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Climate change and human health in the Asia Pacific region: who will be most vulnerable?

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ABSTRACT: Self-organising systems adapt to environmental change, and this ability modulates the relationship between specific exposures and outcomes. Vulnerability can be thought of as the sensitivity of the system to multiple exposures, taking into account the system's ability to adapt. This paper describes 5 causes of vulnerability to climate change in the Asia Pacific region: destructive growth, poverty, political rigidity, dependency and isolation. Impoverished populations are always at greater risk because they have fewer choices. However, rapid increases in population size, density of settlement and use of natural resources may also compromise responsiveness by damaging the buffering capacity of ecological systems against environmental adversity. Public health depends on a responsive social order. Political rigidity may have contributed to recent, severe impacts of climate-related disasters in parts of Asia. Dependency (such as reliance on others for information) is a potent cause of vulnerability because it justifies fatalism. Geographically isolated countries are tied firmly to international fortunes by the increased mobility of people and goods. In these modern circumstances remoteness may be a liability. Vulnerability to climate change will be shaped by many factors, but effects on health will undoubtedly be most severe in populations that are already marginal. For these populations, climate change is one further cause of 'over-load'. The problem of human-induced climate change is global in extent and is long term, but that should not deter policy-makers—measures taken to reduce the future impact of climate change will bring other benefits sooner.

KEY WORDS: Climate change · Vulnerability · Adaptation · Human health · Infectious disease

1. INTRODUCTION

The aims of this paper are to briefly summarise what is known about the likely impacts of climate change on human health in the Asia Pacific region, to examine what makes populations vulnerable to effects of climate change, and to recommend steps that may be taken to reduce such vulnerability.

Vulnerability includes 2 components: sensitivity to displacement (referred to as 'resistance' in ecology texts; Begon et al. 1990) and adaptation (or 'resilience'), the ability to return to an original resting state or achieve a new equilibrium (Watson et al. 1996). Self-organising systems adapt to environmental change, and this ability modulates the relationship between exposure and outcome. Vulnerability can be thought of as the sensitivity of the system to multiple coexistent exposures, taking into account the ability of the system to adapt. Vulnerability may apply to a complex system at any level of organisation, ranging from a cell to an individual to a whole society. The concept has been applied in studies of climate change to outcomes such as hunger (Downing 1992) and infectious disease (Patz & Balbus 1996). Vulnerability to disease and injury may be defined as a state of increased probability of adverse outcomes, for a given environmental exposure. It is implicit that vulnerability is undesirable, and is a relative concept.

2. EFFECTS ON HEALTH OF RAPID CLIMATE CHANGE

The changes in global climate that have been forecast by the IPCC (Houghton et al. 1996) may affect human health both directly and indirectly (Table 1).

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Table 1. Health effects of climate change

Direct
Deaths and illness due to thermal extremes
Injury resulting from floods and storms
Indirect
More widespread vector-borne infections
Increase in other infectious diseases
Respiratory effects of worsening air pollution
Poor nutrition due to agricultural disruption
Ill-health due to social dislocation and migration

The direct effects include injury and illness due to the more frequent heat waves and floods—expected as a result of higher temperatures, extremes of rainfall and thermal expansion of the oceans. The indirect effects are more difficult to specify, but will probably be more important in terms of the magnitude of the disease burden they cause. Indirect effects are mediated via the influence of climate on biological systems (such as disease-carrying vectors or productive agro-ecosystems) or other aspects of the physical environment (for example, photochemical oxidants). The vulnerability of societies to climate change will therefore depend, to some extent, on the ways in which critical ecosystems adapt to climatic change. However, in this paper we focus on social determinants of vulnerability.

The potential effects of global climate change have been reviewed by the Intergovernmental Panel on Climate Change (Watson et al. 1996) and reported in greater detail in a recent WHO/WMO/UNEP publication (McMichael et al. 1996). There is no reason to believe that the Asia Pacific region will be spared; indeed, in many respects the region is particularly susceptible to climate-related injury and illness. Most obviously, Pacific island states and the low-lying coastal countries of Asia are more liable than most countries to damage from rising sea levels. Health problems due to heat waves and photochemical air pollution will be most severe in large cities with high traffic volumes and poor housing. The Asia Pacific region already contains 13 of the 25 largest cities of the world. By 2015, nearly 1 billion people in Asia are expected to be living in cities with a population of over 1 million (UNEP 1997). Within urban areas there is potential for some vector-borne infections, such as dengue fever, to spread to large non-immune populations as temperatures rise and rainfall patterns alter (Martens et al. 1997).

