

Review

Mangrove forests and human security¹

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Received: 21 March 2008

Accepted: 17 July 2008

doi: 10.1079/PAVSNNR20083064

The electronic version of this article is the definitive one. It is located here: <http://www.cababstractsplus.org/cabreviews>

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Abstract

This paper reviews concepts and theories of 'environment and security' and examines their relevance in understanding human–mangrove interactions. Scientists and decision-makers are increasingly interested in the relationship between environmental change and human security. Research on human–mangrove interactions suggests that mangrove forests illustrate this relationship well, at least in terms of the general framing of these issues. Mangroves and the diverse resources and services they provide (wood, food and fuel) are critical to the livelihood security of highly vulnerable coastal populations throughout the tropics. At the same time, their restricted coastal distribution, which is often proximate to population concentrations, makes them the frequent loci of conflict between competing human interests. Studies of mangrove planting and human settlement along the coast demonstrate the value of mangroves for protecting property and livelihood from storm impacts. Observations of the Asian tsunami of 2004 further highlight this protective role and provide a stark reminder that environmental sustainability and human security are often inseparable. Yet, broadly framed discussions of environment and security offer little concrete guidance to researchers and policy-makers tasked with understanding and better managing the relationships between people and mangrove forests in particular contexts.

Keywords: Environmental security, Livelihood security, Mangrove restoration, Non-timber forest products, Fisherfolk, Coastal zone management

Introduction

The economic and environmental values of mangrove forests have long been recognized by researchers [1–4]. But it was the Asian tsunami of 2004 that raised wider appreciation of these unique coastal wetlands. The importance of restoration and protection of mangrove forests is now noted by influential voices as diverse as the Chief Scientist of the World Bank, the Prime Minister of Malaysia, and former US President, Bill Clinton [5]. Yet, these more recent justifications for conserving mangroves are based largely on arguments about their role in human

security [6–8], rather than more conventional economic and conservation arguments (3).

It is unclear what long-term impact this rather novel framing of mangrove conservation will have on policies and programmes aimed at protecting these forests. It is not the aim of this review to consider this question, nor is it the intent to review the extensive literature on the economic values, uses and management of mangroves [3, 4, 9–11]. Rather, the purpose of this review is to consider, in general terms, the relevance of applying concepts and theories of security in understanding human–mangrove interactions. In this respect, it represents a contribution to the now burgeoning academic and policy literature on the relationship between environmental change and human conflict/security, i.e. 'environmental security' [12–17]. More specifically, it will add to recent discussions about security and conflict in forest environments [18–23].

¹Paper originally presented at the special session, 'Mangroves and the protection of coastal areas' IUFRO World Congress, Brisbane, Australia (8–12 August, 2005).

The first section of the review will succinctly review key concepts and theories raised in the literature on environment and security. The main body of the review will then explore how these ideas pertain to mangrove forests by drawing upon selected published literature and my own experience doing research on people–mangrove interactions. The review will conclude with a brief discussion of the key benefits and limitations of defining human–mangrove interactions in security terms.

Environment and Security

Ecological anthropologists have long studied how human populations interact with environmental resources in ways that lead to conflict between groups in mostly pre-modern, tribal societies [24, 25]. By contrast, early policy-relevant thinking about environment and security focused on the environmental impacts (intentional and otherwise) of militarization and warfare [26–28]. Warfare impacts ecosystems, which in turn undermines human livelihood security by degrading agricultural lands, contaminating water supplies and damaging critical natural resources like forests [29]. In addition, conflicts and the threat of violence tend to undermine local law and order (including environmental laws) and may compel people to migrate from their existing homeland environments to different ones [30–33]. Depending on the situation, such changes may result in a relative worsening or lessening of local environmental impacts or, especially in the case of migrations, a shifting of environmental impacts from one region to another [21, 34].

The explicit notion that environmental change can create insecurity and possibly trigger violent conflict among peoples emerged as a significant proposition among social scientists and policy-makers during the late 1980s and early 1990s [35–37]. This reflected a confluence of factors, including declining Cold War security priorities and increasing concern about the possible impacts of pernicious environmental changes such as global warming, ozone depletion, desertification and tropical deforestation [38–43].

In this respect, the writings of Mathews [44], Myers [45], Homer-Dixon [13, 46], Kaplan [47] and others were particularly influential within both academic and policy circles. These authors argued that environmental degradation combined with population growth would lead to resource scarcities that could, especially in the context of unstable Third World governments, create economic hardship and possibly trigger migrations, social unrest and civil (usually subnational) conflict. For example, causal relationships have been posited between environmental decline and political unrest in places as disparate as Haiti, the Philippines and the Middle East.

More recent writings on environment and security have critiqued and, in cases, elaborated on these essentially neo-Malthusian arguments. For example, while recognizing

that deteriorating environmental conditions can contribute to societal insecurity, authors like Collier *et al.* [48], Le Billon [49], Kaimowitz [34] and Thomson and Kanaan [22] emphasize the critical role of poor governance and external financing for creating and sustaining environmental resource conflicts [50]. In short, weak and corrupt governments create opportunities for moneyed interests to exploit valued environmental resources, the profits from which are sometimes used to support conflicts, e.g., civil insurgencies financed by ‘blood diamonds’ or ‘conflict timber’ [22, 49].

