



# Security and Climate Change

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## Introduction: Delimiting Security

As concern mounts over the impacts of global environmental change on social and ecological systems, coinciding with a more fluid international security environment since the end of the Cold War, environmental change is increasingly being understood as a security issue. This is as much a product of national security institutions seeking new *raison d'etres* as it is the dangers of environmental change (Campbell 1992, Dabelko and Simmons 1997, Dalby 1994). The majority of interpretations of environmental security focus on the way environmental change may interact with the same national security concerns that dominated policy throughout the 20<sup>th</sup> century, in particular the way environmental change may trigger violent conflict (Homer-Dixon 1991, Kaplan 1994, Myers 1987). However, as recent developments in environmental security research suggest, the concern with direct international conflict is misplaced, and the security impacts of environmental change will take less direct and more multifarious routes (Lowi and Shaw 2000). Surprisingly, despite climate change being the most prominent and best-studied of the suite of environmental change problems, it has thus far received little systematic analysis as a security issue (but see Stripple 2002, and for partial connections see Brown 1989, Edwards 1999, Rahman 1999, Swart 1996, van Ireland *et al.* 1996, and Wilson 1983). This paper seeks to offer such an analysis.

Security is an accentuated discourse on vulnerability. Like vulnerability, its assessment requires considering the risk of exposure, susceptibility to loss, and capacity to recover. However, like vulnerability and risk, it is more socially constructed than objectively determined. The distinction is that security is attached to the most important of vulnerable entities – for example the nation (national security), basic needs (human security), income (financial security) and property (home security). The process of discursively ‘securitising’ vulnerable referent objects, and defining particular risks, is a political one (Waeber 1995).

In a general sense security is the condition of being protected from or not exposed to danger. It has historically been concerned with safety and certainty from contingency (Dower 1995). Thus Soroos (1997) defines security as “the assurance people have that they will continue to enjoy those things that are most important to their survival and well-being” (p. 236). Depending on *who* is to be secured, and *how* environmental change threatens them, environmental change can be considered as a security issue. However, a question as fundamental as ‘which environmental problems can be considered security issues?’ has vexed environmental security scholarship (Barnett and Dovers 2001, Shaw 1996).

It can be argued that climate change is a security issue for some nation-states, communities and individuals. In the case of atoll-countries such as Tuvalu or Kiribati, for example, there is widespread agreement that climate change and associated sea-level rise threatens the long-term ability of people to remain living on their islands (Rahman 1999, Watson 2000). In this respect it is the most serious form of environmental change and the most serious security problem that these countries face. Indeed, in a worst-case scenario nothing less than their sovereignty is at risk. Further, for Inuit communities living in the Arctic circle where snow cover is less predictable and thinner ice sheets restrict hunting; for families living on low-lying deltas in Bangladesh increasingly prone to flooding; and for people living in the highlands of Papua New Guinea who are increasingly prone to diseases spread by mosquitoes due to changed temperature and rainfall regimes, climate change poses cultural, health, and life-threatening risks comparable to the impact of warfare. So, climate change is a security issue for certain communities, cultures, and countries. Following on from this, in so far as its failure to reduce emissions may spell the end of the habitability of atoll-countries and the displacement of their peoples, the UNFCCC is an important security treaty, making certain negotiating groups such as the Alliance of Small Island States security coalitions (Barnett 2002, Stripple 2002).

Accepting this *prima facie* argument that climate change can be a security issue, this paper aims to explore in greater detail the connections between climate change and security. It does this by following an heuristic guide to the broader environment and security literature to assess the array of linkages between the particular problem of climate change and security (Figure 1).

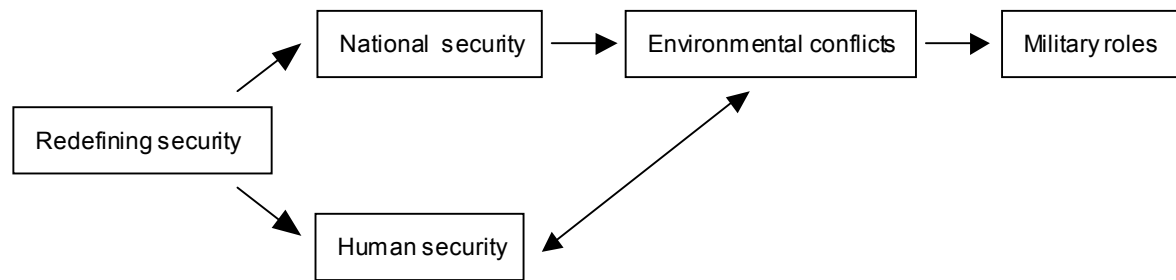


Figure 1: A Guide to Environment – Security Linkages

### Redefining Security and Climate Change

Security is a multifaceted concept. The national referent dominates security discourse. Large scale violent conflict is the concern that receives the most attention from policymakers, and developing military capability to respond to possible violent conflicts consumes large amounts of public resources: worldwide an average of 2.9% of every nation's Gross Domestic Product was spent on defence in 1996 (UNDP 1998). However, alternative risks to security and alternative referent objects (such as humans) are increasingly being considered. One of these risks is environmental change. Climate change, however, has received little attention in this process (but see van Ireland *et al.* 1996, Rahman 1999, and Stripple 2002).

The first person to systematically argue that environmental change is a security issue was Richard Falk. Writing in 1971, when climate change was only a nascent concern, Falk outlined what he called 'the first law of ecological politics' which is strikingly relevant for the issue of adaptation to climate change, namely: "there exists an inverse relationship between the interval of time available for adaptive change and the likelihood and intensity of violent conflict, trauma, and coercion accompanying the process of adaptation" (p. 353). This is a truism of contemporary climate change research: the faster the rate of change, the less time to adapt and the more 'dangerous' climate impacts are likely to be.

In 1977 Lester Brown explored the links between environmental degradation – including climate change – and security. Brown talked of the impact of the deterioration of biophysical systems on national security, identifying four systems under stress: fisheries, grasslands, forests and croplands. His discussion particularly focused on food security, a subject which has subsequently received considerable attention from climate impacts researchers (for example Murdiyarto 2000, Parry *et al.* 1999, Sanchez 2000, Wilkie *et al.* 1999). Brown argued that armed forces are incapable of meeting the challenges posed by climate change, suggesting that disarmament and budgetary reallocations were important policy responses.