Both gains and losses in agriculture are expected as a consequence of global warming. World-wide, the gains and losses may almost cancel out if the most optimistic scenarios are followed (Parry & Rosenzweig 1993). However, the overall picture masks pronounced differences between countries. In general terms, developed countries are expected to do well, while developing countries do poorly (Table 2). In the Asia Pacific region, food demand is expected to increase by about 50% by 2015 and about 100% by 2050; yet densely populated regions are projected to run out of suitable agricultural land by about the year 2000 (UNEP 1997).

3. VULNERABILITY TO CLIMATE CHANGE

The impact of a changing climate is a function of the nature and magnitude of the changes in the environment, and the vulnerability of the individual or population involved. In climate research attention has been paid mostly to alterations in the environment. Studies of vulnerability have been less popular, perhaps seen by some as a distraction from the primary task (of getting greenhouse emissions under control), and rejected by others who already lay claim to the answer, be it free trade, national self-sufficiency or technology (Chen & Kates 1994). Nevertheless we propose 3 reasons for taking issues of adaptation and vulnerability seriously.

First, whilst there is nothing new about variations in climate, if the forecasts are correct, the rate of human-induced change will test the limits of biological and social adaptation. Global average temperature appears likely to rise more rapidly than at any time in the last 10 000 yr, and sea levels will rise at roughly twice the rate of change since the last climatic minimum 40 000 yr ago (Watson et al. 1996).

Second, there are considerable uncertainties involved in forecasting impacts of climate change. These arise from both the limitations of climate fore-

Table 2. Impact of climate change on world cereal production with and without CO_2 enrichment and with increasing levels of adaptation, using the GISS climate model, year 2060. Reference: Fischer et al. (1994)

	Without CO_2	With CO_2	Adaptation level 1	Adaptation level 2
Developing countries	–16.2%	–11.0%	–11.2%	–6.6%
Developed countries	–3.9%	11.3%	14.2%	11.0%
World total	–10.9%	–1.2%	0	1.1%

casts and the assumptions that must be made about social trends. For example, climate models do better at forecasting regional changes than local events, but it is the local environment, by and large, that matters most for health. Global circulation models are more adept at modeling relatively simple climate variables (such as average temperature and rainfall) than complex phenomena (such as tropical storms). Similarly, present models provide a better picture of average change than the variability around a trend line; however, the extreme events (for example, droughts and floods) are most important for many health outcomes. The non-climatic factors that determine disease rates, for any given climate scenario, add formidable compounding uncertainty to the modeling task. The other element in the impact equation, vulnerability, may give clearer direction to policy-makers. This does not mean abandoning primary prevention: mitigation of greenhouse warming is the principal, fundamental response to climate change.

Third, vulnerability to climate change has much in common with vulnerability to other environmental hazards—what we learn about climate may be applicable in other settings (for example, individual and collective susceptibilities to the threats of new and emerging pathogens).

4. CAUSES OF VULNERABILITY

4.1. Destructive growth

During the early 1990s, Indonesia was regarded as one of the new economic powers of Asia: its economy grew at an average of 8% per annum, and the country's population continued to increase rapidly also. Since the beginning of the century the number of people in Indonesia has increased 4-fold, and is now equal to the populations of all other ASEAN (Association of South-East Asian Nations) nations combined. Human fertility in Indonesia has halved since the 1970s, largely as a consequence of an energetic family planning programme, but the demographic momentum is so great that the population of the country is likely to increase by a further 50 million people in the next 15 yr, reaching a total of around 240 million by the early 2010s (Hugo et al. 1987, World Resources Institute 1996).

One result of this growth is likely to be a further shift of population to cities like Jakarta, with exacerbation of the poor physical and social conditions for many inhabitants. Effects of climate change such as more frequent days of extreme heat, air pollution and risk of flooding and storm damage will be felt most in cities that are already stressed. Jakarta is a good example of a city already under severe stress as a result of economic and population growth that cannot be sustained. A practical demonstration in Jakarta of environmental overload is the tendency for flooding of the road from the international airport to the centre of the city to occur; so much water has been drained from artesian systems under the city that subsidence is widespread, leaving large areas of land (including the airport freeway) prone to flooding.