Neo-Marxist ‘political ecology’ brings yet another perspective to environmental security, one that emphasizes structural–political factors, like unequal access to resources, as underlying causes of environmental conflict [15, 51]. These political ecologists point out that, contrary to neo-Malthusian arguments, conflicts between people over environmental resources often arise amidst relative resource abundance, not scarcity. In their view, the issue is not one of competition over physically scarce resources *per se*, but rather competition between interest groups to gain controlled access to highly valued resources [49, 51].

Finally, there exists a parallel thread of environment and security writing that turns much of the aforementioned thinking on its head, so to speak, by de-emphasizing human conflict altogether. Instead, these authors point out that environmental degradation and scarcity often create incentives for cooperation among different interests and may even foster pro-active peace-building initiatives between competing groups or nations [52–54]. The modern proliferation of international environmental agreements and the constructive mobilization of people in protection of threatened environmental resources in many settings is evidence to them that Hobbesian-type outcomes are not inevitable [40, 55].

It is beyond the scope of this review to critique the relative merits of these different perspectives. Human insecurity and the social conflicts that sometimes ensue no doubt result from a combination of interacting factors, some more relevant than others in particular situations. Suffice to say here that some of the sharp differences in the perspectives outlined above reflect differences in the framing of environment and security issues; i.e. researchers are asking different questions about different things [40, 56]. Serious theoretical and methodological criticisms have also been levelled at the environment and security literature, in general, including its imprecise use of concepts and terminology [39, 56–58] and its common tendency to bias evidence collection in favour of pre-determined models or theory [40, 56, 59, 60]. In short, the heady discourse and rhetoric on environment and security has yet to be matched by an equivalent body of compelling, empirical research. These short-comings are unfortunate and will be re-examined briefly hereinafter. The next task, however, is to consider how some of the general concepts and theories of environment and security might have relevance to mangrove forests, in particular.

Mangrove Forests and Human Security

Mangrove Forests and Livelihood Security

Despite widely differing views on the questions to be asked and the causal connections to be considered, a point of general agreement among many environment and security writers is that social unrest and conflict often emerge where there exists actual or perceived threats to peoples' livelihoods. The degree to which local people depend on mangroves is thus important for understanding their possible significance in security terms.

Unlike many upland tropical forests, mangroves offer little in the form of commercially extractable timber. But research from mangrove sites throughout the coastal tropics has revealed widespread, often intensive direct extraction of diverse resources by local people, especially fuelwood, construction wood, fish, shrimp and shellfish [1–4, 9, 11, 61–63]. Mangroves are also critical for sustaining some nearshore fisheries, because their habitat is important for the juvenile stages of many shrimp and fish species [3, 4, 64–66].

These kind of non-timber forest products (NTFP) often do not enter commercial markets and so are grossly under-accounted for in economic statistics. Yet, studies from around the world reveal that NTFPs from mangroves and other tropical forests are widely consumed and form important components of local people's livelihoods, and are especially important for lower income people [67–72]. While income-distribution effects have not been carefully studied among mangrove forest users, these resources are clearly important to coastal communities where, for example, large numbers of impoverished fishing families lack alternative sources of food, fuel and construction materials [2, 63, 73]. Mangrove forests also serve as residential settlement sites for landless fisherfolk, and fishermen often depend on the unobstructed movement through mangrove creeks to gain access to open water with their boats [2, 74].

It is this varied but often significant local dependence on mangrove resources that helps explain the large number of recorded conflicts between coastal residents and aquaculture developers who clear extensive tracts of mangrove forests as their preferred sites for brackish water fish and shrimp ponds (75). Such conflicts were documented in my own research in the Philippines, where I learned that intimidation, bodily injury and murder had occurred as a direct result of conflicts between local fishermen and outsider developers whose claims to mangrove areas threatened to displace customary users.

Resource Scarcity, Inequality and Conflict

Arguments about scarcity- and inequality-driven conflict in mangroves follow from the prior discussion of livelihood dependence. Evidence is clear that mangroves are

becoming more physically scarce: approximately one-third of the world's mangrove forests have been lost in the past 50 years, although rates of loss vary tremendously from region to region [66]. The extent to which remaining forests are degraded is less clear, but also contributes to localized resource scarcity in many areas [63, 76, 77].

The problem of resource scarcity is compounded by rapidly growing human populations in many coastal areas. The Philippines offers a case in point: mangroves once abundant around Manila Bay at the turn of the last century have since been entirely cleared, the combined result of fish pond development, urban infrastructure expansion and residential spread ([78, 79], personal observation). Similarly, in a more rural region of the country, Bais Bay, mangroves have declined in the area over the past 50 years by 75% at the same time in which coastal populations have increased 10-fold [74]. Similar patterns of population growth coinciding with declining mangrove area have been documented along the coastlines of Honduras [80], Vietnam [64] and Bangladesh [81].

