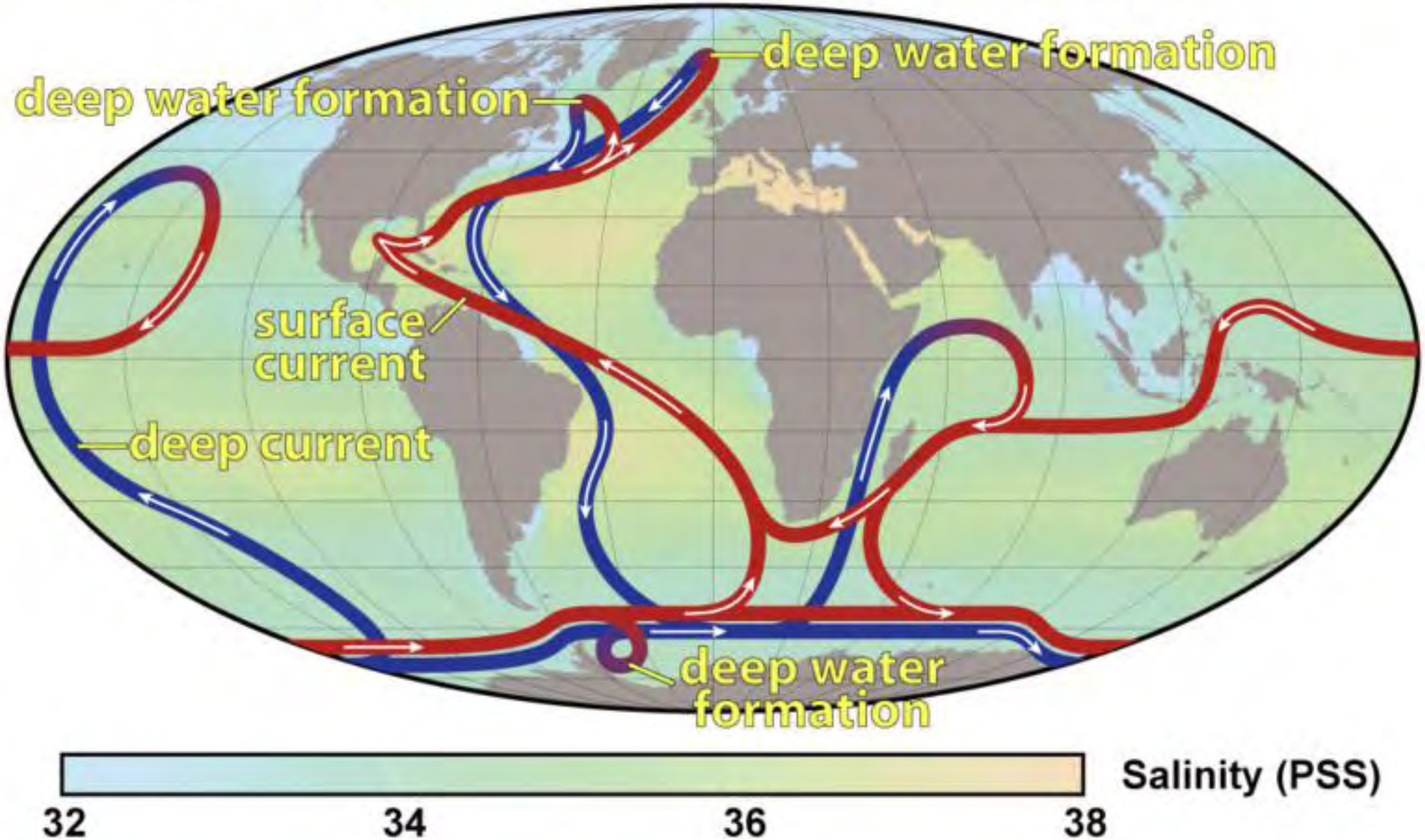
Assessing dangerous climate change through an update of the Intergovernmental Panel on Climate Change (IPCC) ''reasons for concern''

Joel B. Smith[a,1], Stephen H. Schneider[b,c,1], Michael Oppenheimer[d], Gary W. Yohe[e], William Hare[f], Michael D. Mastrandrea[c], Anand Patwardhan[g], Ian Burton[h], Jan Corfee-Morlot[i], Chris H. D. Magadza[j], Hans-Martin Füssel[f], A. Barrie Pittock[k], Atiq Rahman[l], Avelino Suarez[m], and Jean-Pascal van Ypersele[n]

Climate change thresholds for various “Reasons for Concern”



Thermohaline Circulation



Slowing of the Atlantic meridional overturning circulation at 25° N

Harry L. Bryden[1], Hannah R. Longworth[1] & Stuart A. Cunningham[1]
National Oceanography Centre, Empress Dock, Southampton SO14 3ZH, U

Nature **438**, 655-657 (1 December 2005)

The comparison suggests that the Atlantic meridional overturning circulation has slowed by about 30 per cent between 1957 and 2004. Whereas the northward transport in the Gulf Stream across 25° N has remained nearly constant, the slowing is evident both in a 50 per cent larger southward-moving mid-ocean recirculation of thermocline waters, and also in a 50 per cent decrease in the southward transport of lower North Atlantic Deep Water between 3,000 and 5,000 m in depth. In 2004, more of the northward Gulf Stream flow was recirculating back southward in the thermocline within the subtropical gyre, and less was returning southward at depth.

Illustrative impacts

Water

- Runoff and water availability are very likely to increase at higher latitudes and in some wet tropics, including populous areas in E and SE Asia, and decrease over much of the mid-latitudes and dry tropics, which are presently water-stressed areas. ** D9 [F3.4]

- Drought-affected areas will likely increase and extreme precipitation events, which are likely to increase in frequency and intensity, will augment flood risk. Increase of frequency and severity of floods and droughts will have implications on sustainable development. ** N [3.4]

- Water volumes stored in glaciers and snow cover are very likely to decline, reducing summer and autumn flows in regions where more than one sixth of the world population currently live. ** N [3.4]

Runoff changes 2041-2060 (IPCC AR4)

