Drought and Health Implications in Mozambique

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The consequences of drought in Mozambique and the negative health implications to populations include famine, starvation, and epidemics. El Niño (ENSO) events are consistently related to drought in Southern Africa. Current capabilities can provide climate forecasting for Southern Africa with a lead time of up to one year. Thus, Mozambique and Southern African countries should utilize climate forecasting to improve prediction of upcoming anomalous wet or dry periods and to facilitate planning in the fields of agriculture, hydroelectric power, water management, and health. Technological progress in understanding the environment and climate dynamics becomes a matter of development, where poorer countries are disadvantaged. This raises ethical and scientific issues, as well as international policy issues. Governments, UN agencies, scientists, and professionals have an opportunity to improve partnerships among technically advanced nations and the large regions of the globe where the effects of climate and climate changes are exerting severe impacts on populations. [M&GS 1998;5:42-49]

It is well understood that drought presents a great potential for human suffering in Africa [1,2]. In southern Africa, drought and flood are the major effects of the variability in temperature and precipitation associated with the El Niño Southern Oscillation (ENSO) phenomenon. In Mozambique, which is regularly affected by droughts, the severe drought during 1991-1992 was related to ENSO and contributed to epidemics and rodent infestation [3]).

The objectives of this paper are:

- to describe the occurrence of El Niño-related drought in Mozambique, its frequency, and its impact on the most affected areas in the country;
- to assess the drought-related consequences on health during the last two decades in Mozambique; and
- to recommend research proto-

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cols and planning strategies that can assist policy makers in anticipating future droughts and in mitigating their health effects.

El Niño and Global Warming

Global warming and ENSO have been identified as the climatic phenomena responsible for most important weather patterns in the world [4,5,6].

The oceans are the primary memory for the climate system, absorbing heat and circulating it both laterally and vertically. Since 1877, El Niño events [see sidebar, "The El Niño Southern Oscillation"] have occurred every two to seven years (average 4.2 years). Since the mid 1970s, ENSO events have come more often and persisted longer than any previous period [7]. The 1982-83 El Niño was the strongest of the century. Whether or not the increase in El Niño events is due to global warming is a matter of speculation. But there is increasing evidence that deep ocean warming and changes in ocean circulation may be occurring.

Deep ocean warming has been reported from subtropical transects in the Atlantic [8], in the Pacific [9], and in the Indian Oceans [10], in the Arctic Tundra and near the poles [11,12]. Ocean warming increases the hydrological cycle [13], thus altering precipitation patterns that affect the timing of disease outbreaks.

Several models suggest that El Niño events will increase with global warming [14,15,16,17]. The events of the past two decades are consistent with these projections.

In addition, shifts in the ocean "conveyor belt"—which includes the Gulf Stream—may have been historically associated with rapid climate change events, according to ice-core records [18,19,20,21,22,23]. Shifts in the Atlantic ocean temperatures and circulation patterns are now being reported [24]. The world's oceans may indeed be the main repository (capacitor) for the past century's global warming; and changes in El Niño patterns may signal instability in the dynamics of the climate system as a whole.

One climate phenomenon, drought, is recognized as an extreme event that can generate new explosions of activity in the emergence and distribution of diseases. El Niño is consistently related to drought in Southern Africa. "La Niña," a cold Pacific Ocean upwelling that often occurs in years subsequent to El Niño events (e.g., in August 1995), creates opposite, "teleconnected," patterns[1], such as rains and floods in areas that were previously dry [25]. These climatic phenomena—aggravated as they are by human-caused degradation of nature, such as water and ocean contamination, air pollution, deforestation, overharvesting of fish, soil erosion, and uncontrolled urbanization—represent a serious threat to the global ecosystem and to population health.

Figure1. Map of Mozambique. Southern and central provinces are often most severely affected by El Niño events.

Drought in Mozambique

A 1960-1988 study carried out by the National Institute of Meteorology [26] showed that drought is a persistent phenomenon: every year there are periods of drought in some parts of the country, mostly in the southern and central regions. This study enabled researchers to identify the most affected districts of the country, and those that are permanently affected by drought.