These and other sites have experienced conflicts among people with competing interests in mangrove resources [75, 82, 83]. However, the degree to which such conflicts reflect increasing resource scarcity *per se* or are perhaps compounded by existing social inequalities is often difficult to determine. Without doubt, one of the most common sources of documented conflict have been cases where relatively wealthy aquaculture developers have sought to claim and/or clear tracts of mangrove previously used by less wealthy fisherfolk. But conflicts among wealthy pond developers are common [75], and my own research has revealed that conflicts between relatively poor local people over access to mangroves are commonplace as well, even if typically less visible. At least in some cases, the frequency and severity of conflicts appears to increase where mangroves are becoming physically more scarce (personal observation). Perhaps as critical as the presence of inequality *per se* is the fact that wealthy individuals are simply capable of claiming and destroying more mangroves at a faster rate and so are more likely to generate conflict among pre-existing users [84].

Mangrove Governance and Security

Most governments long considered mangroves to be worthless swamplands, so rational policy guiding their management has in most cases been late in coming. Greatly complicating the effective governance of mangroves is their unique ecology being part land and part sea, jurisdictional ambiguities are often present. For example, until recently, regulation of mangrove forest lands in the Philippines fell under the legal jurisdiction of both the Department of Environment and Natural Resources (formerly the Ministry of Forests), whose mandate was to protect and sustainably manage these as forests, and the

Department of Agriculture, whose mandate was to promote brackishwater aquaculture development in these same areas. Thus, government decisions concerning mangroves were made with '... the right hand not knowing what the left hand was doing' [85]. Similar problems of jurisdictional ambiguity over mangroves have been documented in Ecuador [82], Brazil [86], India [83], Indonesia [87] and Thailand [88].

But such ambiguities go beyond government policy and affect informal understandings and customary rules concerning access and use of mangroves by different users. Customary use of mangroves is typically characterized by common access rights, with different uses overlapping but to a large degree accommodating one another [73, 83]. Conflict in such situations arises where, for example, customary boat access or seine fishing rights become impaired by the setting of a fish trap or construction of a dyke (personal observation). But people who depend most directly on mangrove resources for livelihood are typically poor, as noted hereinbefore, and likely marginalized from wider political processes and decision making (personal observation; cf. [89]). Their interests are rarely factored adequately into decisions by governments and private investors about the disposition of mangrove lands for development. The potential for conflict is understandably real in the many cases where large tracts of mangrove are leased to private interests at the expense of customary, common access users [73, 75, 80, 83, 90, 91]. The explosive worldwide expansion of industrial shrimp farming is particularly problematic because the large, short-term profit potentials of these operations tend to create the incentive for corruption of legal mechanisms that might otherwise protect the forests and/or interests of local users [75, 82, 83]. In short, the 'opportunity' for conflict to emerge is enhanced by a lack of shared understandings about rules of access, political marginalization of affected stakeholders, absence of clear government regulations, and ineffective means of regulatory enforcement and dispute resolution.

Mangroves as Buffers against Natural Calamities

Given the enormous damage caused by the Asian tsunami of 2004, it is not surprising that discussions about the security benefits of mangroves have focused on their presumed role in protecting coastlines from wave damage. Yet, this apparent 'protective role' is an aspect of mangrove ecology and economics that has been little studied and so remains poorly understood [4, 92]. It is well known that mangroves will not thrive in environments subject regularly to high wave and current energies. Their role as storm buffers is thus limited or non-existent in many sites where it would be most appreciated [92]. Nonetheless, mangrove forests, where present, can significantly dissipate the energy and impact of waves [93]. Preliminary assessments of post-tsunami affected areas

suggest that mangroves did reduce damage in some, but not all areas where they were present [4, 94–96]. Human settlements and infrastructure are thus at greater risk of storm damage when they build into mangrove areas and eliminate shoreline forests.

Furthermore, the protective value of mangrove forests applies, more generally, to storm events that are a regular occurrence along many tropical shorelines, often inflicting heavy property damage and significant loss of life. In this respect, Badola and Hussain [97] found evidence that mangroves significantly reduced property damage caused by a 1999 cyclone in coastal villages in India. Likewise, research on the impacts of the 1998 Hurricane Mitch in Latin America led Girot [20] to conclude that mangroves are among the most critical habitats worthy of protection because of their value in mitigating the destructive effects of severe storms.

These kinds of storm-protective benefits also appear to be widely acknowledged by people who live and own property along tropical coastlines. Technical literature on brackishwater aquaculture has long recognized that mangroves can protect pond dykes from wave damage [98]. Likewise, research in coastal communities in India and the Philippines has revealed widespread recognition among fishermen and fish pond owners that mangroves help protect shoreline properties from the damaging effects of wind and waves, especially typhoons [73, 97, 99]. In fact, almost half of the people interviewed in ten coastal communities in Bais Bay, Philippines had planted mangroves in front of their homes or adjacent to their fish pond dykes to serve as storm buffers [73].