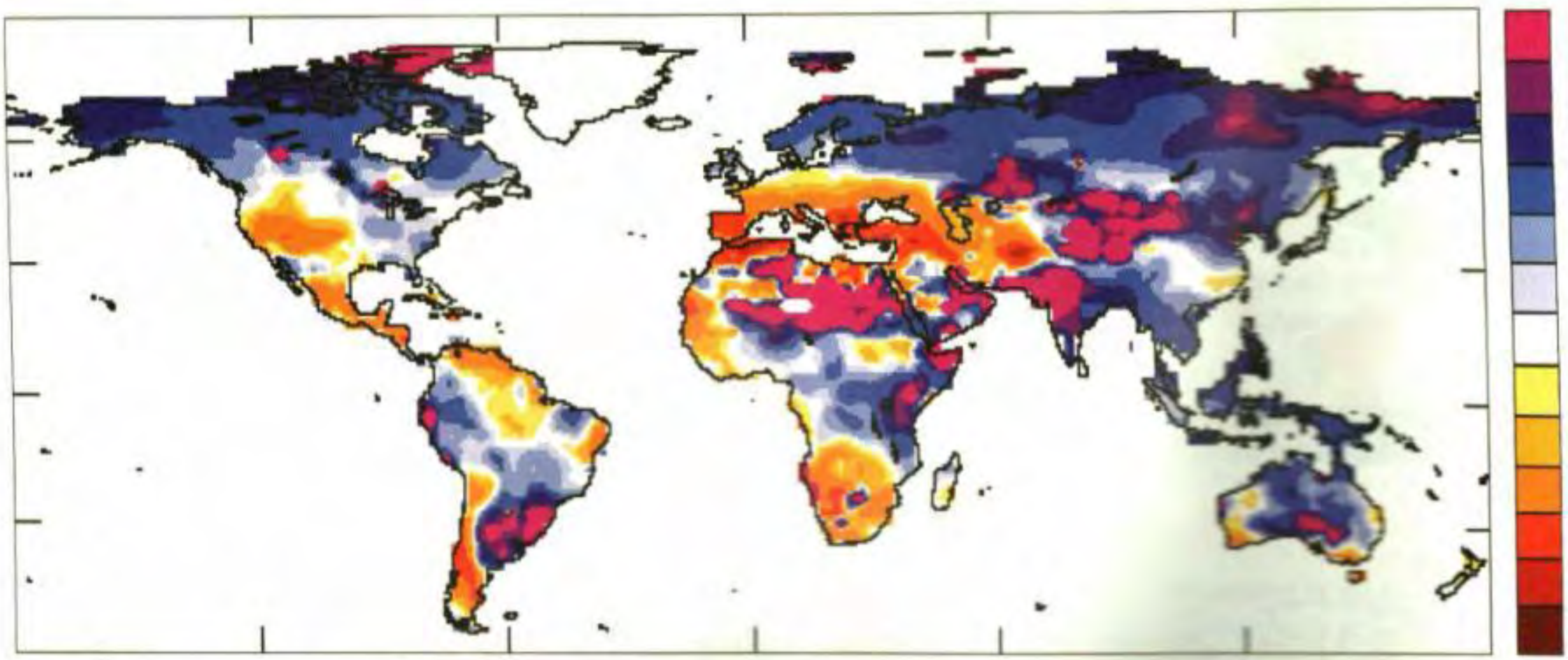


Figure 3.4. *Change in annual runoff by 2041-60 relative to 1900-70, in percent, under the SRES A1B emissions scenario and based on an ensemble of 12 climate models. Reprinted by permission from Macmillan Publishers Ltd. [Nature] (Milly et al., 2005), copyright 2005.*

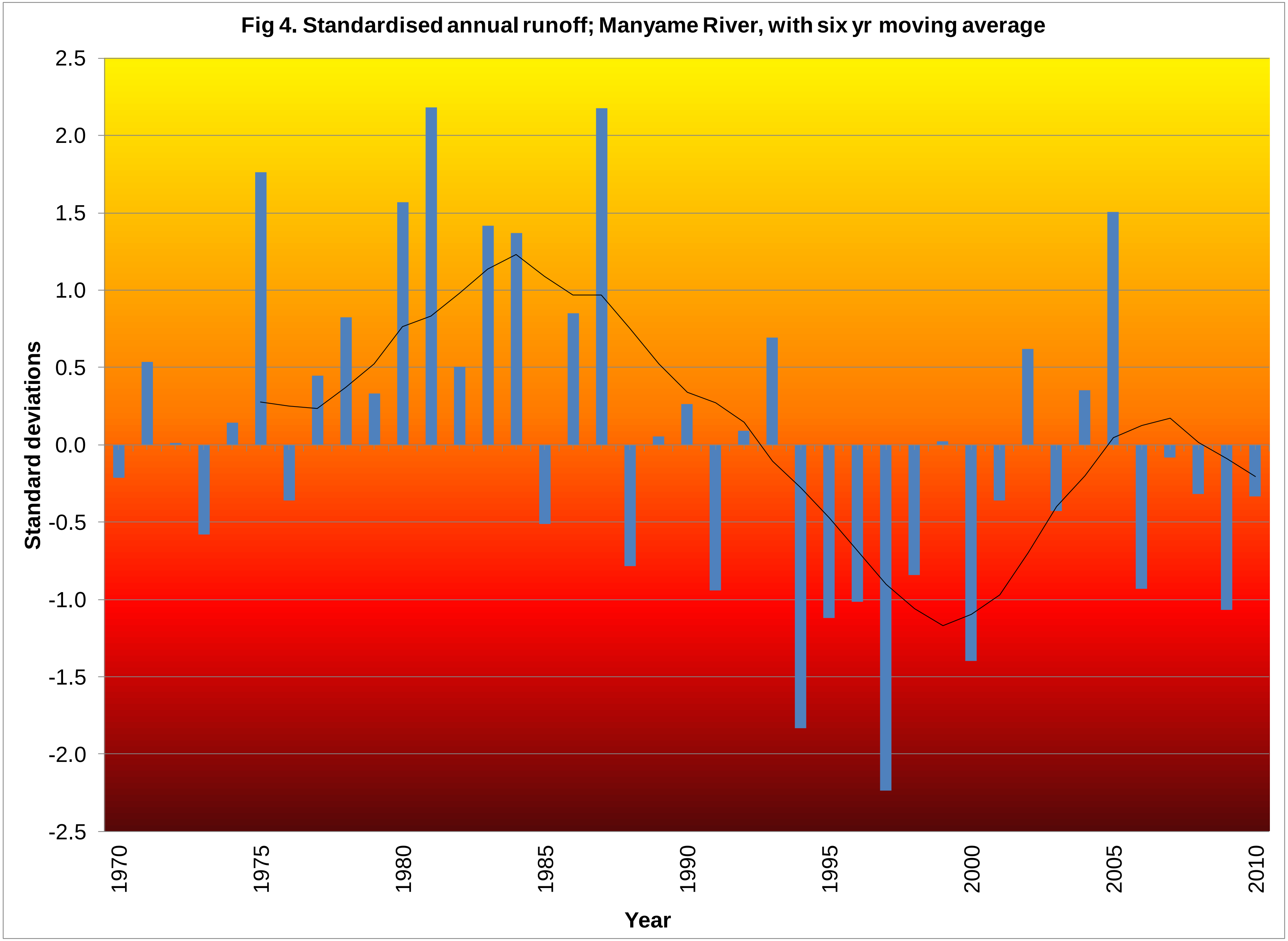
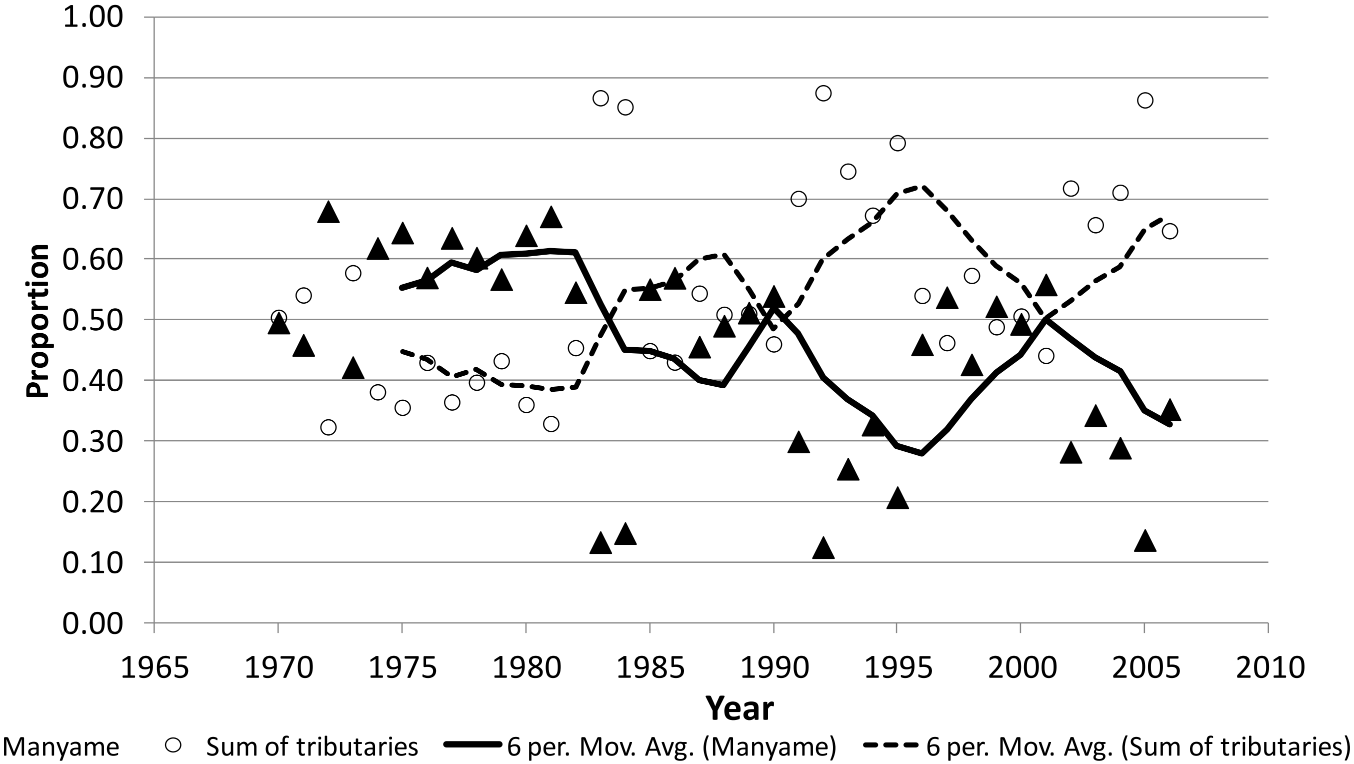


