CLIMATE CHANGE AND DEVELOPMENT

CONSULTATION ON KEY RESEARCHABLE ISSUES

SECTORAL ISSUES
SECTION 2.4. COASTAL ZONES
LAUREL MURRAY

Saleemul Huq and Hannah Reid
Climate Change Group
International Institute for Environment and Development
3 Endsleigh Street, London WC1H 0DD, UK
Tel: (+44 20) 7388 2117
Fax: (+44 20) 7388 2826
Email: saleemul.huq@iied.org hannah.reid@iied.org

Climate Change and Coastal Zones

It is difficult to address coastal zones as a unified subject because of the sheer diversity of environments and range of human activity along coastal zones. About 40 percent of the world's population lives within 100km of the coast -- about 2.2 billion. Coastal zones also support a range of livelihoods and economic sectors including fisheries, agriculture, and commerce. As such, they play an important role in socio-economic development in many countries. Climate change will have a diverse set of impacts on coastal zones due to warming temperatures, changing precipitation, and sea-level rise. The diversity of coastal zones allows for great potential in adaptation to climate change trends and variability. Unfortunately, unsustainable human activity in coastal and marine systems means that many regions are extremely vulnerability to climate change and lack the adaptive capacity. Examples of coastal zone impacts includes,

- Increased levels of inundation and storm flooding, which could threaten agriculture and coastal infrastructure as well as human life.
- Accelerated erosion of beaches, cliffs and wetlands.
- Sea-level rise leading to seawater intrusion into fresh groundwater.
- And encroachment of tidal waters into estuaries and river systems impacting fragile coastal ecosystems and human livelihoods.

Climate change science and modelling has come along way to explore climate change impacts on coastal zones. That being said, research into climate change vulnerability has concentrated on certain coastal sectors and not others. For instance, there is extensive scientific research on coral bleaching, largely because coral reefs are one of the first ecosystems showing the obvious signs of climate change. Research is also undertaken on the vulnerability of coastal infrastructure and strategies for withstanding extreme weather events, not only by the climate change community but also within disaster management and insurance. In particular, large coastal cities have received more attention, in part, because "urbanisation in the developing world is also concentrating poor populations in potentially hazardous areas" (Klein *et al*., 2003, p41). This has created vulnerability hotspots that attract climate change research. On the other hand, there is relatively little literature pertaining to the vulnerability and adaptation of fisheries despite the significance for livelihoods and regional economies. Such gaps in the research must be addressed for a complete understanding of climate change impacts and vulnerability. Current research from coastal zone management can provide information about vulnerabilities to *current* climatic conditions -- a prerequisite for research and policy into future climate changes. Currently, there appears

to be relatively little sharing between the coastal zone management and climate change communities, although international organisations are beginning to explore the interlinkages.

Integrated Coastal Zone Management

Within coastal zone management, climate change is not widely included in research and policy, although Integrated Coastal Zone Management (ICZM) is now beginning to address the implications for their models. ICZM offers a promising platform from which to base climate change adaptation; indeed, climate change will increase the demand for integrated coastal management in many parts of the world. ICZM and climate change adaptation share many of the same principles and approaches: the goal of sustainable development, precautionary principle, and equity. ICZM is also a holistic, multidisciplinary approach that involves a wide range of structural and non-structural tools that could be used for climate change adaptation. Moreover, ICZM involves a bottom-up perspective that balances the dominant top-down approach found within climate change policy. As such, there should be more communication between the two fields; specifically, new climate change models should be fed into current coastal zone management programmes. Unfortunately, there exists a significant divide between coastal zone management research and policy, which hinders the inclusion of climate change adaptation. Although researchers in coastal zone management push for comprehensive approaches such as ICZM, that bring together a range of sectors, most government policies are still highly fragmented among various departments and exhibit many deficiencies that hinder climate change adaptation.

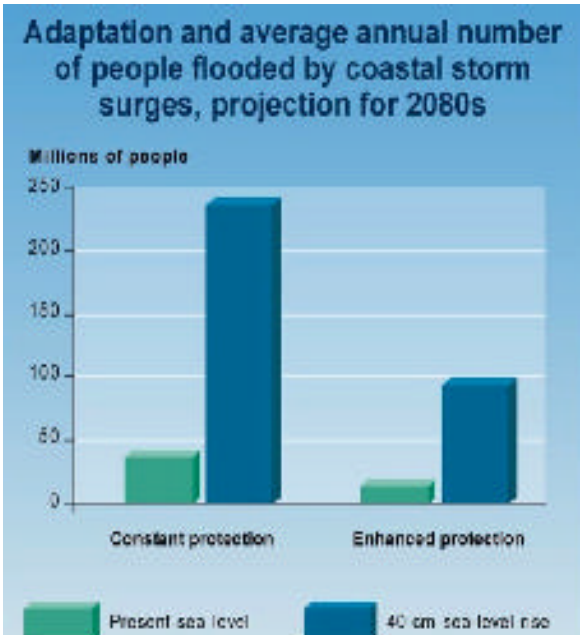
Example of Coastal Infrastructure and Communities

As explained above, coastal zones involve a diverse range of human and natural systems that face unique climate change impacts and adaptation. This section will focus on coastal infrastructure and human communities to illustrate some of the areas for integration between climate change research and development fields. It is important to emphasise that is this is but one example; other important research areas include natural coastal and marine ecosystems (i.e. coral reefs, mangroves, wetlands, and salt water marshes); agriculture (especially with the risk of saltwater intrusion); disease and toxicity; and aquaculture and ocean ranching.