Environmental Security: Response and Adaptation

The degree to which a given environmental change actually translates into a security concern reflects to a large degree how well those affected respond and adapt to that change [13, 42, 51, 89, 100–102]. Where peoples' ability to adapt is restricted by limited choice, few capital endowments, etc. or simply overwhelmed by the scale and degree of change, there is an increased risk of them being pushed into a kind of self-re-enforcing spiral of deepening poverty, intensified environmental degradation and aggravated social conflict [17]. Alternatively, effective adaptation may not only forestall crisis, but may create new opportunities that lead to progressive improvements in environmental sustainability and livelihood security [101, 104]. In this regard, some advocates of the environment and security as fostering peace-building perspective have argued that pro-active investments in environmental conservation should, in fact, be viewed as investments in long-term human peace and security [53].

Conflicts over mangroves are for the most part illustrative of undesirable response and adaptation to change. But there is evidence of constructive adaptation as well. At the political level, many governments are realizing the

value of mangrove forests and are taking steps to rationalize policy and improve management. For example, mangrove laws and policy were radically revised in the Philippines in the 1980s/1990s and, among other changes made were the gazettement for protection of many ecologically significant sites in the country; programmes aimed to empower local community rights in forests; and a more accountable and restrictive aquaculture-permitting process [73, 74, 105]. Policy innovation of this kind is also apparent at the local government level in some jurisdictions [74].

Adaptation to mangrove scarcity is also taking place among local people who use mangroves directly. For example, self-motivated planting and management of mangroves by residents living in coastal areas has been documented in several countries [73, 83, 97, 99, 106–108]. These people plant mangroves as an investment, to protect property from storm damage, or to secure ready supplies of valued wood products [73, 109]. Mangrove reforestation projects financed by governments and non-government organizations are likewise now commonplace in many countries [110–113]. These kinds of initiatives have recently multiplied in response to the Asian Tsunami [114].

Other people are responding to declining availability of mangrove resources by switching to alternatives. For example, many households along the coast in Bais Bay, Philippines have switched cooking fuel from mangrove wood to wood acquired from upland sources or to natural gas [74]. As well, homes along the shore are increasingly built with concrete or non-mangrove wood (personal observation). Transitions to alternatives like this may be actively supported by government policies and programmes such as those which encourage the planting of fast-growing fuel-wood trees on nearby, degraded uplands.

Conclusion

Whether these kinds of responses translate into successful adaptations over the longer term remains to be seen. Outcomes will likely unfold on a case-by-case or region-by-region basis. For example, the planting of mangroves is now widely advocated as a means to increase coastline security, but planting efforts will only succeed where conditions are naturally suitable for mangrove establishment and, equally important, acceptable in the context of ongoing economic and political pressures to claim and develop valued coastal property. In fact, early evidence suggests that many post-tsunami restoration initiatives are encountering problems of this kind [114].

The further challenge is that population and related development pressures are certain to grow along many coastlines [101]. Compounding this, most climate-change scenarios predict rising sea levels and increasingly frequent storm events which will damage and further

squeeze the ecological distribution of mangroves in many areas [74, 115, 116, 117].

Our human ingenuity will certainly be put to test in the coming years, but recent events have revealed that there is a great deal at stake if we fail. For if past economic and environmental arguments for conserving mangroves were not viewed as synonymous with human security, it is perhaps only because we did not put a human face on those whose lives and livelihoods depend on these unique and valuable forests. Tragic as it was, the Asian Tsunami of 2004 gave us this human face and, in so doing, has re-defined mangrove conservation as a human security concern. Yet, the general re-framing of issues like this will only get us so far. Successful mangrove restoration and management in the face of increasing human and environmental stressors will ultimately depend on our understanding of the interactions between people and mangroves in particular contexts and the wider political and economic influences on these interactions. In this respect, the burgeoning literature on environment and security provides little concrete guidance for researchers, managers or policy makers [60].

Acknowledgements

I am grateful to the Scientific Committee of the 2005 IUFRO World Congress (Brisbane, Australia) for encouraging and supporting development of a special session on mangroves and coastal protection, as this provided impetus for writing this paper.

References

1. Christensen B. Management and Utilization of Mangroves in Asia and the Pacific. FAO Environment Paper No. 3. Food and Agriculture Organization, Rome; 1982.
2. Kunstadter P, Bird ECF, Sabhasri S (editors). Man in the Mangroves. United Nations University, Tokyo; 1986.
3. Hamilton LS, Dixon JA, Miller GO. Mangrove forests: an undervalued resource of the land and of the sea. In: Borgese M, Ginsburg N, Morgan JR, editors. Ocean Yearbook 8. University of Chicago Press, Chicago; 1989. p. 254–88.
4. Walters BB, Ronnback P, Kovacs JM, Crona B, Hussain SA, Badola R, *et al.* Ethnobiology, socio-economics and management of mangrove forests: a review. *Aquatic Botany* 2008;89:220–36.
5. Clinton WJ. Six months after. *The New York Times*, 22 June 2005.
6. Hammill A, Brown O, Crawford A. Forests, natural disasters and human security. *Arborvitae* (IUCN/WWF Forest Conservation Newsletter) 2005;27(March):8–9.
7. Kurien J. Tsunamis and a secure future for fishing communities. *Ecological Economics* 2005;55:1–4.
8. O'Brien K. Are we missing the point? Global environmental change as an issue of human security. *Global Environmental Change* 2006;16:1–3.