The most prescient of the early discussions of climate change and security argued that "a climate change that turned the Great Plains of North America into an arid zone would be analogous to a major military disaster", and that as climate change affects basic life support systems "survival – the most elemental of human goals and the first duty of all governments – is called into serious question" (Wilson 1983 p. 71). Like Lester Brown, Wilson argued that military responses and nation-centred *Realpolitik* would not deliver solutions to climate change. An American, Wilson's argument that "sustainable security for this country rests crucially on an active and creative participation in the politics of the world predicament [of environmental change]" seems to have been lost on the current United States government.

After 1989 the argument that environmental change was a security issue for nations and people was increasingly made in both environmental and security journals. This must be considered in the context of dramatically improved relations between NATO and the former USSR, making conventional

understandings of security less relevant. Simultaneously, environmental concerns were increasingly coming to the fore of national and international politics and policy (Dalby 1992).

According to Smil, environmental security has replaced the threat of global nuclear warfare as it shares two characteristics: both are global in reach and the effects of both could be highly devastating (Smil 1997). Indeed, the Toronto Conference in 1988 – the first international meeting of scientists and national policymakers to highlight the dangers of climate change – was called *The Changing Atmosphere: Implications for Global Security*. The conference concluded that: "humanity is conducting an unintended, uncontrolled, globally pervasive experiment whose ultimate consequences could be second only to a global nuclear war". The analogy with nuclear war perhaps overstates the risks of climate change, which will be less immediate and damaging except in the case of low-probability / high-impact events such as melting of the West Antarctic Ice Sheet which would cause sea-level to rise by some 6 meters. Subsequent papers which have considered climate change as a security issue include: Brown 1989, Edwards 1996 and 1999, Ehrlich and Ehrlich 1991, Gleick 1992, Homer-Dixon 1991, Lipschutz and Holdren 1990, Mathews 1989, Page 2000, and Rowlands 1991).

### **National Security and Climate Change**

The referent object that dominates security discourse and policy is the nation state. The impacts of climate change has been considered as a national security issue (see above). It figures in the United States' National Security Strategy (NSS), although in at times incoherent ways as in the 1996 NSS which countenanced the possibility that there might be armed competition between nations for "dwindling reserves of uncontaminated air" (Clinton 1996 p. 26).

Because sovereignty over delineated territory is the material substrata of national security, then physical processes such as sea-level rise may undermine national security in serious ways: for example a 45 cm rise in sea-level will potentially result in a loss of 10.9% of Bangladesh's territory, forcing some 5.5 million people to relocate (IPCC 2001a). Even more severe is the complete loss of habitable territory that may occur on small islands as a result of rising seas and increasing climate variability. However, long before evacuation, the socio-economic impacts of global warming on islands may be "so profound that they dwarf any strategic issue currently confronting a major peacetime economy" (Hoegh-Guldberg *et al.* 2000 p. 4).

National security also has an internal dimension in that it is partly a function of state legitimacy. Governments for whom the material well-being of their people is highly sensitive to external forces such as changing terms of trade, or where material well being is in decline, tend to be relatively more unstable, and the country relatively more prone to internal violent conflict (Rapkin and Avery 1986). There is some analysis that suggests that this holds true for exogenous environmental shocks as well (Hauge and Ellingsen 2001). For Bangladesh, therefore, 5.5 million refugees poses potentially serious problems for state legitimacy and internal harmony. The increasingly frequent and severe hazardous events that are expected as a result of climate change mean more exogenous shocks to all countries, and so possibly less security. Climate change may have many other indirect negative effects that can undermine legitimacy, it may: undermine individual and collective economic livelihood; affect human health through reduced availability of freshwater and food, and by exposing people to new disease vectors; undermine state wealth and military capability; and exacerbate inequalities between people.

The impacts of climate change will have financial costs, and in some cases these are sufficiently large to justify understanding climate change as a security issue. Consider, for example, Hoegh-Guldberg *et al.*'s (2000) estimate that coral bleaching will reduce future GDP by some 40-50% by 2020 in smaller Pacific islands, remembering that these losses are those expected to occur only as a result of coral bleaching and its knock-on effects. Further, the World Bank estimates the losses due to climate change in Kiribati to be in the order of 17-34% of current GDP by 2050 (World Bank 2000a p. 7).

Measures implemented to reduce greenhouse gas emissions will also impose costs to national economies. It is their assumptions about the cost of reducing emissions, and about lost comparative advantage, that apparently underlie U.S. reticence on the Kyoto Protocol. Similarly, the Australian Government has argued that the Kyoto Protocol would particularly adversely affect Australia's economy, and so that country's final Kyoto target is a 108% change above 1990 levels of emissions. But it is the oil exporting economies that are arguably the most at risk from an implemented Kyoto Protocol. Most models suggest that policies to implement the Kyoto Protocol (using a carbon tax as a proxy for response measures) will increase oil prices and reduce demand in developed countries (which account for 60% of world oil consumption), thereby driving down global oil demand and prices, and therefore projected revenues for oil exporters. For example, a 0.45% decline in projected GDP in OPEC countries for 2010 is forecast by Bernstein *et al.* 1999 (see Barnett 2001a for a fuller discussion of this issue). However, these costs of implementing response measures, although experienced differentially among states, are nevertheless small relative to the expected costs of impacts, and so cannot be said to constitute a problem of such a magnitude to warrant considering them as a national security issue. One exception may be Saudi Arabia. Goldstone (2001) argues that Saudi Arabia already demonstrates demographic and development characteristics conducive to political unrest, a situation which may intensify as a result of implementation of the Kyoto Protocol.

Finally, given the dominant concern of national security planners and policymakers with violent conflict and transborder incursions, the issue of whether, and how, climate change may stimulate conflicts and increase migration is important. These issues will be discussed in the following section, suffice it to say now that violent conflict is a security issue for those states that are directly involved, and may indirectly affect other states who may choose to, or be obliged to, intervene as negotiators or peacekeepers, and through disruptions to trade.

### **Climate Change, Violent Conflict and Migration**

If we accept that environmental change is a factor leading to violent conflict, as Homer-Dixon (1999) and Baechler (1999a) suggest, then as a macro-engine for many forms of environmental change such as degradation of grasslands and boreal and tropical forests, desertification, water resource stress, and coral bleaching, climate change may be an exacerbating factor in violent conflict in the future. Violent conflict is defined here as a crisis between groups leading to deaths; a category short of war which is defined as a crisis leading to more than 1000 deaths (Wallensteen and Sollenberg 1997). This fits with Singer's (1972) typology of conflict escalation, starting from competition, rising to contention, then rivalry, conflict, crises, and then violent conflict and ultimately war.