Fig 4. Standardised annual runoff; Manyame River, with six yr moving average
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
-1.0
-1.5
-2.0
-2.5
Standard deviations
1970
1975
1980
1985
1990
1995
2000
2005
2010
Year

Seke Dam (Prince Edward) on 23 rd Feb 2013

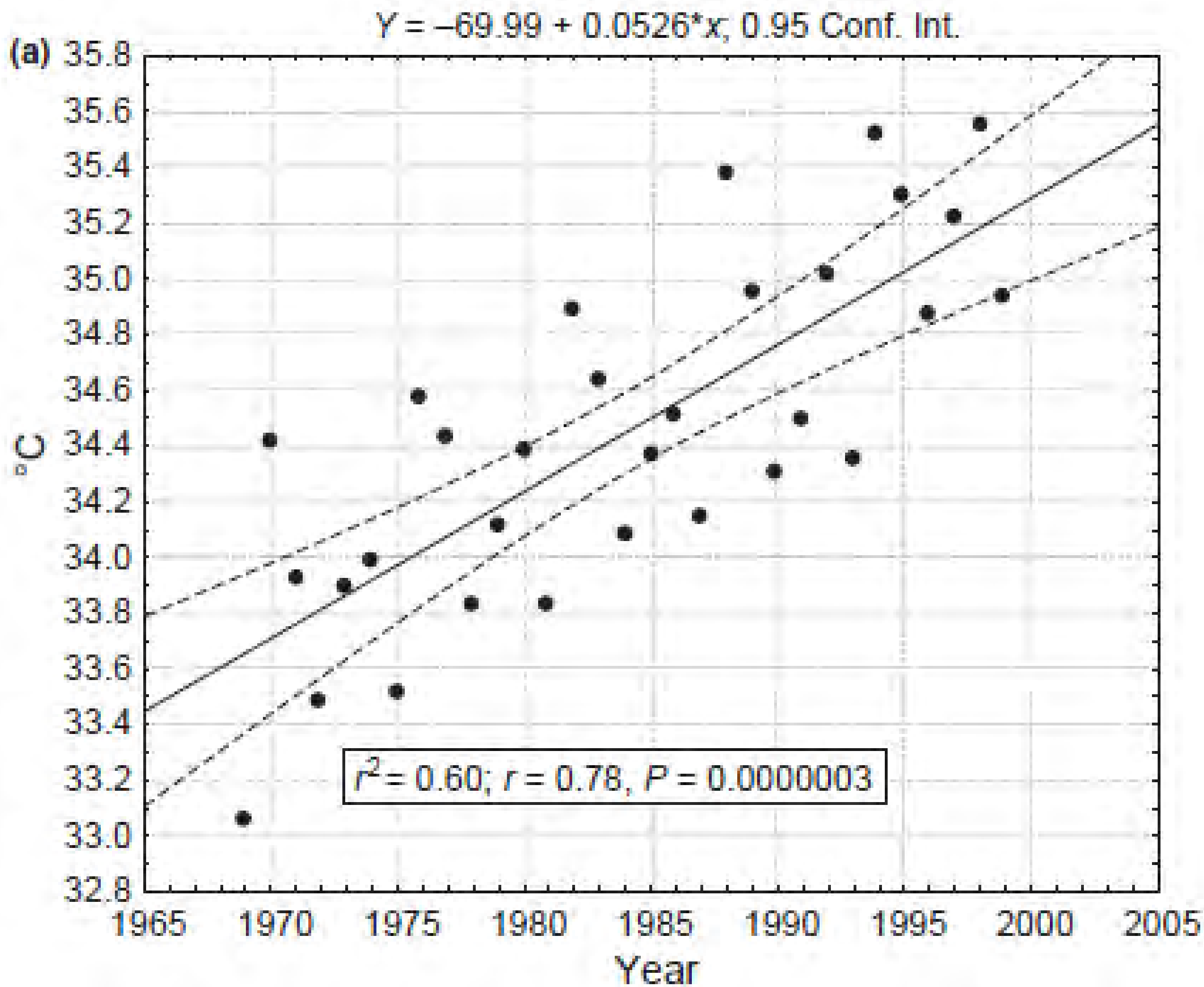
Fig 6. Proportionate flows of sewage bearing streams and Manyame runoff