6 Perspectives in Agriculture, Veterinary Science, Nutrition and Natural Resources

9. Hamilton LS, Snedaker SC (editors). Handbook for Mangrove Area Management. IUCN/UNESCO/UNEP, East-West Center, Honolulu, Hawaii; 1984.
10. FAO. Mangrove Forest Management Guidelines. FAO Forestry Paper 117. Food and Agriculture Organization of the United Nations, Rome; 1994.
11. Bandaranayake WM. Traditional and medicinal uses of mangroves. *Mangroves and Salt Marshes* 1998;2:133–48.
12. Matthew R. Environment and security: concepts and definitions. *National Security Studies Quarterly* 1998;4(4): 63–72.
13. Homer-Dixon T. *Environment, Scarcity, and Violence*. Princeton University Press, Princeton, NJ; 1999. 253 p.
14. Suliman M (editor). *Ecology, Politics and Violent Conflict*. Zed Books, New York; 1999.
15. Peluso NL, Watts M (editors). *Violent Environments*. Cornell University Press, Ithaca, NY; 2001.
16. Dalby S. *Environmental Security*. University of Minnesota Press, Minneapolis, MN; 2002.
17. Matthew R, Halle M, Switzer J (editors). *Conserving the Peace: Resources, Livelihoods and Security*. International Institute for Sustainable Development (IISD) and the World Conservation Union (IUCN), Winnipeg, Canada; 2002. 408 p.
18. Sunderlin WD. Between danger and opportunity: Indonesia and forests in an era of economic crisis and political change. *Society and Natural Resources* 1999;12:559–70.
19. Barber CV. Forests, fires and confrontation in Indonesia. In: Matthew R, Halle M, Switzer J, editors. *Conserving the Peace: Resources, Livelihoods and Security*. International Institute for Sustainable Development (IISD) and the World Conservation Union (IUCN), Winnipeg, Canada; 2002. p. 99–169.
20. Girot PO. Environmental degradation and regional vulnerability: lessons from Hurricane Mitch. In: Matthew R, Halle M, Switzer J, editors. *Conserving the Peace: Resources, Livelihoods and Security*. International Institute for Sustainable Development (IISD) and the World Conservation Union (IUCN), Winnipeg, Canada; 2002. p. 273–317.
21. McNeely JA. Biodiversity, conflict and tropical forests. In: Matthew R, Halle M, Switzer J, editors. *Conserving the Peace: Resources, Livelihoods and Security*. International Institute for Sustainable Development (IISD) and the World Conservation Union (IUCN), Winnipeg, Canada; 2002. p. 29–52.
22. Thomson J, Kanaan R. *Conflict Timber: Dimensions of the Problem in Asia and Africa (Volume I: Synthesis Report)*. United States Agency for International Development, Washington, DC; 2004. 33 p.
23. ETFRN. *Forests and Conflicts*. Special Issue of the European Tropical Forest Research Network Newsletter, Volume 43/4. ETFRN News; 2005. 97 p.
24. Vayda AP. Warfare in ecological perspective. *Annual Review of Ecology and Systematics* 1974;5:183–93.
25. Scaglione R. *Maori Warfare: prefiguring contemporary directions in ecological science*. In: Walters BB, McCay BJ, West P, Lees S, editors. *Against the Grain: The Vayda Tradition in Human Ecology and Ecological Anthropology*. AltaMira Press, Lanham, MD; 2008. p. 27–39.
26. Westing AH. *Warfare in a Fragile World: Military Impact on the Human Environment*. Taylor and Francis, London; 1980.
27. Baechler G. Environmental degradation and violent conflict: hypothesis, research agendas and theory-building. In: Suliman M, editor. *Ecology, Politics and Violent Conflict*. Zed Books, New York; 1999. p. 76–112.
28. Thakur R, Maley W. The Ottawa Convention on Landmines: a landmark humanitarian treat in arms control? *Global Governance* 1999; 5:273–302.
29. Huynh DH, Hai HT. Effects of warfare on natural ecosystems and biodiversity in Vietnam. In: ETFRN, editor. *Forests and Conflicts*. p. 90–2. Special Issue of the European Tropical Forest Research Network Newsletter, volume 43/4. ETFRN News; 2005. p. 90–2.
30. Westing AH. Environmental refugees: a growing category of displaced persons. *Environmental Conservation* 1992;19(3):201–7.
31. Matthew R. People, scarcity and violence in Pakistan. In: Matthew R, Halle M, Switzer J, editors. *Conserving the Peace: Resources, Livelihoods and Security*. International Institute for Sustainable Development (IISD) and The World Conservation Union (IUCN), Winnipeg, Canada; 2002. p. 57–97.
32. Cambrey L. Forestry and conservation activities in hosting refugee areas. In: ETFRN, editor. *Forests and Conflicts*. Special Issue of the European Tropical Forest Research Network Newsletter, Volume 43/4. ETFRN News; 2005. p. 50–2.
33. Reuveny R. Ecomigration and violent conflict: case studies and public policy implications. *Human Ecology* 2008;36:1–13.
34. Kaimowitz D. Resources, abundance and competition in the Bosawas Biosphere Reserve, Nicaragua. In: Matthew R, Halle M, Switzer J, editors. *Conserving the Peace: Resources, Livelihoods and Security*. International Institute for Sustainable Development (IISD) and The World Conservation Union (IUCN), Winnipeg, Canada; 2002. p. 171–94.
35. Lonergan S. *Environment and Security: An overview of issues and research priorities for Canada*. Canadian Global Change Program Technical Report No. 96-1, Royal Society of Canada; 1996.
36. Dabelko GD, Simmons PJ. Environment and security: core ideas and US Government initiatives. *SAIS Review* 1997;17(1):127–46.
37. Schwartz P, Randall D. *An Abrupt Climate Change Scenario and Its Implications for United States National Security*. United States Department of Defense, Washington, DC; 2003. 22 p.
38. Ullman RH. Redefining security. *International Security* 1983;8:129–53.
39. Levy MA. Is the environment and national security issue? *International Security* 1995;20(2):35–62.
40. Schrad ML. Threat level green: conceding ecology for security in eastern Europe and the former Soviet Union. *Global Environmental Change* 2006;16:400–22.
41. Campbell KM, Gullledge J, McNeill JR, Podesta J, Ogden P, Fuerth L, *et al.* *The Age of Consequences: The Foreign Policy and National Security Implications of Global Climate Change*. Center for Strategic and International Studies and