It is necessary to be cautious about the links between climate change and conflict. Much of the analogous literature on environmental conflicts is more theoretically than empirically driven, and motivated by Northern theoretical and strategic interests rather than informed by solid empirical research (Barnett 2000, Gleditsch, 1998). This in part reflects the long-standing difficulties in finding meaningful evidence of the determinants of violent conflict and war. General findings for which there is some evidence are that: major powers are more likely than other countries to be involved in war; high levels and rapid growth in military spending tend to be associated with war; poverty and inequality are prevalent in many cases of subnational conflict and coups d'état; recent violence is a good predictor of future violence; 'strong states' with an ability to monopolise the use of force and manage collective actor problems tend to be less prone to internal conflict; democracies tend to be less prone to internal violent conflicts and war; the most important disputed issue in past violent conflicts has been territory; and violence is more likely between neighbouring groups and countries (Gleditsch 2001, Raknereud and Hegre 1997, Vasquez 1993).

Nevertheless, on the basis of existing environment-conflict research there is simply insufficient evidence and too much uncertainty to make anything other than highly speculative claims about the effect of climate change on violent conflict; a point that both policy makers and climate scientists

should not lose sight of. Ultimately, as Baechler argues, there is a need for more “elaborate case studies” which are linked with other studies of conflict that deal with interacting “crucial issues such as poverty, ethnicity and state” (Baechler 1999b p.108). Only then can assessments of utility for policy be delivered. Three criteria can be used to frame and scale such a research programme: political scale (between or below states); the nature of governance; and the nature of the environmental changes affected by climate change. These will now be discussed in turn.

#### *Political Scale*

Despite the ambiguity of past environment-conflict research, there is common agreement that there are links (if vague) between environmental change and violent conflict. However, it has not been shown that environmental factors are the only, or even important factors leading to conflict (Homer-Dixon and Blitt 1998, Baechler 1999c). Other factors such as poverty and inequities between groups, the availability of weapons, ethnic tension, external indebtedness, institutional resilience, state legitimacy and its capacity and willingness to intervene, seem to matter as much if not more than environmental change *per se* (see Baechler 1999b). Importantly, it has been comprehensively demonstrated that environmental factors do not, and nor are they likely to, trigger open conflict between nation-states, even in transnational water catchments (Baechler 1999a, Homer-Dixon and Percival 1996, Wolf 1999). So, except in the case of low-probability / high-impact events such as widespread loss of land as a result of melting of the West Antarctic Ice Sheet, climate change impacts are unlikely to be a factor in international violent conflicts (Litfin 1999). This applies equally to climate change mitigation, where it seems extremely unlikely that violence will erupt between states over disagreements about greenhouse gas emission reductions, although changes in the political economy of energy may lead to new rivalries between states. Thus, conflicts in which environmental change appears to be a contributing factor tend to be within rather than between states, and it is at this sub-state level that a climate change-conflict research agenda would most profitably focus.

#### *The Nature of Governance*

The political and economic structure of the state is critical in preventing environmental conflicts. Industrialised economies partake of a global division of labour and resources which affects a global division of environmental degradation as environmental externalities are transferred to developing countries. So, developed countries have tended to experience less environmental damage. Also, up to a certain level of mean per capita income, developed countries tend to have lower levels of localised pollution, although as important as increased wealth is an equitable distribution of power within states (Torras and Boyce 1998). In addition, it can be argued that the levels of wealth in the industrialised world allow for institutions that provide stability and resilience to environmental change. Well-financed government, the insurance industry, transport and communications infrastructure, a degree of democratic participation, and a base level of personal affluence all seem to help hedge against turmoil in the face of environmental stress (Barnett 2001b). Finally, trade between similarly affluent liberal-democracies assists in the transfer of necessary food and technology that helps enhance resilience and decreases the likelihood of crises within (and between) states. So, relative to developed countries, developing countries must contend with more potentially conflict-inducing environmental changes.

‘Strong states’ tend to be less prone to internal conflicts. Their capacity to foster collective action and identity mitigates against debilitating conflicts among heterogeneous groups. They have effective administrative hierarchies and they control the legitimate use of force, which helps manage potential internal challengers. They also have the capacity to mediate impending conflicts before they turn violent. Both democracies and strongly authoritarian regimes appear to experience relatively less inter-state conflicts (Eckstein and Gurr 1975). Weak states and states undergoing transition to alternative governance structures are relatively more prone to internal violent conflict. Importantly, inequities within states has been proven to be a factor in many violent conflicts, as well as being a factor in relatively greater levels of environmental damage (Boyce *et al.* 1999, Gleditsch 2001). This points to a potential correlation between environmental degradation and conflict. Hauge and Ellingsen (2001) find that there is a (albeit weak) correlation between environmental degradation, state regime type, and

internal conflict. Therefore, in addition to focussing at the intra-state level, a climate change-conflict research agenda would most profitably focus on those transition economies and transition democracies where income inequalities are high. This is not to say, however, that severe climate impacts, particularly low-probability/high impact events such as slowing of the oceanic thermohaline circulation in the North Atlantic, could not ultimately contribute to violent conflict in the developed world in the future.

### *The Nature of Environmental Change*

Discussions of violence and environmental conflict are directly and indirectly informed by a more long-standing concern of conflict studies with resource conflicts. At times discussions of environmental conflict tend to be far more about *resources* than *environments* (for example see Magno 1997 and Mandel 1994). To be sure, the distinction is difficult; freshwater, forests, fisheries and soils can all be seen as providing resources as well as ecological services, and certainly all are at risk of reduction and degradation from climate change. The question – what is an environmental conflict? – is therefore important. Libiszewski's answer is that environmental conflicts are characterised by the degradation of one or more of renewable resources, environmental sinks, and living spaces (Libiszewski 1992). This is because, as a general rule, resources are those things that have economic value, and conflict is only likely when the cost of substitutes (if available) are so high as to make violence a cheaper option – and this is rarely the case. Environmental functions are those things that cannot be so easily or cheaply substituted through technological developments and market forces, in particular spatial and temporal contexts. These include renewable resources such as potable freshwater at local and regional scales, fuelwood at the local scale, fish at local and regional scales, and fertile soils at local and regional scales. Thus Homer-Dixon's terminology of 'renewable environmental resources' is sufficiently precise (Homer-Dixon 1999). So, a climate change-conflict research agenda would profitably focus on areas where renewable resources are particularly sensitive to climate change.