One response of the Indonesian government to population growth has been to move people from the most densely populated part of the country (Java) to other islands in the archipelago. Between 1969 and 1989 more than 600 000 families were relocated (Hugo et al. 1987). Often, new settlements had to be placed in areas previously considered marginal. For example, many transmigration camps were established in low-lying, swampy areas on the north coast of Sumatra and the southern coast of Kalimantan, areas that would be at particular risk of damage due to sea-level rise, salination and increased storm activity.

Indonesia is an example of a country already stretching the limits of the environmental systems that support public health, and for this reason its population is vulnerable to additional pressures, such as those that may follow from rapid climate change.

4.2. Poverty

When poverty is combined with rapid alterations in climate then familiar threats to health are encouraged and new sources of trouble are likely to emerge. Papua New Guinea (PNG) provides an example: it has a large population (approximately 3.8 million) in comparison with other Pacific states, and is rich in natural resources, but there are formidable linguistic, cultural and geographic divisions within the country. As a consequence, economic development has been slow, and many people receive rudimentary health and social services. In terms of the 1996 United Nations Human Development Index, PNG (ranked 126th internationally) is one of the most impoverished countries in Asia, ahead of only Myanmar (ranked 133rd), Bangladesh (143rd) and Cambodia (156th) (United Nations Development Program 1996). National statistics for PNG show high mortality and high fertility, compounded by low literacy rates. High rates of preventable mortality (for example, maternal mortality of almost 1%; World Resources Institute 1996) indicate limited access to effective primary medical care.

Little is known about the likely effects of climate change in PNG, but those disturbances that do occur are likely to have severe impacts. For example, there is concern about the spread of endemic malaria from coastal areas of PNG to the densely populated high-

lands. In the past, the highland populations have been protected by altitude—both insect vector and parasite have been deterred by the low temperatures on the central plateau (approximately 1500 m above sea level). This barrier will be diminished with global warming: it has been estimated that isotherms will rise by 300 m with a doubling of effective CO_2 (McGregor 1990).

Control of new and resurgent infections such as malaria depends on 3 fundamental capacities: effective surveillance, community involvement in and acceptance of control measures, and an intact public health infrastructure to deliver services (Lifson 1996). PNG is lacking in all three, and as a result the population is highly vulnerable to vector-borne diseases. Poverty affects individuals as well as groups: many people exposed for the first time to infections such as malaria and dengue will be vulnerable due to chronic illness and poor nutrition.

Poverty makes some countries in the Asia Pacific region particularly vulnerable to the effects of tropical storms and flooding. Bangladesh experiences only 1% of all cyclones world-wide, but almost 50% of deaths from cyclones occur in that country (Amadore et al. 1996). The Japanese record provides a contrast—typhoons frequently pass across the country, but mortality per typhoon has varied markedly over the last 70 yr (Fukuma 1993). The impact of these storms was greatest in the period 1941 to 1960, and since then has declined steeply. The recent improvement has been most marked for typhoons of intermediate severity (not surprising since this is where adaptive strategies are likely to make the greatest difference). Possible explanations include better land management, coastal protection, communications and early warning systems and housing (Watson et al. 1996).

4.3. Political rigidity

Adaptation to environmental change requires a responsive social order, and the greater the rate of environmental change the more important social flexibility is. Autocracies endure predictable adversity, but do poorly when certainties shift rapidly. The greater than expected impact of flooding in the Democratic People's Republic of Korea (DPRK or North Korea) in 1995 and 1996 illustrates the susceptibility of tight, centralised political systems to climate-related disasters.

In August 1995 the wet season rains in DPRK were heavier than usual, leading to widespread flooding. In the major cities the rising rivers were contained, but heavy damage was done in the countryside, including destruction of crops, housing and communications. It took some while before the implications of the damage were apparent. Approximately half a million people were left homeless, but the greatest problem was shortage of food. The impact of the flooding was much more severe than had been anticipated by international relief agencies. In December 1995, the International Red Cross estimated that around 1.2 million t of grain, one-tenth of the entire world's food aid, would be needed to avoid famine (International Federation of Red Cross and Red Crescent Societies 1996). Initially it was expected that emergency supplies would be required only for a period of months; by the end of the year it was recognised that the country would need support for much longer. Food shortages continued throughout 1996, and worsened: in early 1997 official food rations were reduced to 100 g of rice (approximately 350 calories) per adult per day (Tomlinson 1997). Little is known about the effects on the health of the population but reports from United Nations observers suggest that severe malnutrition is now common, especially in rural areas (Tomlinson 1997).