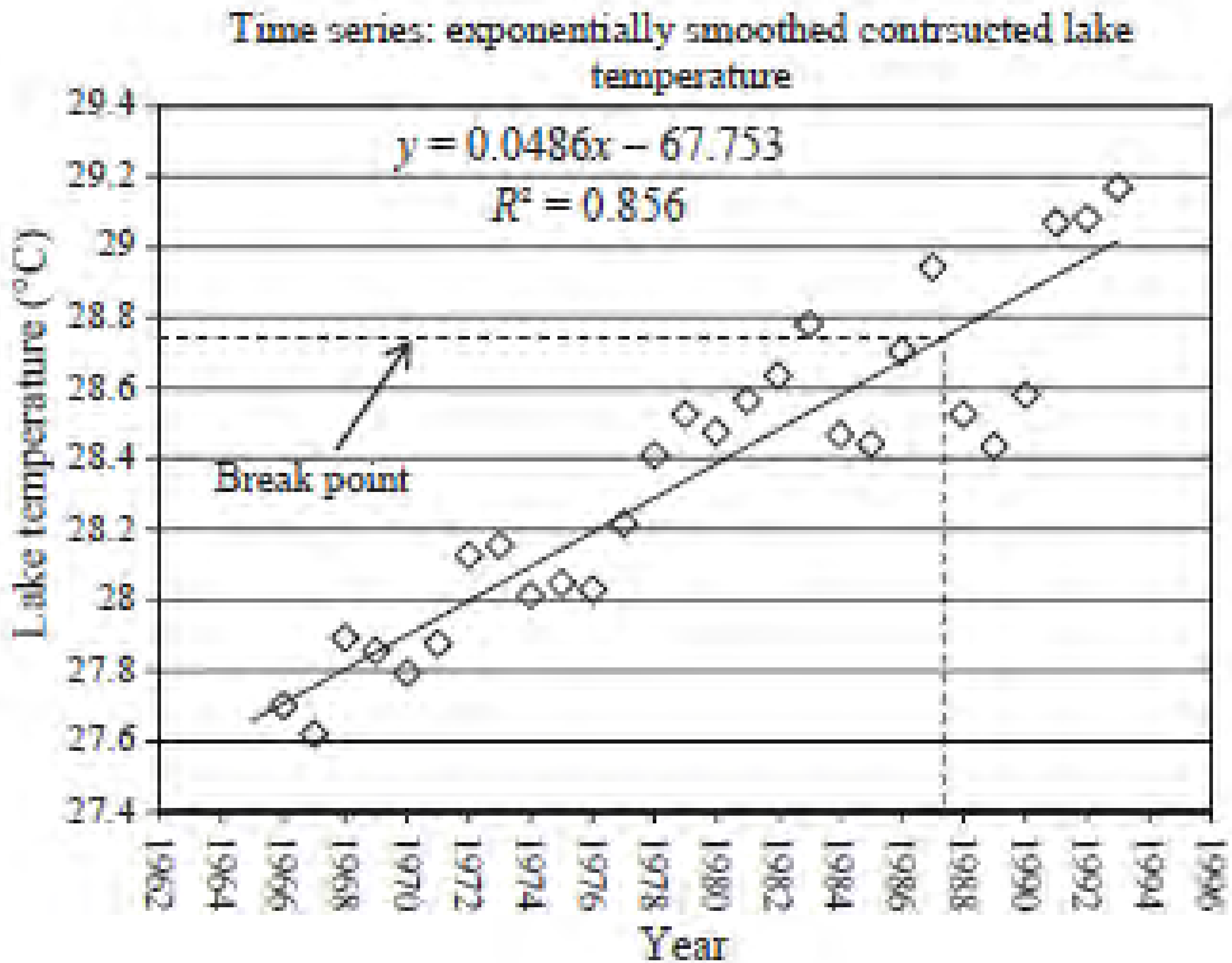
Water scarcity: Harare

Ecosystem function: Kariba case study

Lake Temperature: L. Kariba (Magadza 2012)



Lake Temperatures; L Kariba (Magadza 2012)