The last two severe droughts in Mozambique occurred during the 1982/84 El Niño (the largest El Niño of the century, with a temperature anomaly 3-4 degrees C warmer than average) and during the 1991/92 El Niño, the latter initiating the most prolonged El Niño (1991-1995) since record keeping began in 1877. The drought of 1982 to 1984 affected one third of the country's population and eight of 11 provinces. The most seriously affected provinces were Inhambane, Gaza, and Maputo, in the southern region of Mozambique [27,28]. The drought in Inhambane persisted into 1984. Since then, the annual rainfall in the southern region of the country has been less than the normal average.

The drought of 1991 to 1992, which strongly affected both Mozambique and the entire southern African region, aggravated even more the precarious living conditions of Mozambicans, who also were affected at that time by civil war [28,29]. A peace agreement was signed in October 1992 and democratic elections were held in October 1994. Despite the fact that there was now some political stability, the situation with regard to population health was exacerbated by a drought in 1994-1995, affecting several districts of the southern and central regions of Mozambique [30].

Drought and Its Impact on Health Status in Mozambique

Drought has negative consequences on the health status and socioeconomic well

The El Niño Southern Oscillation

The Southern Oscillation refers to the difference in sea-level atmospheric pressures between Tahiti and Darwin, Australia. A negative Southern Oscillation Index (SOI) is associated with slackening of easterly winds (westerly-blowing); allowing the western warm pool (WWP) to shift to the east. Thus a negative SOI is associated with an El Niño event in which anomalously warm water reaches the west coast of South America. This usually occurs around Christ-mas time (thus El Niño has been dubbed "The Christ Child").

El Niño events affect the jet stream and are statistically related to extreme weather events in specific areas of the globe [59]. For example, northeast Brazil usually experiences drought, while

being of populations. Drought is strongly related to limited food supplies, whether cultivated or taken from pastoral production, and thus has a direct impact on the nutritional status of populations and on increased population vulnerability to epidemics.

Nutritional Impacts

Famine

Famine and food shortage are outcome variables in an equation with multiple inputs, namely political, social, technological, meteorological, and economic. Famines are generally classified as slow-onset disasters that may be precipitated by factors such as prolonged drought, flood, cyclone, or civil strife. In Mozambique, famine has been related to natural disasters, primarily drought. As a consequence of the drought of 1982-1984, 4,000,000 people (one-third of the total population at that time) were directly affected and an estimated 100,000 people died. This drought was described as the worst in 50 years [27,28].

During the drought of 1991-1992 an estimated 1,320,000 people were directly affected, forcing them to seek refuge in urban areas and causing accelerated population growth in the major urban centers of the country. The government launched an emergency appeal for an additional 300,000 tonnes of food in the form of cereals [26,31]. This drought also killed more than 370,000 cattle in Zimbabwe; crop production was reduced by more than 70%; and 625,000 people required assistance in Namibia. Botswana's maize crop failed and South African farmers required drought aid: with a previous average of eight millions tonnes of maize produced annually, only two million tonnes were delivered to the grain marketing board [32].

Cassava Related to Thiocyanate Intoxication

A spastic paraparesis (Konzo) epidemic occurred in Mozambique in 1981 related to thiocyanate intoxication. A total of 1,102 cases were reported [33]. This epidemic—and the succeeding one—were associated with consumption of insufficiently processed bitter cassava during drought. Serial measurement of urinary thiocyanate concentrations showed a marked seasonal variation, with a peak coincident with the cassava harvest [34]. Since 1981, further "konzo" outbreaks have occurred during war and drought in cassava-staple districts. In 1992, a total of 186 cases were reported and, in 1993, a total of 108 cases. These epidemics occurred frequently in Nampula and Cabo Delgado in the north, at that time experiencing a severe drought. Other provinces of the country namely, Manica and Gaza in