- Center for New American Security, Washington, DC; 2007. 119 p.
42. Barnett J, Adger WN. Climate change, human security and violent conflict. *Political Geography* 2007;26:639–55.
 43. Raleigh C, Urdal H. Climate change, environmental degradation and armed conflict. *Political Geography* 2007;26:674–94.
 44. Mathews JT. Redefining security. *Foreign Affairs* 1989;68(2):162–77.
 45. Myers N. Environment and security. *Foreign Policy* 1989;74 (Spring):23–41.
 46. Homer-Dixon T. On the threshold: environmental change as causes of acute conflict. *International Security* 1991;16(2):76–116.
 47. Kaplan RD. The coming anarchy. *Atlantic Monthly* 1994;272(2):44–76.
 48. Collier P, Hoeffler A, Soderbom M. On the Duration of Civil War. Policy Research Working Paper 2681. The World Bank, Washington, DC; 2001.
 49. Le Billon P. The political ecology of war: natural resources and armed conflicts. *Political Geography* 2001;20:561–84.
 50. de Jong W, Donovan D, Abe KI. Underlying causes of extreme conflict and tropical forests. In: ETFRN, editor. *Forests and Conflicts*. Special Issue of the European Tropical Forest Research Network Newsletter, Volume 43/4. ETFRN News; 2005. p. 14–16.
 51. Barnett J. Security and climate change. *Global Environmental Change* 2003;13:7–17.
 52. Brock L. Peace through parks: the environment on the peace research agenda. *Journal of Peace Research* 1991;28: 407–23.
 53. Matthew R, Switzer J, Halle M. Introduction. In: Matthew R, Halle M, Switzer J, editors. *Conserving the Peace: Resources, Livelihoods and Security*. International Institute for Sustainable Development (IISD) and The World Conservation Union (IUCN), Winnipeg, Canada; 2002. p. 1–27.
 54. Weinthal E. From environmental peacemaking to environmental peacekeeping. *Environmental Change and Security Project Report* 2004;10:19–23.
 55. Broad R. The poor and the environment: friends or foes? *World Development* 1994;22:811–22.
 56. Gleditsch NP. Armed conflict and the environment: a critique of the literature. *Journal of Peace Research* 1998;35:381–400.
 57. Litfin KT. Constructing environmental security and ecological interdependence. *Global Governance* 1999;5:359–77.
 58. Paris R. Human security: paradigm shift or hot air? *International Security* 2001;26(2):87–102.
 59. Ross ML. How do natural resources influence civil war? Evidence from thirteen cases. *International Organization* 2004;58:35–67.
 60. Vayda AP. Causal explanation as a research goal: A pragmatic view. In: Walters BB, McCay BJ, West P, Lees S editors. *Against the Grain: the Vayda Tradition in Human Ecology and Ecological Anthropology*. AltaMira Press, Lanham, MD; 2008. p. 317–67.
 61. Lacerda LD (editor). *Conservation and Sustainable Utilization of Mangrove Forests in Latin America and African Regions (Part 1: Latin America)*. Mangrove Ecosystem Technical Reports 2. International Society for Mangrove Ecosystems and International Tropical Timber Organization, Tokyo; 1993.
 62. Dahdouh-Guebas F, Mathenge C, Kairo JG, Koedam N. Utilization of mangrove wood products around Mida Creek (Kenya) amongst subsistence and commercial users. *Economic Botany* 2000;54(4):513–27.
 63. Walters BB. Patterns of local wood use and cutting of Philippine mangrove forests. *Economic Botany* 2005;59(1):66–76.
 64. de Graaf GJ, Xuan TT. Extensive shrimp farming, mangrove clearance and marine fisheries in the southern provinces of Vietnam. *Mangroves and Salt Marshes* 1998;2:159–66.
 65. Ronnback P, Troell M, Primavera JH, Kautsky N. Distribution pattern of shrimp and fish among *Avicennia* and *Rhizophora* micro-habitats in the Pagbilao Mangroves, Philippines. *Estuarine, Coastal and Shelf Science* 1999;48:223–34.
 66. Alongi DM. Present state and future of the world's mangrove forests. *Environmental Conservation* 2002;29(3):331–49.
 67. Nepstad DC, Schwartzman S (editors). *Non-timber Products from Tropical Forests*. *Advances in Economic Botany* 9. New York Botanical Garden, Bronx, New York; 1992.
 68. Kaimowitz D. *Forest and Rural Livelihoods in Developing Countries*. Centre for International Forestry Research, Bogor, Indonesia; 2002.
 69. Vedeld P, Angelsen A, Sjaastad E, Berg GK. Counting on the Environment: Forest Incomes and the Rural Poor. *Environmental Economics Series Paper No. 98*. The World Bank, Washington, DC; 2004. 95 p.
 70. Belcher B, Ruiz-Perez M, Achdiawan R. Global patterns and trends in the use and management of commercial NTFPs: Implications for livelihoods and conservation. *World Development* 2005;33(9):1435–52.
 71. McSweeney K. Natural insurance, forest access, and compounded misfortune: Forest resources in smallholder coping strategies before and after Hurricane Mitch, Northeastern Honduras. *World Development* 2005;33(9):1453–71.
 72. Sunderlin WD, Angelsen A, Belcher B, Burgers P, Nasi R, Santoso L, *et al.* Livelihoods, forests, and conservation in developing countries: an overview. *World Development* 2005;33(9):1383–402.
 73. Walters BB. Local management of mangrove forests in the Philippines: successful conservation or efficient resource exploitation? *Human Ecology* 2004;32(2):177–95.
 74. Walters BB. People and mangroves in the Philippines: fifty years of coastal environmental change. *Environmental Conservation* 2003;30(3):293–303.
 75. Stonich S, Vandergeest P. Violence, environment, and industrial shrimp farming. In: Peluso NL, Watts M, editors. *Violent Environments*. Cornell University Press, Ithaca, NY; 2001. p. 261–86.
 76. Kairo JG, Dahdouh-Guebas F, Gwaba PO, Ochieng C, Koedam N. Regeneration status of mangrove forests in Mida Creek, Kenya: a compromised or secured future? *Ambio* 2002;31:562–8.