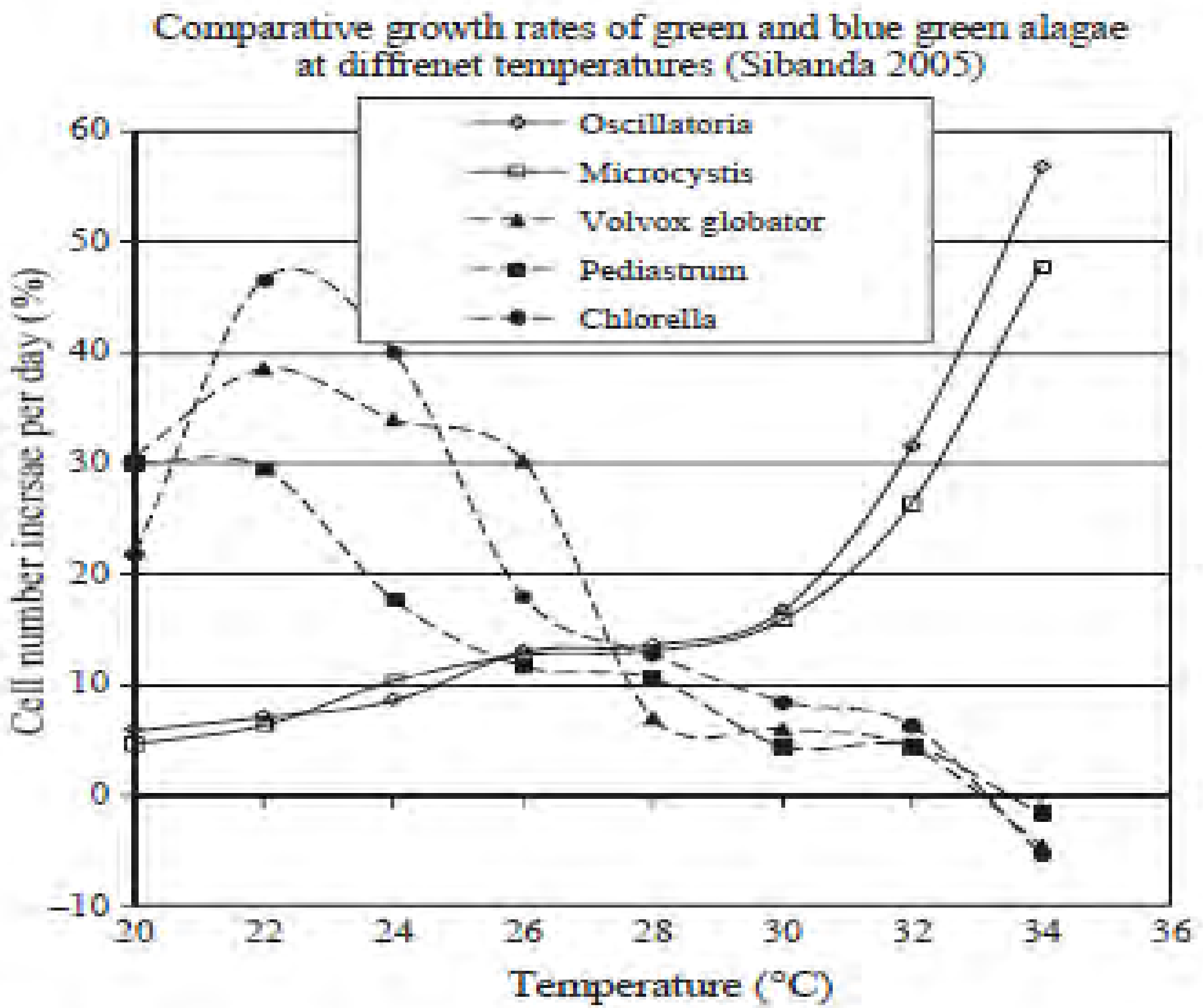


Fig. 7. Comparative growth rates of Chlorophyceae and Cyanophyceae at different temperatures (data from Sibanda 2005).

Impact of climate change

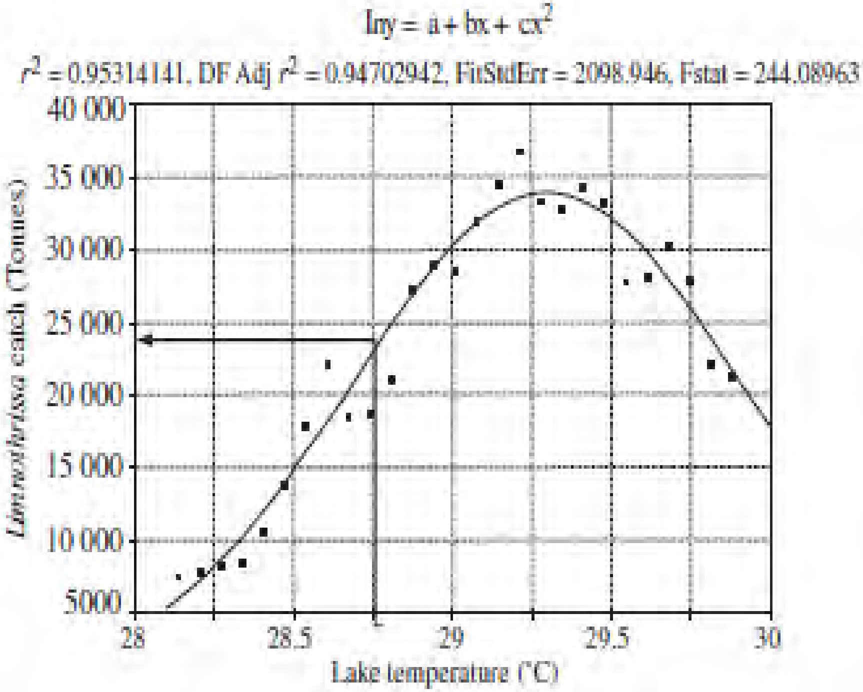


Fig. 3. Plot of *Limnothrissa* catches against epilimnion lake September/October/November temperature.