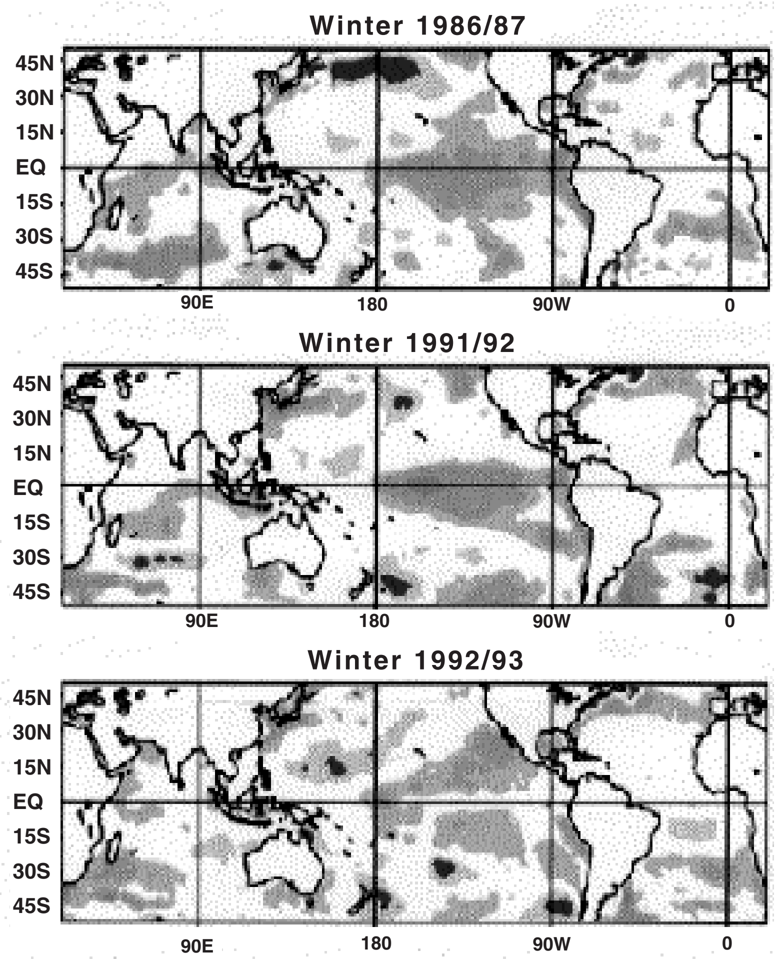

Figure 2. Drought in Mozambique and elsewhere in sub-Saharan Africa has been associated with the El Niño Southern Oscillation (ENSO), the effects of which may increase as a result of global warming. Shaded areas in maps indicate warmer than usual sea surface temperatures during recent El Niño winters. Map source: Center for Climate Analysis.

the center and south, have reported cases of spastic paraparesis. All these epidemics were associated with bitter cassava consumption and drought [35].

Water-Borne Diseases

Cholera

Since 1973, when the first cases were diagnosed in Maputo city, Mozambique has been affected by the seventh and current cholera pandemic[2]. A cholera outbreak occurred during the drought in 1983-84, at which time seven of the eleven provinces—mostly the central and southern provinces in the most drought-stricken area—were affected. Thereafter, cholera occurred cyclically, but in 1989 the largest (i.e., having the widest geographical spread, the greatest number of cases, and the most severe mortality) and longest epidemic in the country began, ending in June 1994.

The highest incidence of cholera in the history of Mozambique was reported in 1992: more than 31,000 severe cases and 750 deaths. This last outbreak was precipitated by the severe drought that occurred in 1991-1992, compounded by precarious and vulnerable conditions under which people live in the major urban centers of the country [36]. At that time, the major urban centers affected by cholera suffered a very significant shortage of water supply. The Pongue river, which supplies water to Beira city in Central Mozambique, was reduced to one percent of the normal flow. Flow was also very low in the Limpopo, Incomati, Maputo, and Umbeluzi rivers, all located in the southern region of the country. People were forced to improvise new sources of water—some shared with animals—and for multiple purposes (consumption, washing, and bathing). Wells were unprotected and well water was untreated and uncontrolled [36].