8 Perspectives in Agriculture, Veterinary Science, Nutrition and Natural Resources

77. Walters BB. Ecological effects of small-scale cutting on Philippine mangrove forests. *Forest Ecology and Management* 2005;206:331–48.
78. Brown WH, Fischer AF. Philippine mangrove swamps. Bulletin 17, Bureau of Forestry, Department of Agriculture and Natural Resources, Manila; 1918.
79. Cabahug Jr DM, Ambi FM, Nisperos SO, Truzan Jr TC. Impact of community-based mangrove forestation to mangrove dependent families and to nearby coastal areas in Central Visayas: a case example. In: National Mangrove Committee, editors. *Mangroves of Asia and the Pacific: Status and Management*. Natural Resources Management Center, Ministry of Natural Resources, Quezon City, Philippines; 1986. p. 441–66.
80. Dewalt BR, Vergne P, Hardin M. Shrimp aquaculture development and the environment: people, mangroves and fisheries on the Gulf of Fonseca, Honduras. *World Development* 1996;24:1193–208.
81. Bashirullah AKM, Mahmood N, Matin AKMA. Aquaculture and coastal zone management in Bangladesh. *Coastal Management* 1989;17:119–27.
82. Meltzoff SK, LiPuma E. The social and political economy of coastal zone management: shrimp mariculture in Ecuador. *Coastal Zone Management Journal* 1986;14: 349–80.
83. Bhatta R, Bhat M. Impacts of aquaculture on the management of estuaries in India. *Environmental Conservation* 1998;25:109–21.
84. Vayda AP, Walters BB. Against political ecology. *Human Ecology* 1999;27:167–79.
85. Primavera JH. A critical review of shrimp pond culture in the Philippines. *Reviews in Fisheries Science* 1993; 1:151–201.
86. Glaser M, Oliveira R. Prospects for the co-management of mangrove ecosystems on the North Brazilian coast: Whose rights, whose duties and whose priorities? *Natural Resources Forum* 2004;28:224–33.
87. Armitage D. Socio-institutional dynamics and the political ecology of mangrove forest conservation in Central Sulawesi, Indonesia. *Global Environmental Change* 2001;12:203–17.
88. Vandergeest P, Flaherty M, Miller P. A political ecology of shrimp aquaculture in Thailand. *Rural Sociology* 1999;64(4):573–96.
89. Adger WN. Vulnerability. *Global Environmental Change* 2006;16:268–81.
90. Bailey C. The social consequences of tropical shrimp mariculture development. *Ocean and Shoreline Management* 1988;11:31–44.
91. Stonich S, Bailey C. Resisting the blue revolution: contending coalitions surrounding industrial shrimp farming. *Human Organization* 2000;59(1):23–36.
92. Lugo AE. What we do and don't know about the role of waves in mangrove ecosystems. Paper presented in the special session, 'Mangroves and the protection of coastal areas', IUFRO World Congress, Brisbane, Australia, 8–12 August 2005.
93. Mazda Y, Magi M, Ikeda Y, Kurokawa T, Asano T. Wave reduction in a mangrove forest dominated by *Sonneratia* sp. *Wetlands Ecology and Management* 2006;14:365–78.
94. Dahdouh-Guebas F, Jayatissa LP, Di Nitto D, Bosire JO, Lo Seen D, Koedam N. How effective were mangroves as a defense against the recent tsunami? *Current Biology* 2005;15(12):R443–7.
95. MSSRF. Tsunami and Pichavaram mangroves. Report of the Centre for Research on Sustainable Agriculture & Rural Development, M.S. Swaminathan Research Foundation 2005. Available from: URL: <http://www.mssrf.org> (downloaded 16 January 2005).
96. Parish F, Tong Yiew C, Lee D. Overview of the tsunami and coastal wetland biodiversity. Presentation at the Special Session on Tsunami and Coastal Wetlands, Asian Wetland Symposium, Bangkok, 9–10 February 2005.