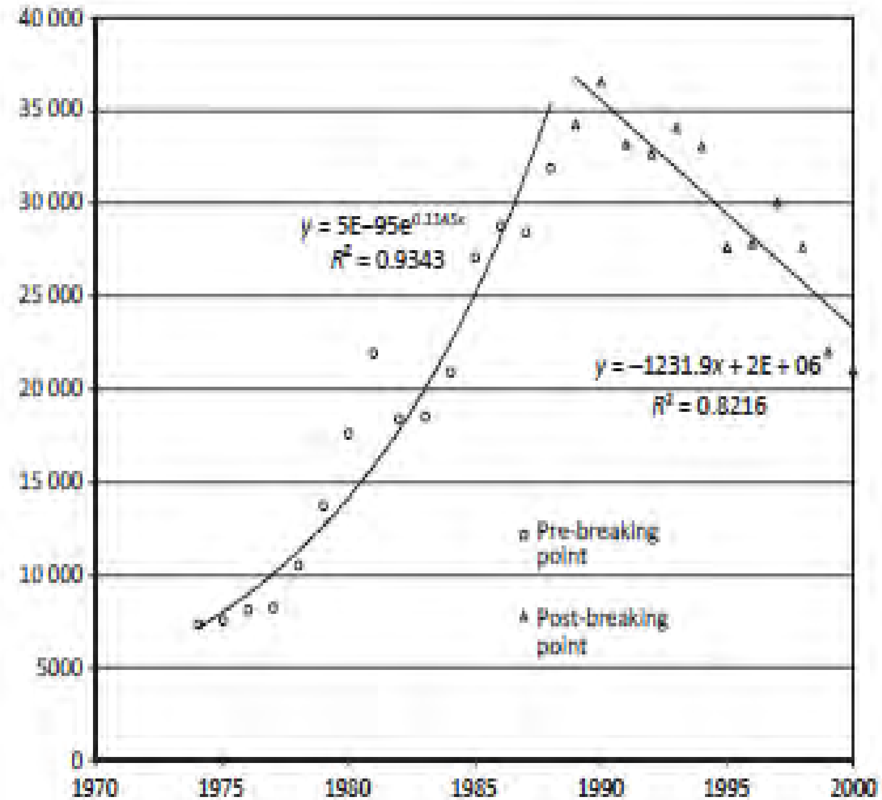
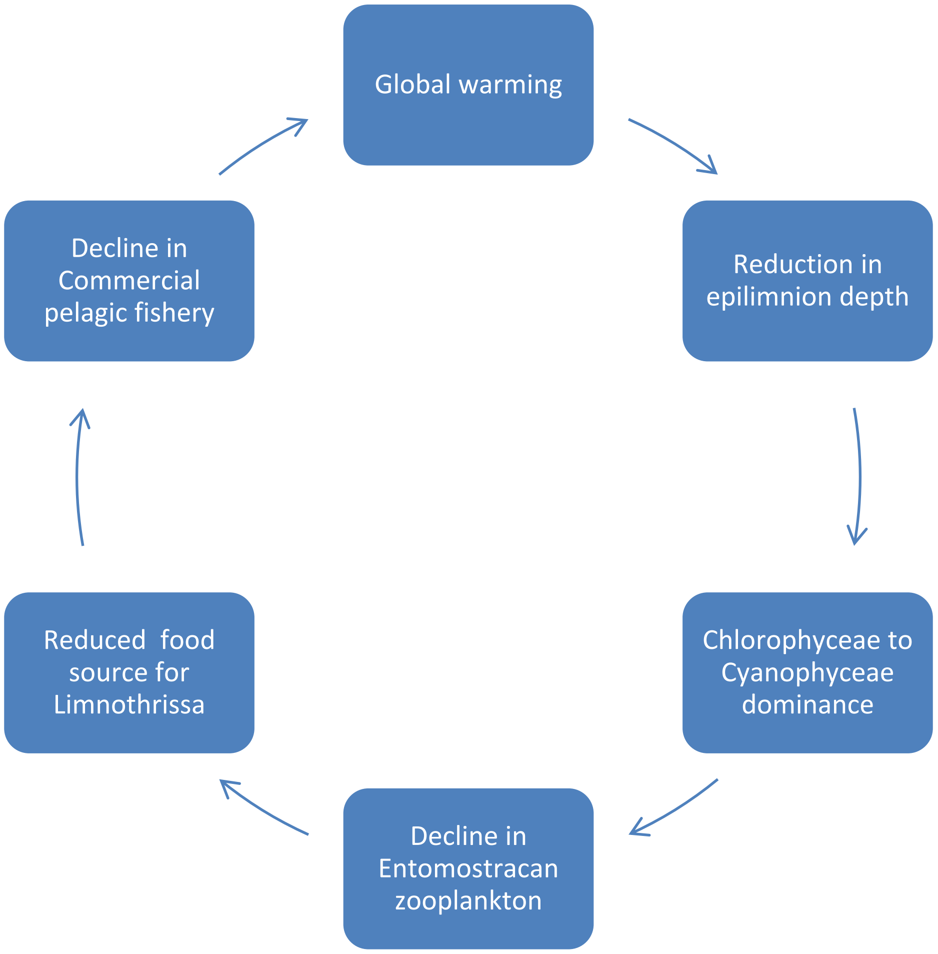


Fig. 4. Pre- and post-break point *Limnothrissa* catch trends, showing exponentially-growing fishery prior to 1988, and linear decline thereafter.

Ecosystem changes in L. Kariba (Magadza 2012)

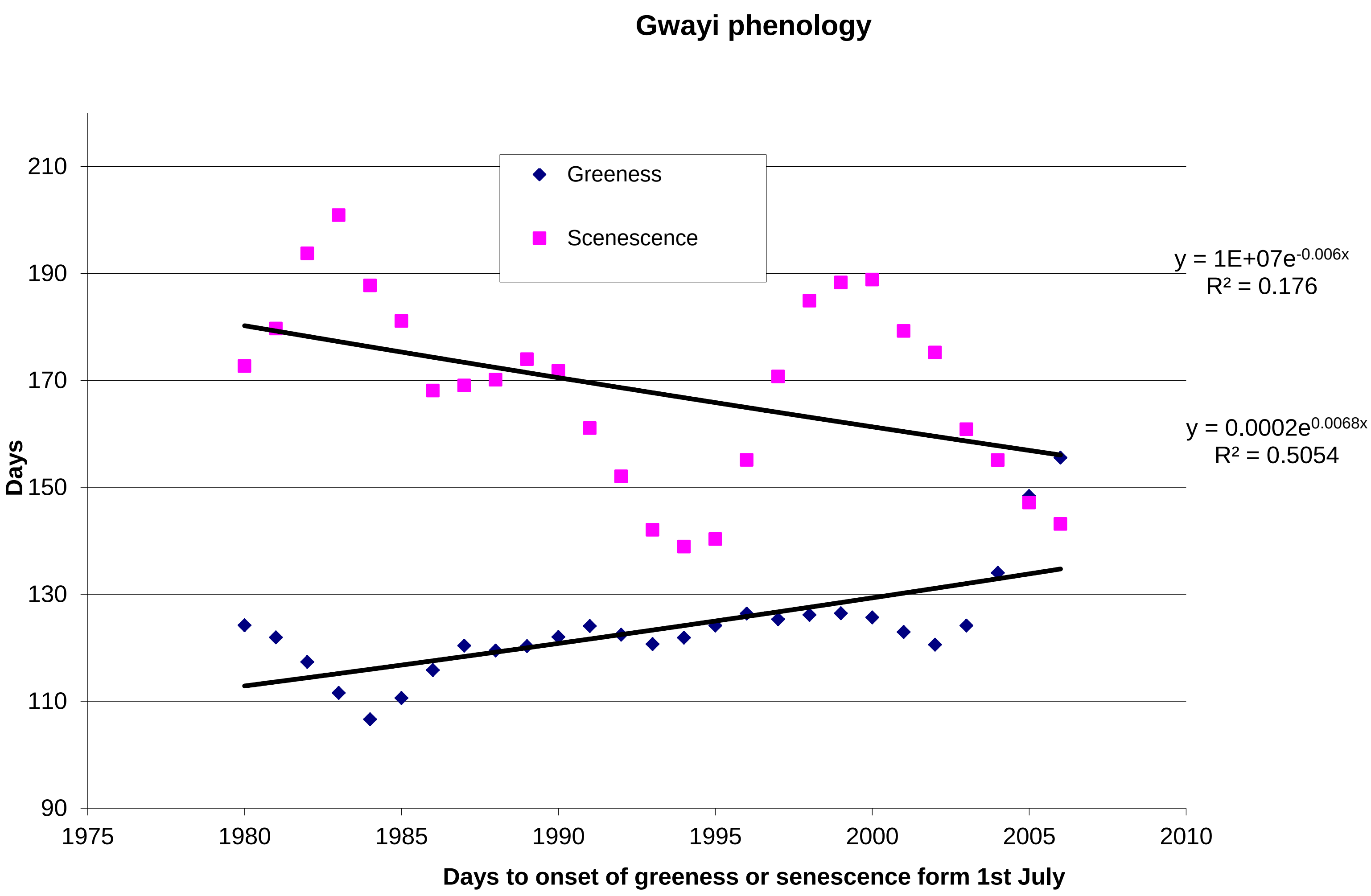


Forestry and Biodiversity

- Changes in forestry productivity and phenology have a variety of impacts on ecosystems
  - Herbivorous mammals‘ reproductive cycles are synchronised with the primary producers.
  - Migratory insectivorous species synchronise their migration to the life cycle on insects that feed on the forest products.
- These behaviours have evolved over millions of years.