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Dysentery

In June 1992, an outbreak of dysentery (*Shigella dysenteriae* type 1) hit the country. Zambézia, Tete, Manica, and Sofala were the most affected provinces. In 1993, 80% of the country's districts were affected and more than 47,000 cases of dysentery were reported. In 1994, about 77,000 cases were reported. Although the epidemic was related to population movements after war and to poor levels of sanitation and poverty [37], the dysentery epidemic was contemporaneous with the cholera epidemic. Drought played an important role in the dissemination of cholera [36] and, while there are no statistical data confirming a causal relationship, the authors believe it probable that drought contributed to the spread of Shigella dysenteriae type 1 in Mozambique[3].

Vector-Borne Diseases: Plague

The first plague outbreak reported in Mozambique occurred in 1976, in Mutarara district, Tete province, with 15 cases and six deaths. The second outbreak followed in 1977 with 97 cases and 14 deaths. In 1978 12 cases and no deaths were reported [38]. In September 1994, an outbreak of plague was reported in Mutarara district, with 226 cases and three deaths. These outbreaks were related to severe drought in southern Africa associated with ENSO in both periods, 1976 and 1994. Centripetal movement of wild rodents toward domestic rodents looking for sustenance, and centrifugal movement of people hunting for rodents, were considered

southeast Brazil and Peru experience heavy rains and often flooding. Southern Africa has a strong "signal," and usually experiences drought.
The opposite pattern is associated with a cold ENSO event ("La Nina"). Thus a positive SOI and anomalously cold water appear near South America and Southern Africa often experiences heavy rains and flooding during La Nina or cold ENSO events. The event that began in August, 1995, for example, was associated with flooding in Mozambique and South Africa, and there were upsurges in malaria.

2. Most of the previous pandemics of cholera were in the 19th century. The seventh began when El Tor left the Bay of Bengal region in the 1960s. It arrived in Africa in the 1970s, and in Latin America in 1991. The present pandemic encompasses more areas of the globe than any other in this century. (A new strain—V cholera O139 Bengal—emerged in the Bay of Bengal in 1992, and could become the agent of an eighth pandemic. Early detection in the marine environment will be important.)

3. Lack of hand washing, for example, is an important factor in the transmission of the Sd1 strain and is a direct consequence of drought. Reduced waterflow can also concentrate microorganisms.