The IPCC suggests that the most sensitive natural systems to climate change are: coral reefs, mangroves, boreal and tropical forests, polar and alpine ecosystems, prairie wetlands, and remnant native grasslands (IPCC 2001b). Climate change may affect scarcities of renewable environmental resources in these regions. Human systems that are most sensitive to climate change include: water supply systems, forestry activities, agricultural systems, and coastal zones and fisheries (IPCC 2001b). In terms of broad geographical regions and on the basis of the central scenarios from the range of all emissions scenarios (see IPCC 2000), the IPCC sees Africa as being highly vulnerable to climate change, particularly due to decreased water availability, enhanced food insecurity, impacts on human health, and increased desertification (IPCC 2001a). Asia is likely to have problems with food security and flooding, but overall is probably less vulnerable than Africa (although at the upper end of the range of emissions scenarios food security would be very substantially impacted by changes in the South Asian monsoon). Latin America is also less vulnerable than Africa, but is nevertheless likely to experience increasingly severe and possibly increasingly frequent climatic variations largely due to changes in the El Niño Southern Oscillation (ENSO), as well as decreasing biodiversity and reduced crop yields. Of all developing regions, however, it is the small island states that are most vulnerable to climate change through sea surface warming and coral bleaching, droughts and flooding, and changes in ENSO. However, the small island states have experienced much less violent conflict since colonisation relative to the other developing regions, and have much less capacity for violence – at least in terms of the availability of weapons. Europe, Australia and New Zealand, and North America are relatively much less vulnerable to climate change than developing regions largely by virtue of their considerably greater adaptive capacity.

### *Migration, conflict and climate change*

In many of the reported cases of environmentally-induced conflicts the movements of people and subsequent inter-group rivalry has played an important role (see Baechler 1999a, Gizewski and Homer-Dixon 1998, Goldstone 2001, Howard and Homer-Dixon 1998, Klötzli 1994, Percival and



Homer-Dixon 2001, Swain 1993). The point of contention in the literature is the extent to which environmental change is a factor in migration decisions, which is not unlike the problem of causality in determining the role of environmental change in violent conflicts.

Most migration is not international but rather occurs within individual countries, and most international migration occurs between developing countries (Russell 1995). Much migration is seasonal and cyclical rather than permanent. The best predictor of migration patterns in the future is recent migration patterns. People rarely migrate for environmental reasons alone. A range of factors, including economic opportunity, operate in unison, and these are in flux as a consequence of the economic and cultural effects of globalisation. A sensitive understanding of the way climate change may induce more migration in any particular place requires understanding the way it will interact with other factors, and the ways these factors may change, as climate change will have uneven impacts on even proximate social and ecological systems.

What is less contentious is that sometimes the influx of migrants into new areas can be a significant factor in violent conflict. Nevertheless, by no means all, indeed very few, large scale migrations end in conflict, as Goldstone observes:

“the crucial element is not migration per se; economic migration often leads to substantial benefits for both migrants and the destination country. What appears to matter for conflict are those cases wherein migration leads to clashes of national identity” (2001 p. 96).

Identity conflicts are in no way natural outcomes of inter-group mixing, rather they are the product of political forces seeking to gain power or defend against perceived threats to power. Group identity is socially constructed and malleable (Walker 1993). It is therefore less the movement of people and more the political responses to that movement that matters most in conflicts in which immigration is a factor. The receptiveness of leaders of both immigrant and host groups is very important for peaceful adaptation and settlement, and prior negotiation may well pave the way for peaceful and sustainable relocations.

Nevertheless, large migrations have at times lead to conflict, and large migrations are likely as a consequence of climate change. If they are to occur at all, climate-induced conflicts are most likely as a result of migration (van Ireland *et al.* 1996, Rahman 1999). In the first instance it will be climatic extremes and increasing climate variability that will enhance migration as soils are degraded, water supplies contaminated and depleted, housing, livestock and infrastructure damaged, insurance costs rise, and lives are lost. Communities generally adapt and are generally resilient to extreme events. However, as climate becomes increasingly variable extreme events may become more frequent and more severe, and this may stretch the limits of adaptability and resilience, making migration an attractive, if not the only option. Sea-level rise is very likely to induce large scale migration in the longer-term. According to Nicholls *et al.* (1999) by 2080 the flood risk for people living on islands will be 200 times greater than in a situation where there was no global warming. Therefore, to avoid climate-induced migration and the subsequently enhanced risk of violent conflict, slowing the rate and ultimately reducing the amount of greenhouse gas emissions, as well as enhancing adaptive capacity to extreme weather events is essential.

It is likely that for social-ecological systems that are highly sensitive to climate change existing avenues of migration will be explored first. In developing countries planning for enhanced internal migration and international immigration is required given that they are more vulnerable to the impacts of climate change and most existing migration is within and between developing countries. For example, many of the 5.5 million people living on the Ganges Delta in Bangladesh who will be forced to relocate with a 45cm rise in sea-level may seek to move inland within Bangladesh, but a significant number may seek to move to neighbouring India and Pakistan – and previous migration of this kind has been a factor in violence in the region (Swain 1996). Existing patterns of ‘environmental refugees’ may also be indicative of the places from where climate migrants might emerge as these represent

movements from areas already under environmental stress, and possibly under increasing stress due to climate change.\*

For those countries already dealing with large influxes of migrants, and for those likely to receive increasing numbers of migrants as a consequence of climate change, strategic assessment and forward planning for climate immigrants should be a policy priority. Throughout the world, immigration policies require rethinking. Closing out immigrants may be of marginal effectiveness and, particularly for developed countries, morally difficult to sustain since it is their emissions that will have caused the problem. A potentially more effective and respectable policy option would be controlled acceptance and resettlement of immigrants and promotion of racial tolerance domestically. Carefully timed acceptance of immigrants from an early stage can ease adjustment for immigrants and host communities alike, and can help relieve population-environment pressures in places that are sensitive to climate change.