Why did the floods have such a severe effect? One reason (relevant to climate scenarios that forecast a dramatic reduction in the return period for extreme weather events) is that the country suffered a double blow. In 1996 there was again unusually heavy rain and flooding. The areas of the country that were directly affected were not those that had been flooded in 1995. However, the effect on a weakened social system was felt nation-wide, especially as agricultural output had been declining for some time. The production of food grain per head of population fell by 45% from 1989 to 1994, and grain yield per hectare dropped by 40% over the same period (World Food Programme, quoted in International Federation of Red Cross and Red Crescent Societies 1996). DPRK operates a highly centralised food storage and redistribution system, and vital road and rail links were cut by the floods. There was little variety in agricultural practice across the country—choice of crops and land management were prescribed by the central government—so local communities had few opportunities to adapt their farming to local conditions. In general the political system in DPRK does not encourage experimentation, diversity of practice, or devolution of decision-making.

North Korea has achieved significant successes in the past, in the rebuilding of the country following a destructive civil war, and the provision of comprehensive social services such as housing, education and health care (Hoare 1995). However, when circumstances changed rapidly (for example, the break up of the Soviet Union in 1989 and consequent loss of cheap oil supplies, and then the death of Kim Il Sung in July 1994) the public health infrastructure was exposed as brittle and susceptible to challenge.

4.4. Dependency

Sea-level rise is a major threat for many Pacific Island states (Table 3). Yet in some countries there is an expressed sense of powerlessness, and a reluctance to give the issue high priority. One explanation for this may be the lack of information that is generated locally, is controlled locally, and is appropriate to local concerns.

The Kingdom of Tonga is not as seriously exposed as some other nations, but a rise of the magnitude forecast by the IPCC would have significant impacts on agriculture and human settlement. In Tonga, weather data are collected from various sites around the Kingdom, but analyses are carried out by the Meteorological Service in Wellington, New Zealand. Forecasts are provided from Fiji, storm warnings from Hawaii. Scientists from at least 5 countries have installed tide gauges in the Kingdom, but there is little coordination between research groups, the data are exported overseas, and for local people there is little sense of ownership of the problem or the information that is needed to respond (Nunn & Wadell 1992). It is apparent that 'concepts of dependency and marginality apply to scientific endeavour and to the planning process with respect to global change as much as to the realm of economic development' (Nunn & Wadell 1992).

Dependency of any kind, including reliance on others for information, is hazardous, especially in a rapidly changing world. This is partly a matter of degree: no one individual or group can be entirely self-sufficient. However, dependency such as that commonly experienced in Tonga and other developing countries is harmful in 2 ways. First is the issue of security, the danger of being cut off from essential data. (Maps of Tonga, for example, were printed by the Directorate of Overseas Surveys in Great Britain, but the cartography services in Britain have now been contracted out to private suppliers, who may be reluctant to do small, uneconomic print runs for distant Pacific customers.) Second, there are considerations of ownership and relevance: when problems are defined by outsiders in foreign and inaccessible terms, those directly affected cannot participate in seeking solutions. This point is made frequently in the literature on the health of indigenous peoples (see, for example, Durie 1994).

Table 3. Pacific island states ranked by susceptibility to sea level rise (ranking based on equal weighting to altitude, island numbers, total land area and island type; Pernetta 1990). References: Pernetta (1990), World Resources Institute (1996), Asia & Pacific Review (1997)

Nation	Major island type	GNP per capita 1994 (US $)	Population (1995)	Maximum altitude (m)	Susceptibility to sea level rise
Tokelau	Atoll	4000	1500	4	Extreme
Marshall Islands	Atoll	2500	54700	4	
Tuvalu	Atoll, raised coral	–	9500	4	
Line Islands	Raised coral	–		8	
Kiribati	coral, atoll	730	78400	81	
Micronesia	Various	1890	105700	791	Severe
Palau	Coral	3250	16500	207	
Pitcairn	Coral, atoll	–	50	304	
Nauru		12000	10500	71	
French Polynesia	Volcanic, atoll	7000	218000	2237	
Cook Islands	Volcanic, varied	2750	19100	652	
Niue	Coral	2250	2500	67	
Tonga	Various	1640	98200	1125	
American Samoa	Volcanic	8000	54800	931	Moderate
Fiji	Mixed	2220	774800	1323	
New Caledonia	Mixed	11000	182200	1628	
N Marianas	Volcanic	–	56700	965	
Solomon Islands	Mixed, volcanic	1200	367800	2446	
Vanuatu	Mixed	1300	164100	1979	Modest
Wallis and Fatuna	Volcanic	3000	14400	769	
Easter Island	Volcanic	–	2811	600	
Papua New Guinea	Mixed	1120	4302000	4694	
Guam	Mixed	11800	149300	393	
Western Samoa	Volcanic	900	163400	1857	