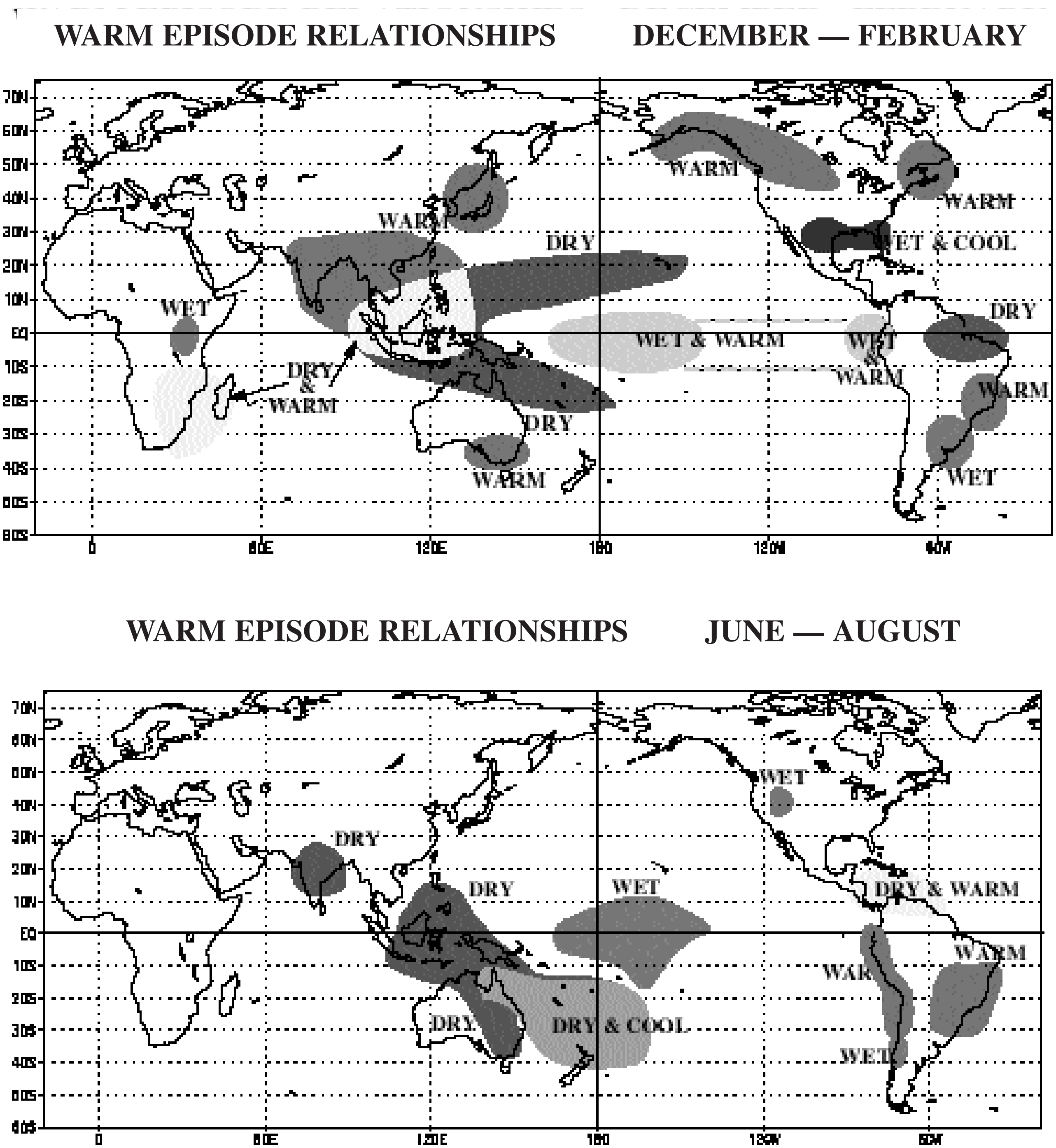

Figure 3. El Niño-induced anomalies in climate patterns, as a result of which different regions of the world may experience varying combinations of warmer, cooler, wetter, and/or drier weather. *U.S. National Oceanographic and Atmospheric Administration graphic.*

important to the origin of the outbreak [25,39]. Drought conditions also reduce populations of predators of rodents and alter food sources for these opportunistic species [40]. Rodent infestation can also ravage crops.

The Need for Climate Forecasting

One may describe three levels of responses to emerging diseases. The first is the need for greater surveillance and response capability; training, and better communication systems, such as the Program for Monitoring Emerging Diseases (PROMED). The second level (midstream) involves the integration of health surveillance with ecological monitoring and improved climate and weather forecasting. The third (upstream) involves addressing the underlying environmental conditions that increase vulnerability, and energy policies that impact the climate system.

Integration of health and environmental monitoring and the use of climate forecasting and health early warning systems (HEWS) of climate and weather conditions conducive to outbreaks [41] may become more feasible and can facilitate early, environmentally sound public health interventions (e.g., vaccinations, cleanups, Bti applications, etc.). The El Niño signal can provide early warning of conducive weather conditions for specific regions of the globe.

Much of the impact of global environmental change will fall on poorer nations, such as Mozambique, that are more vulnerable to the consequences due to their compromised socioeconomic conditions. Technological progress in understanding the environment and climate dynamics becomes a matter of development, where poorer countries are disadvantaged. This raises ethical and scientific issues, as well as international policy issues. Governments, UN agencies, scientists, and professionals have an opportunity to improve partnerships between the technically advanced nations and the large regions of the globe that are less equipped to deal with climate change and extreme climatic variability [42].

Better understanding of the connections between the environment and disease emergence can promote broader awareness among scientists and policy makers as to the nature of environmental and social vulnerabilities to the spread of emerging infectious diseases and the role of human activities (e.g., land-use change, excessive use of chemicals and antibiotics, and others) in altering the biological controls over opportunistic pests and pathogens.