The challenges of climate change to immigration policy are evident in Oceania. It is incumbent on Australia, New Zealand and the United States to prepare for greater numbers of Pacific Island immigrants, as these countries are capable of accommodating larger numbers of people, they already have substantial populations of Pacific Islanders, and they are in no small way responsible for climate change. The Prime Minister of Tuvalu, Ionata Ionata said in February 2000 that "Tuvaluans are seeking a place they can permanently migrate to should the high tides eventually make our homes uninhabitable" (Fiji Times February 23). New Zealand has said it would accommodate up to half of Tuvalu's population should they be required to leave their homelands due to climate change. However, not all Pacific Island countries are talking about refuge. The Marshall Islands publicly rejected the topic during interviews at the sixth Conference of Parties in 2000 (Fraser 2000), and Kiribati has consistently refused to consider it, with climate change officer Nakibae Teuatabo saying: "I think of emigration as being the stage where you know you're losing the battle. We're nowhere near that" (in Pearce 2000).

To conclude, much further research is required before making confident predictions about climate change and violent conflict. A research programme looking to empirically investigate climate-conflict linkages in greater detail would be most effectively targeted at the sub-state level, in weak states or states in economic transition where levels of inequality are high, and at areas where renewable environmental resources are highly sensitive to climate change. Critical to any such assessment is the role of emigration and immigration.

### **The Military and Climate Change**

As the organisations principally responsible for national security, and commanding a large share of public resources for that purpose, the world's militaries will increasingly have to adapt to the challenges of climate change. Militaries are major emitters of greenhouse gases. A crude indicator of the scale of this can be gained from taking the share of a country's GNP spent on its military as representative of the military's share of that country's overall greenhouse gas emissions (assuming military emissions per unit of GNP are the same as the national mean of emissions per unit of GNP). Following this procedure: military expenditure was 11.7% of 1995 GNP in the Russian Federation, so the Russian armed forces emit roughly 185 million metric tons of CO<sub>2</sub>; military expenditure was 3% of 1995 GNP in the United Kingdom, so the UK armed forces emit some 17 million metric tons of CO<sub>2</sub>; and military expenditure was 3.8% of 1995 GNP in the United States, so by this reckoning, the US armed forces emit some 210 million metric tons of CO<sub>2</sub> (data from World Bank 2000b). Indeed,

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\* Environmental refugees is a contentious term, see MacKellar *et al.* 1998, and Lonergan and Swain 1999. For this reason this discussion avoids the term 'refugee' as much as possible.

military expenditure accounted for 2.9% of world production in 1996, so worldwide military activity may be responsible for more greenhouse gas emissions than all of the United Kingdom. In this respect, militaries are a problem rather than a solution to environmental insecurity.

Recognising the growing need for national governments to reduce greenhouse gas emissions, a number of armed forces are voluntarily becoming involved in greenhouse gas reduction programmes. The Australian Department of Defence has joined the Australian Greenhouse Challenge and is seeking to cut its emissions by 13% by 2004. In February 2001 the United Nations Environment Programme, The US Environmental Protection Authority and the US Department of Defence hosted a conference on 'The Importance of Military Organisations in Stratospheric Ozone Protection and Climate Protection' which was attended by representatives from more than 35 countries and sought to share experiences of greenhouse gas reduction within the armed forces. The US Department of Defence claims to have reduced its greenhouse gas emissions by 20% between 1990 and 1996 (and so could well give lessons to other Government agencies) (DOD 2000). Nevertheless, with more than 250 000 trucks, 22 000 aircraft and hundreds of ships, a smaller US military would yield far greater reductions in greenhouse emissions than its ecological modernisation (DOD 2000).

Apart from the emissions arising from military activity, military expenditure displaces spending on environmental and social goals. For example, an April 1997 press release from the Australian Ministry for Defence gave the following annual fuel costs for Australia's various weapons platforms: F-111 aircraft – A\$8 million; F/A-18 aircraft – A\$19 million; DDG destroyers – A\$19 million; and FFG frigates – A\$15 million. The total annual fuel bill for operating Australia's eight major weapons platforms in 1997 was A\$48.6 million; to compare, Federal funding for renewable energy research and development in 1998 was A\$16 million (Parer 1998).

Should climate change have drastic impacts militaries may become involved in conflicts and peacekeeping. Indeed, this is central to the United State Department of Defense's environmental security policy:

DOD's view of 'environmental security' [also comprises] . . . understanding where environmental conditions contribute to instability and where the environment fits into the war and peace equation; bringing defense-related concerns to the development of national security; [and] studying how defense components can be used as instruments of U.S. global environmental policy (p. 133 of the 1996 *Environmental Change and Security Project Report*).

However, such a reactive position, and the subsequent resources consumed in that quest, are unlikely to provide environmental security for any group (except, in a perverse way, for the U.S. DOD).

### **Human Security**

That climate change poses risks to human welfare is relatively uncontentious in both climate science and climate policy circles. People living on atolls, on coasts, in areas affected by ENSO, in drought-prone areas, and in arctic regions are all likely to experience negative impacts from climate change. The problem is not just that there will be long-term incremental changes such as sea-level rise, but also increasingly variable (less predictable) climate and increasingly severe and frequent extreme weather events. These will require considerable institutional adjustments, and raise the possibility of violent conflicts that will further undermine welfare and livelihoods. Security in this sense is human security.

The United Nations Development Program (UNDP) has put forward the concept of human security to assist in the framing of development and equity issues, seeing it as being:

concerned with how people live and breathe in a society, how freely they exercise their many choices, how much access they have to market and social opportunities – and whether they live in conflict or peace.

Human security is not a concern with weapons – it is a concern with human life and dignity (UNDP 1994 p. 22-23).

This is clearly germane to the impacts of climate change on individual and community welfare and livelihoods.

Inequality and vulnerability are central to understanding both environmental insecurity and the impacts of climate change (Stripple 2002). Environmental insecurity is the double vulnerability of people that arises when underdevelopment and impoverishment are compounded by human-induced environmental change (Barnett 2001b). For example, Bangladeshis have a life expectancy twenty one years less than Australians, and a Bangladeshi woman is ninety times more likely to die when giving birth than a woman from Australia (UNDP 1998). There are therefore clear inequities between these two groups regardless of climate impacts. However, Australians produce eighty times more greenhouse gases than Bangladeshis, and within 50 years up to 11% of Bangladesh could be flooded due to sea-level rise, whereas a much smaller amount of Australia's surface is likely to be flooded. Australia has much greater wealth as a nation, as do its people, giving them the resources to adapt at some economic but otherwise relatively little social cost. The difference is that for most Australians climate change is a problem of adaptation, but for the majority of Bangladeshis the problem is a matter of survival: they are insecure. There are therefore discrepancies in responsibility for and vulnerability to climate change, and this underlies the dialectical nature of human environmental (in)security (Barnett 2001b).