Phenology changes. (Gumbi 2010)

Changes in onset bud burst and leaf fall in a deciduous hardwood forest, Gwayi



Biodiversity

IPCC Summary findings-1

- • *some ecosystems have already been affected by changes in climate and are considered to be particularly sensitive to changes in regional climate, eg. coastal (including coral reefs) and high altitude and latitude ecosystems.*

- • *regional changes in climate, particularly increases in temperature, have already affected a diverse set of physical and biological systems in many parts of the world. These include changes in species distributions (or ranges), population sizes, the timing of reproduction or migration events and lengthening of growing season in the mid- to high-latitudes in northern hemisphere. Some of these changes could lead to population or species extinction, especially in species whose ranges are restricted altitudinally or by other barriers (e.g., lack of suitable habitat)*

IPCC Summary findings 2

- ***increased frequency of coral bleaching in some reefs has been linked to increased sea surface temperatures of 1°C as commonly occurs during El Nino events.***
- ***changes in marine systems, particularly fish populations, are clearly linked to large-scale climate shifts and affect socio-economic systems.***
- ***changes in stream flow, floods, and droughts have impacted goods and services from ecosystems (e.g.. freshwater fisheries, wetland flows) and socio-economic systems***
- ***increases in water temperature have caused an increase in summer anoxia in deep waters of stratified lakes with possible effects on their biodiversity***

IPCC Summary Findings 3

Extreme climatic events have and would continue to have major impacts on biodiversity.

. **Examples include**:

- ***projected higher maximum temperatures, more hot days and heat waves could lead to increased heat stress in livestock and wildlife***

- ***projected increasing minimum temperatures, fewer cold days, frost days and cold waves could lead to extended range and activity of some pest and disease vectors***

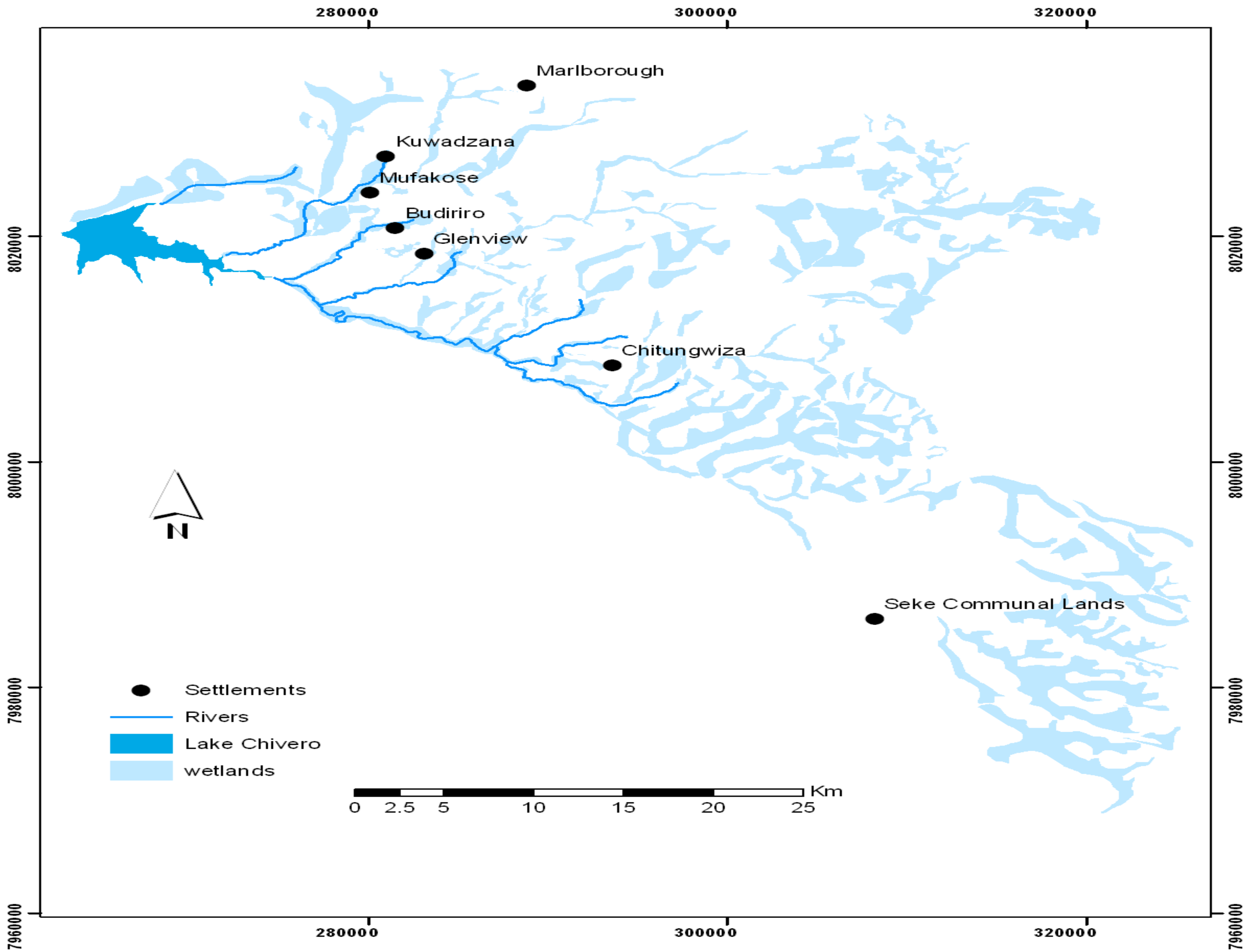
- ***projected increased summer drying over most mid-latitude continental interiors and associated risk of drought could lead to decreased water resource quantity and quality, physiological stress on animals through changes in forage quality, decreased rangeland productivity in drought- and flood-prone regions and increased risk of forest and rangeland fires***

Biodiversity prospects

- Independent of climate change, biodiversity is forecast to decrease in future due to multiple stresses, in particular increased land use intensity and the associated destruction of natural and semi-natural habitat.
- Paleoecology data suggest that biota at global level should produce three new species per year. However current extinction rates are higher than this.

The human impact: the Lake Chivero watershed

Wetlands distribution in Lake Chivero watershed: total estimated area = 40 000 ha (After Nyarumbu 2012)



Mahusekwa seep, Chihota.