An Urgent Need for Planning

The Mozambican government—conscious of drought and other natural disasters and interested in diminishing the impact of these phenomena—established the Department for the Preven-tion and Combat of Natural Disasters (DPCCN) in 1980 to carry out relief operations in the regions of the country affected by drought. With the beginning and the intensification of the civil war, however, DPCCN was diverted from this mission and was transformed into an agency that could respond only to acute emergency situations. Time and resources were unavailable to develop a real planning process for emergency management as a whole.

In addition, the five sites established for seismology surveillance were destroyed during the war and while more than 500 sites had been established for hydrological surveillance, only 16 are now functioning.

Thus, the longer term activities aimed at prevention, mitigation, and preparedness for disasters were not consolidated [43]. DPCCN did, however, define some early warning systems in the country: for example, the National Institute of Meteorology provides rainfall surveillance, while the National Institute of Agriculture monitors crop production. The Ministry of Health also defined two early warning systems to cope with natural disasters, namely the Nutrition Surveillance and the Epidemiological Surveillance systems. These systems provide an overall view of health problems related to emergencies and disasters, including drought.

Despite these early warning systems, the efforts have not been sufficient to cope with drought in Mozambique. The elaboration of a multi-sectoral plan on preparedness and emergency management in the country is urgent. The key components of this plan should include:

1) Identification of risk areas for drought;

2) Multinational agreements for managing and sharing rivers and other waterways.

1) Identification of risk areas for drought: This is the first step in preventing serious consequences for the population, for agriculture, and for the environment. The national plan on preparedness and emergency management should define the role that each institution is expected to play and specify channels for data collection, analysis, and distribution. Greater integration of efforts to collect data on health and the global environment is needed.

The problem of drought in Mozambique is affected by global and regional issues. The ENSO phenomenon, interacting with regional sea surface temperatures and wind patterns, strongly affects weather patterns in the region. Improved regional modelling, taking into account local phenomena, are needed for enhanced predictability. Using numerical models, for example, scientists predicted the 1991-92 ENSO one year in advance. Current capabilities can provide ENSO forecasting for southern Africa with a lead time of up to one year [44].

Climate Change and Human Health

The influence of the environment on health has been considered since the earliest days of medical practice. Hippocrates discussed the distribution and occurrence of diseases influenced by interactions between humans and the earth's climate. Today there is a worldwide scientific consensus that humans have altered global climate in substantial and, perhaps, detrimental ways. Global environmental change affects health either directly (e.g., heat waves increasing mortality from cardiovascular diseases) or indirectly (e.g., effects on vector- and water-borne diseases [45,46,47]. Climate changes, including alterations in temperature and rainfall, play an important role in the emergence of new diseases and in the reemergence of diseases that had been brought under control through immunization and other public health measures [48,49,50]. Vector-borne diseases (e.g., dengue and yellow fever, malaria, trypanosome, plague, and hantavirus) and water-borne diseases (e.g., cholera) are reemerging and spreading [51,52,53,54,55, 56,57,58].

Other international initiatives and programs are helping to develop a multinational network of research and application centers to produce and distribute forecast guidance products. Thus, southern African countries should prioritize initiatives addressed to utilize climate forecasting to improve prediction of upcoming anomalous wet or dry periods, for planning in the fields of agriculture, hydroelectric power, water management, and health. Most global circulation models project that El Niño episodes will become more frequent and endure longer with a continued global warming trend.

2) Multinational agreements for managing and sharing rivers and other waterways: Many waterways are shared among the 11 neighboring nations that make up the southern African region. Mozambique should establish agreements with neighboring countries for the control of international rivers that supply water used for agriculture, hydroelectric power, and water consumption for the main urban centers of the region. Further, integrated development projects should be elaborated for the risk areas most affected by drought. ❧