### **Conclusions: Problems and Possibilities for a Climate–Security Discourse**

Climate change is a security problem for some states, cultures and communities through its likely impacts on ecosystems and their inhabitants, and through its indirect effects on development and political stability. But, what does it serve us to speak of climate change in these terms and what are the implications of doing so? This is an important question that is taken up in the broader environmental security literature, although with little specific reference to the problem of climate change. The crux of the problem is that national security discourse and practice tends to appropriate all alternative security discourses no matter how antithetical. It absorbs and then militarises and nationalises other security problems and referents in ways that neutralise their efficacy whilst maintaining the power of the security establishment (Brock 1997, Dalby 1994, Deudney 1991). This has been the experience of environmental security.

Environmental security was originally written with the intention of exposing the inadequacy of militarised practices of security, the porous nature of sovereignty in the face of environmental change, and to elevate environmental problems from the level of 'low politics' to 'high politics' so that states would commit as much energy and resources to address environmental problems as they do to other security problems (this is what meant by 'securitisation'). However, the result has not been trade-offs in military security for environmental security, or increased resources and energy devoted to enhancing environmental security. Instead, environmental change problems have been militarised; the emphasis has been placed on environmental change as cause of violent conflict rather than human insecurity; and on exogenous environmental threats to the state for which unspecified Others were seen to be responsible, as opposed to attending to domestic causes of environmental change (Barnett 2001b, Dalby 1999).

So, understanding climate change as a security issue risks making it a military rather than a foreign policy problem, and a sovereignty rather than a global commons problem. This may help justify further securing of the unsustainable livelihoods of the North in the way of George Bush Snr at the United Nations Conference on Development in 1992, and George W Bush over the Kyoto Protocol. It may also lead to increased attention on securing territory against undesirable knock-on effects of climate impacts such as environmental refugees, and on preparing for conflicts in important trading areas in the way of the formation of the US Rapid Deployment Force after the OPEC oil crises.

Despite these problems with any potential climate-change security discourse, it may nevertheless have some utility. Security communicates a certain *gravitas* that is arguably necessary in climate change policy. In that climate change is a security problem for certain groups, identifying it as such suggests that it is an issue that warrants a policy response commensurate in effort if not in kind with war.

A critical and ambiguous concept in the UNFCCC is its reference to ‘dangerous’ levels of climate change. Because it is an accentuated discourse on vulnerability, security encapsulates danger much better than concepts such as sustainability, vulnerability or adaptation, and it offers a framework in which danger can be recast as widespread risks to welfare and (in the case of small island states) sovereignty.

Security can also serve as an integrative concept which links local (human security), national (national security) and global (international security) levels of environmental change and response. It also integrates mitigation and adaptation as both are essential to security from climate risks. Finally, understanding processes that render groups insecure – and climate change is but one of these – brings to the fore issues of equity and the operation of the international political-economy. Further, although it should not be overstated, security addresses the possibility of violent social upheaval. It also brings military expenditure and its environmental impacts into consideration.

The ability of conventional national security discourse and policy to appropriate climate change is a matter of how climate security risks are understood, and who talks about them. Through a grounding in the findings of the Intergovernmental Panel on Climate Change, a climate change-security discourse could better resist appropriation from conventional national security as its key concerns will be rooted in respectable science rather than conjecture. If used by IPCC scientists, a climate change-security discourse will have a legitimacy that renders it less amenable to appropriation and rewriting by conventional national security institutions. If such a discourse downplayed and was cautious on the issue of violent conflict and refugees, and if it pointed to the equity issues that attend climate change risks, then it might helpfully integrate science and policy and usefully elucidate the nature of the ‘danger’ which the UNFCCC ultimately seeks to avoid.

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### **References**

- Baechler, G., 1999a. Environmental degradation in the south as a cause of armed conflict, in Carius, A., and Lietzmann, K. (Eds), *Environmental Change and Security: A European Perspective*. Springer-Verlag, Berlin, 107-130.
- Baechler, G., 1999b. Environmental degradation and violent conflict: hypotheses, research agendas and theory building, in Suliman, M. (Ed), *Ecology, Politics and Violent Conflict*. Zed Books, London and New York, 76-112.
- Baechler, G., 1999c. *Violence Through Environmental Discrimination: Causes, Rwanda Arena, and Conflict Model*. Kluwer, Dordrecht.
- Barnett, J., 2000., Destabilising the environment-conflict thesis. *Review of International Studies* 26 (2), 271-288.