Unsupervised livestock grazing on wetland causing wetland compaction and degradation and loos of hydrological function

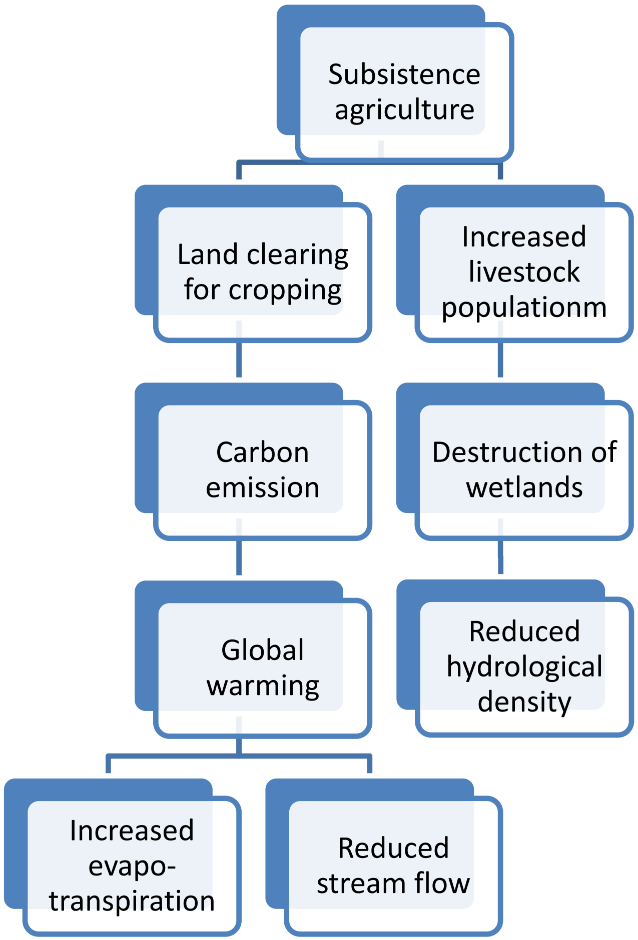
An erosion terraced wetland caused by drying of wetland due to compaction by cattle : Chihota

Degraded sphagnum bog

Cattle grazing on Nyamabishi dam, Chihota, built 1958

Silt interception

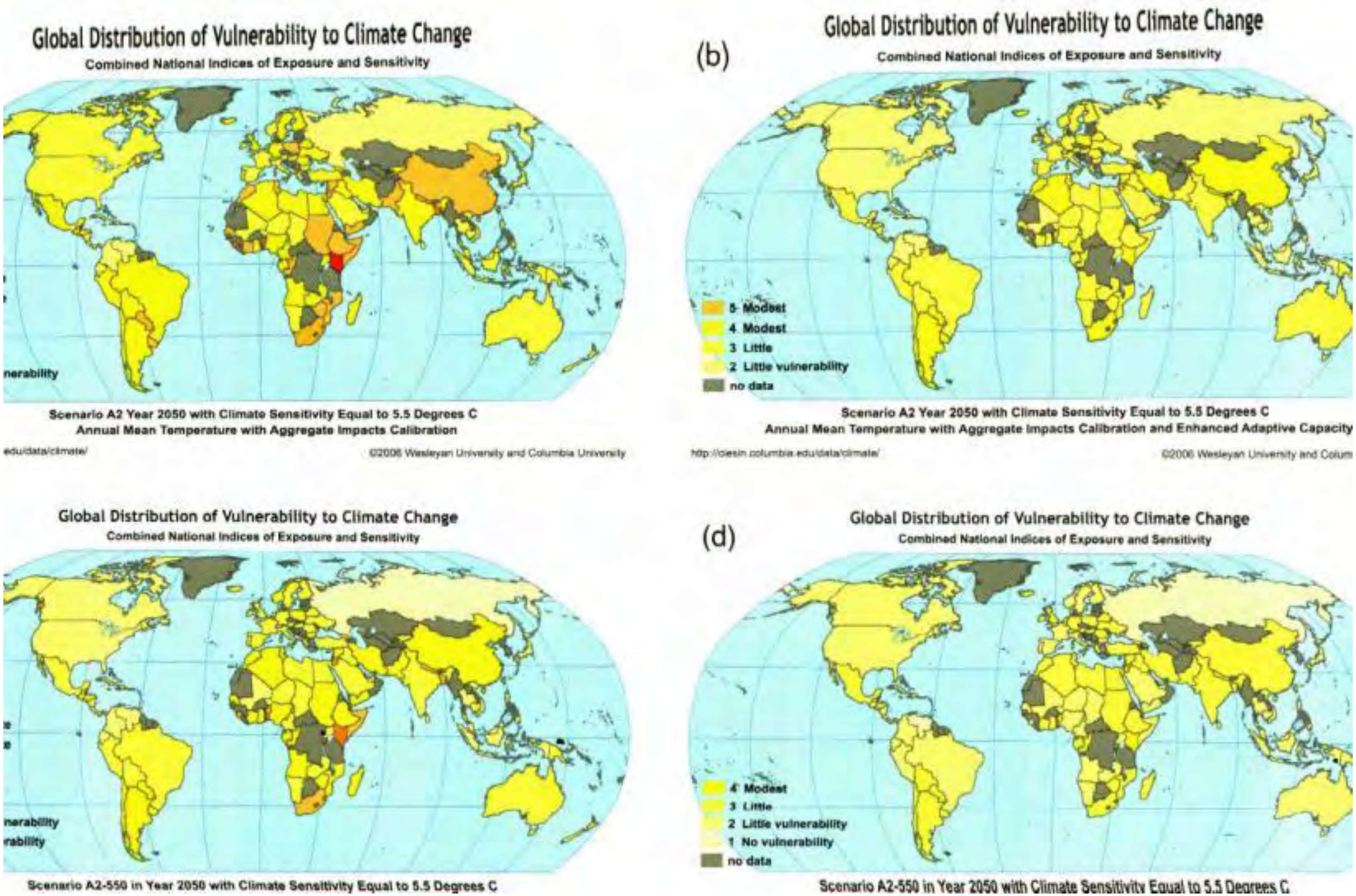
Aggravating land use to L. Chivero watershed aridification.



Vulnerability Definition (IPCC)

Vulnerability **is the degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude and rate of climate variation to which a system is exposed, its sensitivity, and its adaptive capacity.**

Global distribution of vulnerability under the IPCC Scenario A



Vulnerability

- Vulnerability wholly attributable to CC
  - cryosphere ecosystems
  - High mountain ecosystems
  - Coral reefs
  - Etc
    - Limited capacity for ecosystem adaptation
- Combination of CC and Land use.
  - Wetland ecosystems
  - Sub humid savannah ecosystems
  - Costal ecosystems
    - Mitigatory measures within human capability

Africa is the most vulnerable continent to climate because of lack of adaptive capacity

Is Africa too far behind to appreciate climate impact issues?