References

1. **Parker DJ, Thompson PM.** Floods and Tropical Storms. In: The challenge of African disasters. UNITAR/WHO 1991:38-59.
2. **Glantz MH, Katz RW.** African drought and its impacts: revived interest in a recurrent phenomenon. Desertification Control Bulletin 1987;14.
3. **Epstein PR, Chikwenhere GP.** Environmental factors in disease surveillance. Lancet 1994;343:1440-41.
4. **Dobson AP, Carper RJ.** Global warming and potential changes in host-parasite and disease vector relationships. In: Peters R, Lovejoy T, eds. Global warming and biodiversity. New Haven: Yale University Press. 1992:201-17.
5. **Nicholls N.** El Niño-Southern oscillation and vector borne disease. In: Health and climate. London: The Lancet. 1994.
6. **Ropelewski CF, Halpert MS.** Global and regional scale precipitation patterns associated with the El Niño/Southern Oscillation. Mon Weather Rev 1987;115:1606-26.
7. **Trenberth KE, Hoar TJ.** The 1990—1995 El Niño-Southern Oscillation Event: Longest on record. Geophys. Res. Lttrs. 1996;23:57-60.
8. **Parrilla G, Lavin A, Bryden H, Garcia M, Millard R.** Rising temperatures in the sub-tropical North Atlantic Ocean over the past 35 years. Nature 1994;369:48-51.
9. **Thwaites T.** Are the antipodes in hot water? New Scientist 12 November 1994:21.
10. **Bindoff NL, Church JA.** Warming of the water column in the southwest Pacific. Nature 1992;357:59-62.
11. **Travis J.** Taking a bottom-to sky "slice" of the Arctic Ocean. Science 1994;266:1947-8.
12. **Regaldo A.** Listen up! The world's oceans may be starting to warm. Science 1995;268:1436-7.
13. **Graham, NE.** Simulation of recent global temperature trends. Science 1995;267:666.
14. **Zebiak SE, Cane MA.** Natural climate variability in a coupled model. In: Schlesinger ME (ed). Greenhouse gas-induced climatic change: A critical appraisal of simulations and observations. Amsterdam: Elsevier Science Publishers BV. 1991.
15. **Manabe S, Stouffer RJ.** Century-scale effects of increased atmospheric CO2 on the ocean-atmosphere system. Nature 1993;364:215-218.
16. **Meehl GA, Washington WM.** South Asian summer monsoon variability in a model with double atmospheric carbon dioxide concentration. Science 1993;260:1101-4.
17. **Bengtsson L, Schlese U, Roeckner E, Latif M, et al.** A two-tiered approach to long-range climate forecasting. Science 1993;261:1026-29.
18. **Broecker WS.** Unpleasant surprises in the greenhouse? Nature 1987;328:123-126.
19. **Mayewski PA, Meeker LD, Whitlow S, et al.** The atmosphere during the Younger Dryas. Science 1993;261:195-197.
20. **Dansgaard W, Johnson SJ, Clausen HB, et al.** Evidence for general instability of past climate from a 250-yr ice-core record. Nature 1993;364:218-220.
21. **Greenland Ice-Core Project (GRIP) members.** Climate instability during the last interglacial period recorded in the GRIP ice core. Nature 1993;364:203-207.
22. **Pearce F.** Southern oceans hold key to climate. New Scientist 5 April 1997:21.
23. **Tziperman E.** Inherently unstable climate behavior due to weak thermohaline ocean circulation. Nature 1997;386:592-595.
24. **Chang P, Link JI, Hong LI.** A decadal climate variation in the tropical Atlantic Ocean from thermodynamic air-sea interactions. Nature 1997;385:516-518.
25. **Glantz MH, Katz RW, Nicholls N.** Teleconnections linking worldwide climate anomalies. Cambridge: Cambridge University Press. 1991.
26. **Ferreiro S, Moyo S, Marques IP.** Zonas afectadas por ciclones tropicais e secas em Mozambique no período 1960-1988. Instituto Nacional de Meteorologia-Mozambique (unpublished).
27. **Ratilal P.** Mozambique: using aid to end emergency. UNDP 1989:40-46.
28. **Msengezi T.** The drought situation in Mozambique. Southern Africa News Features. May 1992:1-2.