- Barnett, J., 2001a. The Issue of 'Adverse Effects and the Impacts of Response Measures' in the UNFCCC. Tyndall Centre for Climate Change Research Working Paper 5, Norwich.
- Barnett, J., 2001b. The Meaning of Environmental Security: Ecological Politics and Policy in the New Security Era. Zed Books, London and New York.
- Barnett, J., 2002. Global Warming and the Security of Atoll-Countries. Macmillan Brown Centre for Pacific Studies Working Paper, Christchurch.
- Barnett, J. and Dovers, S., 2001. Environmental security, sustainability and policy. *Pacifica Review* 13 (3), 157–169.
- Bernstein, P., Montgomery, D., Rutherford, T., Yang, G., 1999. Effects of restrictions on international permit trading: The MS-MRT model, in Weyant, J., (Ed), *The costs of the Kyoto Protocol: a multi-model evaluation*. *The Energy Journal*, 221-256.
- Boyce, J., Klemer, A., Templet, P., Wills, C., 1999. Power distribution, the environment and public health: a state-level analysis. *Ecological Economics* 29, 127-140.
- Brock, L., 1997. The environment and security: conceptual and theoretical issues, in Gleditsch, N. (Ed), *Conflict and the Environment*. Kluwer, Dordrecht, 17-34.
- Brown, L., 1977. *Redefining National Security*. Worldwatch Paper No.14, Worldwatch, Washington.
- Brown, N., 1989. Climate, ecology and international security. *Survival* 31 (6), 519-532.
- Campbell, D., 1992. *Writing Security: United States Foreign Policy and the Politics of Identity*. Manchester University Press, Manchester.
- Clinton, W., 1996. *U.S. National Security Strategy of Engagement and Enlargement*. The White House, Washington.
- Dabelko, G., Simmons, P. 1997. Environment and security: core ideas and U.S. government initiatives. *SAIS Review* 17 (1), 127-146.
- Dalby, S., 1992. Ecopolitical discourse: 'environmental security' and political geography. *Progress in Human Geography* 16 (4), 503-522.
- Dalby, S., 1994. The politics of environmental security, in Kakonen, J., (Ed), *Green Security or Militarized Environment?* Aldershot, Dartmouth, 25-53.
- Dalby, S., 1999. Threats from the south: geopolitics, equity and 'environmental security, in Deudney, D., Matthew, R., (Eds), *Contested Grounds: Security and Conflict in the New Environmental Politics* State University of New York Press, Albany, 155-185..
- Deudney, D., 1991. Environment and security: muddled thinking. *The Bulletin of Atomic Scientists* 47 (3), 23-28.
- DOD (United States Department of Defense)., 2000. *U.S. Department of Defense: Climate Change, Energy Efficiency, and Ozone Protection*. Office of the Deputy Under-Secretary of Defense (Environmental Security), Washington.
- Dower, N., 1995. Peace and security: some conceptual notes, in Salla, M., Tonetto, W., Martinez, E., (Eds), *Essays on Peace: Paradigms for Global Order*. Central Queensland University Press, Rockhampton, 18-23.

- Eckstein, H., and Gurr, T., 1975. *Patterns of Authority: A Structural Basis for Political Inquiry*. Wiley, New York.
- Edwards, M., 1996. Climate change, worst-case analysis and ecocolonialism in the Southwest Pacific. *Pacifica Review* 8 (1), 63-80.
- Edwards, M., 1999. Security implications of a worst-case scenario of climate change in the South-west Pacific. *Australian Geographer* 30 (3), 311-330.
- Ehrlich, P. and Ehrlich, A., 1991. Population growth and environmental security. *Georgia Review* 45 (2), 223-232.
- Falk, R., 1971. *This Endangered Planet: Prospects and Proposals for Human Survival*. Random House, New York.
- Fraser, G., 2000. Sea-level rise, hurricanes, it is no paradise on small islands. *The Earth Times* November 15.
- Gizewski, P. and Homer-Dixon, T., 1998. The case of Pakistan, in Homer-Dixon, T., Blitt, J., (Eds), *Ecoviolence: Links Among Environment, Population, and Security*. Rowman and Littlefield, Lanham, 147-200.
- Gleditsch, N., 1998. Armed conflict and the environment: a critique of the literature. *Journal of Peace Research* 35 (3), 381-400.
- Gleditsch, N., 2001. Armed conflict and the environment, in Diehl, P., Gleditsch, N., (Eds), *Environmental Conflict*. Westview Press, Boulder, 251-272.
- Gleick, P., 1992. Effects of climate change on shared fresh water resources, in Mintzer, I., (Ed), *Confronting Climate Change*. Cambridge University Press, Cambridge, 127-140.
- Goldstone, J., 2001. Demography, environment, and security, in Diehl, P., Gleditsch, N., (Eds), *Environmental Conflict*. Westview Press, Boulder, 84-108.
- Hauge, W. and Ellingsen, T., 2001. Causal pathways to conflict', in Diehl, P., Gleditsch, N., (Eds), *Environmental Conflict*. Westview Press, Boulder, 36-57.
- Hoegh-Guldberg, O., Hoegh-Guldberg, H., Stout, D., Cesar, H., Timmerman, A., 2000. *Pacific in Peril: Biological, Economic and Social Impacts of Climate Change on Pacific Coral Reefs*. Greenpeace, Amsterdam.
- Homer-Dixon, T., 1991. On the threshold: environmental changes as causes of acute conflict. *International Security* 16 (2), 76-116.
- Homer-Dixon, T., 1999 *Environmental Scarcity and Violence*. Princeton University Press, Princeton.
- Homer-Dixon, T. and Blitt, J., (Eds) 1998. *Ecoviolence: Links Among Environment, Population, and Security*. Rowman and Littlefield, Lanham.
- Homer-Dixon, T. and Percival, V., 1996. *Environmental Scarcity and Violent Conflict: Briefing Book*. American Association for the Advancement of Science, Toronto.
- Howard, P. and Homer-Dixon, T., 1998. The case of Chiapas, Mexico, in Homer-Dixon, T., Blitt, J., (Eds), *Ecoviolence: Links Among Environment, Population, and Security*. Rowman and Littlefield, Lanham, 19-66.

- IPCC (Intergovernmental Panel on Climate Change). 2000. Special Report on Emissions Scenarios. Cambridge University Press, Cambridge.
- IPCC (Intergovernmental Panel on Climate Change). 2001a. Technical summary: climate change 2001: impacts, adaptation, and vulnerability, in *Climate Change 2001: Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Third Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge University Press, Cambridge.
- IPCC (Intergovernmental Panel on Climate Change). 2001b. Summary for policymakers: climate change 2001: impacts, adaptation, and vulnerability, in *Climate Change 2001: Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Third Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge University Press, Cambridge.
- Kaplan, R., 1994. The coming anarchy. *Atlantic Monthly* 273 (2), 44-76.
- Klötzli, S., 1994. The Water and Soil Crisis in Central Asia – a Source for Future Conflicts? ENCOP Occasional Paper No. 11. Centre for Security Policy and Conflict Research, Zurich.
- Libiszewski, S., 1992. What is an Environmental Conflict? ENCOP Occasional Paper No. 1. Centre for Security Policy and Conflict Research, Zurich.
- Lipschutz, R. and Holdren, J., 1990. Crossing borders: resource flows, the global environment and international stability. *Bulletin of Peace Proposals* 21 (2), 121-133.
- Litfin, K., 1999. Environmental security in the coming century, in Paul, T., Hall, J., (Eds), *International Order and the Future of World Politics*. Cambridge University Press, Cambridge.
- Lonergan, S. and Swain, A., 1999. Environmental degradation and population displacement. AVISO Bulletin, Issue No. 2. Global Environmental Change and Human Security Project, Vancouver.
- Lowi, M., Shaw, B., (Eds) 2000. *Environment and Security: Discourses and Practices*. Macmillan Press, Hampshire, and St. Martins Press, New York.
- MacKellar, F., Lutz, W., McMichael, A., Suhrke A., 1998. Population and climate change, in Rayner, S., Malone, E., (Eds), *Human Choice and Climate Change, Volume 1: The Social Framework*. Batelle Press, Ohio, 89-193.
- Magno, F., 1997. Environmental security in the South China Sea. *Security Dialogue* 28 (1), 97-112.
- Mandel, R., 1994. *The Changing Face of National Security: A Conceptual Analysis*. Greenwood Press, Westport.
- Mathews, J., 1989. Redefining Security. *Foreign Affairs* 68 (2), 162-177.
- Murdiyarsro D., 2000. Adaptation to climatic variability and change: Asian perspectives on agriculture and food security. *Environmental Monitoring and Assessment* 61 (1), 123-131.
- Myers, N., 1987. Population, environment and conflict. *Environmental Conservation* 14 (1), 15-22.
- Nicholls, R., Hoozemans, F., Marchand, M., 1999. Increasing flood risk and wetland losses due to global sea-level rise: regional and global analyses. *Global Environmental Change* 9 (supplementary issue), 69-87.
- Page, E., 2000. Theorizing the link between environmental change and security. *RECIEL* 9 (1), 33-43.