4.5. Geographic isolation

Countries such as New Zealand have traditionally regarded their remoteness as a strength in public health terms. Distance may have been a barrier against disease and disorder in the past, but increased frequency and speed of transport of people and goods around the world now make it very difficult for any country to keep pathogens out.

Island ecosystems developed separately from those on the continents, forming 'eccentric corners of the evolutionary process' (Leakey & Lewin 1996) that are particularly vulnerable to invading species. Mammals (especially humans and rats) have been the most destructive newcomers in the past, but other pests are important. For example, in 1996–97 New Zealand spent NZ $8 million to eradicate the recently introduced *Orgyia thyellina* (white-spotted tussock moth), a threat to horticulture and forestry.

Two factors promote the spread of pathogens: increasing volumes and speed of international trade, and reduced spending on border controls and surveillance. It is not known exactly how the tussock moth (a native of northern Asia) was transported to New Zealand, but it is likely to have arrived with imported household goods or second-hand cars. More than 6000 used cars per month were imported into New Zealand from Japan during 1996, a doubling in numbers over the previous 3 yr. There was no effort to increase surveillance in proportion to the increased volume of goods from overseas: indeed during the same period (1993–96) funding for border controls was reduced by two-thirds (Hutching 1996).

Tussock moth is at worst a minor threat to human health, but it does serve as a model for other insects that could be significant threats if they became established in New Zealand. For example, the mosquito-borne disease dengue has been an increasing problem in the South Pacific in recent decades. Since the early 1970s, epidemics have been frequent during La Niña conditions, which are associated with anomalously high temperature and rainfall (Fig. 1). In New Zealand there have as yet been no cases of locally transmitted dengue or other key arboviruses such as Japanese Encephalitis or Ross River virus, despite the fact that viraemic individuals from elsewhere in the region must enter the country regularly (Weinstein et al. 1995). Furthermore, several species of exotic mosquitoes (such as *Aedes notoscriptus*) which are already established in New Zealand have transmitted disease under laboratory conditions.

The significance of climate change is that new ecological niches will be created; in countries such as New Zealand that lie in the temperate zone, vector activity is likely to increase. Higher temperatures could increase the epidemic potential by reducing development times, increasing survival probabilities and biting frequency for the mosquito, and reducing replication time for the virus. Rising temperatures will increase the area of New Zealand which is receptive to establishment of vectors such as *Aedes aegypti* (the most important vector for dengue in the region; a domesticated species adapted to warm conditions) and *Aedes albopictus* (a cold adapted species; Weinstein et al. 1995).

5. MEASURES TO REDUCE VULNERABILITY TO CLIMATE CHANGE

The most vulnerable human populations are those that are currently marginal, in terms of location or resources. It is well known that the plant communities most at risk from climate change are those confined to ecological margins (such as coasts, mountains, polar regions). The same is true for human communities, which may be considered 'on the edge' geographically (for example, the low-lying Pacific Island states) or economically (countries like Papua New Guinea).

Previous strengths may turn out to be liabilities. Ecologists report that highly specialised species dominate in stable conditions, but tend to do badly when the environment alters rapidly. In a similar vein, human social systems that did well in the past may be