97. Badola R, Hussain SA. Valuing ecosystems functions: an empirical study on the storm protection function of Bhitarkanika mangrove ecosystem, India. *Environmental Conservation* 2005;32(1):85–92.
98. Adams W, Montalban HR, Martin C. Cultivation of bangos in the Philippines. *The Philippine Journal of Science* 1932; 47:1–35.
99. Walton M, Samonte-Tam G, Primavera JH, Edwards-Jones G, Le Vay L. Are mangroves worth replanting? The direct economic benefits of a community-based reforestation project. *Environmental Conservation* 2006;33:335–43.
100. Homer-Dixon T. *The Ingenuity Gap*. Alfred A. Knopf, New York; 2000.
101. Adger WN, Hughes TP, Folke C, Carpenter SR, Rockstrom J. Socio-ecological resilience to coastal disasters. *Science* 2005;309:1036–9.
102. Smit B, Wandel J. Adaptation, adaptive capacity and vulnerability. *Global Environmental Change* 2006; 16:282–92.
103. UNEP. Vulnerability of people and the environment: challenges and opportunities. In: *Global Environmental Outlook 4: Environment and Development*, United Nations Environment Program; 2007. p. 301–60.
104. Weaver DC. The hurricane as an economic catalyst. *Journal of Tropical Geography* 1968;27:66–71.
105. DENR. *Compilation of Mangrove Regulations*. Coastal Resources Management Committee, Department of Environment and Natural Resources, Quezon City, Philippines; 1990. 47 p.
106. Fong FW. Perspectives for sustainable resource utilization and management of nipa vegetation. *Economic Botany* 1992;46:45–54.
107. Weinstock JA. *Rhizophora* mangrove agroforestry. *Economic Botany* 1994;48:210–3.
108. Barbier EB. Natural barriers to natural disasters: replanting mangroves after the tsunami. *Frontiers in Ecology and the Environment* 2006;4(3):124–31.
109. Chambers R, Leach M. Trees to meet contingencies: savings and security for the rural poor. *Social Forestry Network Paper 5a*, Overseas Development Institute, London; 1987. 29 p.
110. Saenger P, Siddiqi NA. Land from the sea: the mangrove afforestation program in Bangladesh. *Ocean and Coastal Management* 1993;20:23–39.

111. Stevenson NJ, Lewis RR, Burbridge PR. Disused shrimp ponds and mangrove rehabilitation. In: Streever W, editor. *An International Perspective on Wetland Rehabilitation*. Kluwer Academic, Amsterdam; 1999. p. 277–97.
112. ITTO. *ITTO Guidelines for the Restoration, Management and Rehabilitation of Degraded and Secondary Tropical Forests*. ITTO Policy Development Series No. 13. International Tropical Timber Organization, Yokohama, Japan; 2002. 84 p.
113. Lewis RR. Ecological engineering for successful management and restoration of mangrove forests. *Ecological Engineering* 2005;24:403–18.
114. Check E. 2005. Roots of recovery. *Nature* 2005;438:910–1.
115. Taylor D, Sanderson PG. Global changes, mangrove forests and implications for hazards along continental shorelines. In: Sidle RC, editor. *Environmental Changes and Geomorphic Hazards in Forests*. International Union of Forest Research Organizations and CABI Publishing, New York; 2002. p. 203–26.
116. Duke NC. Changing climate changing mangroves. Paper presented in the special session, 'Mangroves and the protection of coastal areas', IUFRO World Congress, Brisbane, Australia, 8–12 August 2005.
117. Gilman E, Ellison J, Duke NC, Field C. Threats to mangroves from climate change and adaptation options: a review. *Aquatic Botany* 2008;89:237–50.