29. Seca de 1992. Direcção Nacional de Aguas. Relatório No.10, Maio 1992.
30. Ministerio de Agricultura de Moçambique. Sistema Nacional de Aviso Previo para a Segurança Alimentar: Situação da Campanha Agricola Junho/Julho 1995. Relatório Final Vol 8, 1995.
31. UNDP-Mozambican Government. Emergency Appeal for Drought 1992.
32. Chidowore R. The effects of drought on agriculture. Southern Africa News Features. October, 1992.
33. Casadei E, Cliff J, Jansen P, et al. "Mantakassa" Uma epidemia de neuropatia tropical associada com intoxicação crónica por cianeto, em área de consumo de mandioca na Província de Nampula, Moçambique. Revista Médica de Moçambique. 1984;2(1):1-34.
34. Casadei E, Cliff J, Neves J. Surveillance of urinary thiocyanate concentration after epidemic spastic paraparesis in Mozambique. J Trop Med Hyg. 1990;93:257-261.
35. Cliff J. Doenças relacionadas com a mandioca em Moçambique, 1981-1993. Revista Medica de Moçambique. Março 1994;5(1):2-5.
36. Aragón M, Barreto A, Tabbard P, Chambule J, et al. Epidemiologia da cólera em Mozambique no período de 1973-1992. Revista de Saúde Pública. 1994;28(5):332-6.
37. Aragón M, Barreto A, Chambule J, Noya A, Tallarico M. Shigellosis in Mozambique: The 1993 outbreak rehabilitation — a follow-up study. Tropical Doctor, October 1995;25:159-162.
38. WHO. Human plague in 1988. Weekly Epidemiological Record 1989;64:345-47.
39. Barreto A, Aragón M, Epstein PR. Bubonic plague outbreak in Mozambique, 1994. [letter]. The Lancet 1995;345:983-84.
40. Epstein PR, Chikwenhere GP. Biodiversity questions (letter). Science 1994;265:
41. Epstein PR, Pena OC, Racedo JB. Climate and disease in Colombia. Lancet 1995;346:1243-44.
42. Haines A, Epstein PR, McMicheal AJ. Global health watch: monitoring impacts of environmental change. In: Health and climate. London: The Lancet. 1994.
43. Rising to the challenge, Mozambique Emergency. CENE-DPCCN. Maputo 1988.
44. Cane MA, Zebiak SE, Dolan SC. Experimental forecasts of El Niño. Nature 1986;321:827-832.
45. McMicheal A. Global environmental change and human population health: a conceptual and scientific challenge for epidemiology. Int J Epidemiol 1993;22: 1-8.
46. Kalkstein LS. The impacts of global climate change on human health. Experientia 1993;49: 1-11.
47. World Health Organization. Potential health effects of climatic change: report of the WHO Task Group. Geneva: WHO, 1990.
48. Epstein PR. Emerging diseases and ecosystem instability: new threats to public health. Am J Public Health. 1995;85:168-172.
49. Maurice J. Fever in the urban jungle. New Scientist Oct 16, 1993.
50. Wilson M. Infectious diseases: an ecological perspective. BMJ 1995;311.
51. Levins R, Awerbuch T, Brinkmann U, et al. The emergence of new diseases. Am Sci. 1994;82:52-60.
52. Rogers DJ, Randolph SE. Distribution of tsetse and ticks in Africa: past, present and future. Parasitol Today 1993;9: 266-72.
53. Okello GBA, Agata N, Ouma J, et al. Outbreak of yellow fever in Kenya. Lancet. 1993;341: 489.
54. Leovinsohn ME. Climatic warming and increased malaria incidence in Rwanda. Lancet. 1994;343: 714-718.
55. Centers for Disease Control and Prevention. Update: outbreak of hantavirus infection — United States, 1993. MMWR 1993;42:441-443.
56. Centers for Disease Control and Prevention. Update: outbreak of hantavirus infection-United States, 1993.MMWR. 1993;42:612-614.
57. Ramamurthy E, Garg S, Sharma R, et al. Emergence of novel strain of Vibrio cholerea with epidemic potential in southern and eastern India. Lancet. 1993;341:703-704.
58. Albert MJ, Siddique AK, Islam S, et al. Large outbreak of clinical cholera due to Vibrio Cholereae non-01 in Bangladesh. Lancet. 1993;341:704.
59. Kiladis GN, Diaz HF. Global climatic anomalies associated with extremes in the Southern Oscillation. J Climate 1989;2:1069.