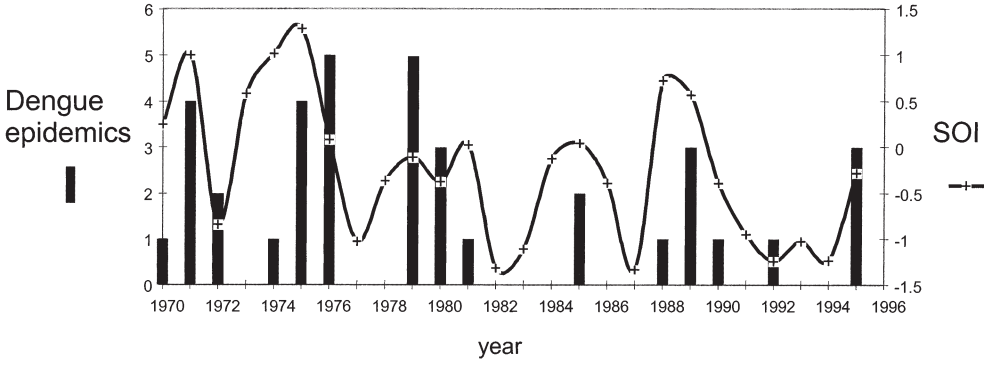

Fig. 1. Dengue fever epidemics in the South Pacific 1970–1995, and the Southern Oscillation Index (Hales et al. 1996)

liabilities in a time of rapid change (such as may accompany global warming). Possible examples include highly centralised, rigid political structures, and communities relying on geographical isolation as a barrier against foreign pathogens.

One advantage of looking at the problem of climate change from the perspective of vulnerability is that it is relatively easy to identify robust interventions. These are 'robust' in the sense that the returns are relatively insensitive to the uncertainties of climate scenarios; and reducing vulnerability to climate change will have many other benefits. 'Robust' or 'no regrets' strategies do not substitute for concerted efforts to understand, and respond to, the underlying causes of global warming. It would be foolish and dangerous to imagine that human society can anticipate and contain the full range of unmitigated climate change. What the vulnerability approach does offer is a wider range of policy options.

Examples include better forecasting of climate and of climate impacts. Benefits of such technology are already apparent in sectors such as agriculture, where farmers can be advised to prepare for a high likelihood of droughts or floods on the basis of a better understanding of the El Niño cycle. (This cycle serves as a useful model in many respects for climate change research, but it is uncertain how the frequency and intensity of the cycle will change under global warming.) Relatively little forecasting has been attempted in the health sector. The same modelling techniques that have been applied to estimating the impacts of future climate change on kiwi fruit and dairy herds could be used to gain a better understanding of where, and under what circumstances, significant human disease vectors are likely to get a foothold in New Zealand, for example. This knowledge would have great value to public health authorities, whatever the precise trajectory of global climate over the next century.

Sustainable management of at-risk resources is one way of moving away from ecological margins. Examples include improved land-use practices in areas that are already stressed (e.g. arid zones) and protection of coastal resources in areas threatened by sea-level rise. (The risks of rising sea levels in parts of the South Pacific are amplified by short-sighted environmental policies, such as unregulated sand mining.)

It is becoming clear that unequal distributions of income and other benefits are not only harmful for the health of the poor, but affect also the well-being of the entire population (Wilkinson 1997). One mechanism that has been proposed is a loss of social cohesion and civil commitment caused by wide disparities in society and reflected in an increase in a range of health-damaging behaviours. There are similarities in studies of vulnerability to famine, which have shown that networks of social entitlement are highly protective against hunger (Sen 1980). Reducing inequalities in welfare (in the sense of levelling up, not levelling down) is likely to make populations less vulnerable to threats to food production, and many others besides.

All countries in the region are affected by the condition of the weakest. This paper has discussed mainly the vulnerability of individual countries, but the region as a whole needs to be considered also. Effects of climate change in one corner of the region are likely to be felt elsewhere as well. These include migration from islands threatened by sea level rise and spread across borders of uncontrolled infectious disease.

6. CONCLUSIONS

Reviews of climate change impacts are often couched in terms of 'winners and losers'. It is true that the effects are likely to be unevenly shared, and, in a narrow sense, some groups may benefit from the new environment. However, in a broader sense, there may be only one player, who turns out to be a loser. For example, in the world food trade those who buy are more likely to be losers under climate change than those who sell, yet, in terms of the ecological systems that enable us to live on this planet, we are all buyers.

What distinguishes 'winners' from 'losers' in the future will probably differ little from what separates present winners from present losers. Vulnerability, or susceptibility to suffer adversely from hazardous exposures, is on the whole a generic quality. To prepare for future uncertainties (of which climate change is only one) we need to better understand those factors that currently make some populations vulnerable to ill-health.

It is difficult to plan for the future, particularly when the exact nature of climate change is not known, let alone the precise consequences for health. Focussing on vulnerability may be one means of making tractable what appears in the eyes of many to be a distant and diffuse problem. Measures taken to reduce the future impact of climate change will have other benefits sooner.