- Parer, W., 1998. Coalition Spending on Renewable Energy Research and Development More Than Double Last Year of Labour. Media Release, Ministry for Resources and Energy, Canberra.
- Parry, M., Rosenzweig C., Iglesias A., Fischer G., Livermore M., 1999. Climate change and world food security: A new assessment. *Global Environmental Change* 9 (supplementary issue), 51-67.
- Pearce, F., 2000. Turning back the tide. *New Scientist* 165 (2225).
- Percival, V. and Homer-Dixon, H., 2001. The case of South Africa, in Diehl, P., and Gleditsch, N., (Eds), *Environmental Conflict*. Westview Press, Boulder, 13-35.
- Rahman, A., 1999. Climate change and violent conflicts, in Suliman, M., (Ed), *Ecology, Politics and Violent Conflict*. Zed Books, London and New York, 181-210.
- Raknereud, A. and Hegre, H., 1997. The hazard of war: reassessing the evidence for the democratic peace. *Journal of Peace Research* 34 (4), 385-404.
- Rapkin, D. and Avery, W., 1986. World markets and political instability within less developed countries. *Co-operation and Conflict* 21 (2), 99-117.
- Rowlands, I., 1991. The security challenges of global environmental change. *The Washington Quarterly* 14 (1), 99-114.
- Russell, S., 1995. *International Migration: Implications For The World Bank*. Human Resources Development and Operations Policy Working Papers Number 54. World Bank, Washington.
- Sanchez, P., 2000. Linking climate change research with food security and poverty reduction in the tropics. *Agriculture, Ecosystems & Environment* 82 (1-3), 371-383.
- Shaw, B., 1996. When are environmental issues security issues? *Environmental Change and Security Project Report* 2, 39-44.
- Singer, D., 1972. The correlates of war project: interim report and rationale. *World Politics* 24(2), 243-270.
- Smil, V., 1997. China's environment and security: simple myths and complex realities. *SAIS Review* 17 (1), 107-126.
- Soroos, M., 1997. *The Endangered Atmosphere: Preserving a Global Commons*. University of South Carolina Press, Columbia.
- Stripple, J., 2002. Climate change as a security issue, in Page, E., Redclift, M., (Eds), *Human Security and the Environment: International Comparisons*. Edward Elgar, Cheltenham.
- Swain, A., 1993. Conflicts over water: the Ganges water dispute. *Security Dialogue* 24 (4), 429-439.
- Swain, A., 1996. *The Environmental Trap: The Ganges River Diversion, Bangladeshi Migration and Conflicts in India*. Department of Peace and Conflict Research Uppsala University Report, Sweden.
- Swart, R., 1996. Security risks of global environmental changes. *Global Environmental Change* 6 (3), 187-192.
- Torras, M. and Boyce, J., 1998. Income, inequality, and pollution: a reassessment of the environmental Kuznets curve. *Ecological Economics* 25, 147-160.

UNDP (United Nations Development Program), 1994. Human Development Report 1994. Oxford University Press, New York.

UNDP (United Nations Development Program), 1998. Human Development Report 1998. Oxford University Press, Oxford and New York.

van Ireland, E., Klaassen, M., Nierop, T., van der Wusten, H., 1996. Climate Change: Socio-Economic Impacts and Violent Conflict. Dutch National Research Programme on Global Air Pollution and Climate Change, Report No. 410 200 006, Wageningen.

Vasquez, J., 1993. The War Puzzle. Cambridge University Press, Cambridge.

Waever, O., 1995. Securitization and desecuritization, in Lipschutz, R., (Ed), On Security. Columbia University Press, New York, 46-86.

Walker, R., 1993. Inside/Outside: International Relations as Political Theory. Cambridge University Press, Cambridge.

Wallensteen, P. and Sollenberg, M., 1997. Armed conflicts, conflict termination and peace agreements 1989-96. Journal of Peace Research 34 (3), 339-358.

Watson, R. 2000. Presentation of the Chair of the Intergovernmental Panel on Climate Change to the Sixth Conference of Parties of the United Nations Framework Convention on Climate Change. November 13, Geneva. <http://www.ipcc.ch>

Wilkie, D., Morelli, G., Rotberg, F., Shaw, E., 1999. Wetter isn't better: global warming and food security in the Congo Basin. Global Environmental Change 9 (4), 323-328.

Wilson, T. 1983. Global climate, world politics and national security, In Nanda, V., (Ed), World Climate Change: The Role of International Law and Institutions. Westview Press, Boulder, 71-77.

Wolf, A., 1999. 'Water wars' and water reality: conflict and co-operation along international waterways, in Lonergan, S., (Ed), Environmental Change, Adaptation, and Security. Kluwer Academic Publishers, Dordrecht, 251-265.

World Bank. 2000a. Cities, Sea, and Storms: Managing Change in Pacific Island Economies. World Bank, Washington.

World Bank 2000b. World Development Report 1999/2000. Oxford University Press, Oxford.

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