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LITERATURE CITED

Amadore L, Bolhofer WC, Cruz RV, Feir RB, Freysinger CA and 9 others (1996) Climate change vulnerability and adaptation in Asia and the Pacific: workshop summary. Water Air Soil Pollut 92:1–12

Asia & Pacific Review (1997) The world of information. Economic and business report. Walden, London

Begon M, Harper J, Townsend C (1990) Ecology, individuals, populations and communities. Blackwell, London

Chen RS, Kates RW (1994) Climate change and world food security. Global Environ Change 4:3–6

Downing TE (1992) Climate change and vulnerable places: global food security and country studies in Zimbabwe, Kenya, Senegal and Chile. Research Report No. 1. Environmental Change Unit, University of Oxford

Durie M (1994) Whaiora-Maori health development. Oxford University Press, Oxford

Fischer G, Frohberg K, Parry ML, Rosenzweig C (1994) Climate change and world food supply, demand and trade. Who benefits, who loses? Global Environ Change 4:7–23

Fukuma Y (1993) Objective evaluation of preparedness against typhoon, by typhoon classification. J Meteorol Res 45:159–196

Hales S, Weinstein P, Woodward A (1996) Dengue fever in the South Pacific: driven by El Niño Southern Oscillation? Lancet 348:1664–1665

Hoare J (1995) North Korea. Oxford University Press, Oxford

Houghton JJ, Meiro Filho LG, Callander BA, Harris N, Kattenberg A, Maskell K (eds) (1996) Climate change 1995—the science of climate change. Contribution of Working Group I to the Second Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge

Hugo GJ, Hull TH, Hull VJ, Jones GW (1987) The demographic dimension in Indonesian development. Oxford University Press, Singapore

Hutching G (1996) The tale of the white-spotted tussock moth. Forest & Bird (New Zealand) August:14–19

International Federation of Red Cross and Red Crescent Societies (1996) World disasters report 1996. Oxford University Press, Oxford

Leakey R, Lewin R (1996) The sixth extinction. Biodiversity and its survival. Weidenfeld & Nicolson, London

Lifson A (1996) Mosquitoes, models and dengue. Lancet 347: 1201–1202

Martens W, Jetten T, Fock D (1997) Sensitivity of malaria, schistosomiasis and dengue to global warming. Clim Change 35:146–56

McGregor GR (1990) Possible consequences of climatic warming in Papua New Guinea with implications for the tropical southwest Pacific area. In: Pernetta JC, Hughes PJ (eds) Implications of expected climate changes in the South Pacific region: an overview. UNEP Regional Seas Reports and Studies No. 128. United Nations Environment Program, p 25–40

McMichael AJ, Haines A, Slooff R, Kovats S (eds) (1996) Climate change and human health. World Health Organisation, Geneva

Nunn P, Wadell E (1992) Implications of climate change and sea level rise for the Kingdom of Tonga. SPREP Reports and Studies Series no. 58. South Pacific Regional Environment Programme, Apia, Western Samoa

Parry ML, Rosenzweig C (1993) Food supply and risk of hunger. Lancet 342:1345– 1347

Patz JA, Balbus JM (1996) Methods for assessing public health vulnerability to global climate change. Clim Res 6: 113–125

Pernetta JC (1990) Projected climate change and sea level rise: a relative impact rating for the countries of the Pacific basin. In: Pernetta JC, Hughes PJ (eds) Implications of expected climate changes in the South Pacific region: an overview. UNEP Regional Seas Reports and Studies No. 128. United Nations Environment Program, p 14–24

Sen A (1980) Poverty and famines: an essay on entitlement and deprivation. Clarendon Press, Oxford

Tomlinson R (1997) Malnutrition grips North Korea. Br Med J 314:1147

UNEP (United Nations Environment Program) (1997) Global environment outlook—1. UNEP, New York

United Nations Development Program (1996) Human development report 1996. Oxford University Press, New York

Watson RT, Zinyowera MC, Moss RH, Dokken DJ (eds) (1996) Climate change 1995—impacts, adaptations and mitigation of climate change: scientific-technical analyses. Contribution of Working Group II to the Second Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, New York

Weinstein P, Laird M, Calder L (1995) Australian arboviruses: at what risk New Zealand? Aust NZ J Med 25:666–669

Wilkinson RG (1997) Socioeconomic determinants of health: health inequalities: relative or absolute material standards? Br Med J 314:591–4

World Resources Institute (1996) World resources. A guide to the global environment 1996–97. Oxford University Press, New York