In many developing countries, coastal communities (including important urban centres) and physical coastal infrastructure are highly vulnerable to changes in sea-level rise and extreme weather events. There are many coping strategies currently employed with disaster

management, especially those of disaster preparedness and risk reduction (please see section on *Climate Change and Disaster*). Coastal zone management also offers inroads for climate change adaptation. For instance, the protection and enhancement of natural coastal ecosystems, including coral reefs and mangroves, may offer a cost-effective means for protecting coastal communities and infrastructure. As seen with the Asian Tsunami (December, 2005), mangroves acted as an important natural sea-wall for many areas, minimising the impact on coastal communities. There are also many regulatory and technological approaches that could be adapted from current coastal zone management practices. In extreme cases, coastal infrastructure and communities may have to be relocated at large expense and social-economic upheaval. However, as proposed by Klein *et al*. (2003), relocation of vulnerable coastal sites could be integrated with ongoing development plans. For example, growing coastal cities should consider climate change impacts to shape expansion proposals. Furthermore, recovery and reconstruction efforts after an extreme event may provide an opportunity to consider relocation and redevelopment possibilities.

Figure 1: Adaptation and Average Number of People Flooded by Coastal Surges, Projections for 2080*



* IPCC, 2001

Emerging priority research themes: Vulnerability of fisheries and fishing communities to climate change.

Fisheries represent a significant proportion of nutrient intake and employment in coastal areas in the developing world. While vulnerability of fisheries and vulnerability of fishing-dependent communities is driven by external stressors and by underlying structural factors, the quantification and measurement of these driving forces has not been undertaken. The benefits of research in this area would be a more precise targeting of adaptation action and interventions to the most vulnerable fisheries systems.

Source: Katrina Brown and Neil Adger, Tyndall Centre

Technologies for Adaptation to Climate Change in Coastal Zones

Source: Richard Klein

Ever since humans have lived near the sea, they have increasingly developed and applied technologies to reduce their vulnerability to coastal hazards. The same technologies can be applied to adapt to expected impacts of climate change. Technologies are available to develop information and awareness for adaptation in coastal zones, to plan and design adaptation strategies, to implement them, and to monitor and evaluate their performance.

Information Development and Awareness Raising

Data collection and information development are essential prerequisites for coastal adaptation, particularly to identify adaptation needs and priorities. The more relevant, accurate and up-to-date the data and information available to the coastal manager, the more targeted and effective adaptation strategies can be. Coastal adaptation requires data and information on coastal characteristics and dynamics, patterns of human behaviour as well as an understanding of the potential consequences of climate change. It is also essential that there is a general awareness among the public, coastal managers and decision-makers of these consequences and of the possible need to take appropriate action.

Large-scale global and regional data repositories have been established for a great number of climatic and socio-economic variables relevant to coastal zones. Useful as they may be, coastal adaptation to climate change will require more detailed information than these readily available data sets can provide. Technologies are available to increase the understanding of the coastal system (involving data collection and analysis), to conduct climate impact assessment in coastal zones (so that the severity of potential impacts can be quantified for given scenarios) and to raise public awareness (that some form of adaptation is necessary).

Planning and Design

When the available data and information point toward a potential problem that would justify taking action, the next stage is to decide which action could best be taken and where and when this could best be implemented. The answers to these questions depend on prevailing criteria that guide local, national or regional policy preparation, as well as on existing coastal development and management plans that provide the broader context for any adaptation initiative. A number of decision tools are available to assist in the planning and design process, including cost-benefit analysis, cost-effectiveness analysis, risk-effectiveness analysis and multi-criteria analysis. Where data are available, input into these decision tools could come from models simulating relevant coastal morphological, ecological and human changes over time.

The quality and effectiveness of the planning and design process is influenced by the context in which decisions are made. The successful implementation of many coastal policies, including adaptation to climate change, depends on the effective involvement of communities throughout the planning process. Moreover, local expertise will be required for successful technology implementation, application, maintenance and enforcement.

Implementation

Once all options for coastal adaptation have been considered and the most appropriate strategy has been selected and designed, implementation is the next stage. An adaptation strategy to sea-level rise can comprise one or more options that fall under the three broad categories protect, retreat and accommodate. A range of technologies are available for each of these categories, most of which require strategic planning; few will be implemented autonomously. Technologies to protect against sea-level rise can be implemented both reactively and proactively, while most retreat and accommodation options are most effectively implemented in an anticipatory manner.

To date, the assessment of possible response strategies has mainly focused on protection, although the need to identify and evaluate the full range of coastal adaptation technologies is widely recognised. The range of appropriate technologies will vary amongst and within countries, and different stakeholders may prefer competing options for the same area. This potential for conflict is one of the reasons why adaptation to climate change is recommended to take place within the framework of integrated coastal zone management.

Monitoring and evaluation

It is recommended practice in any field of policy that the performance of implemented measures is periodically or continuously evaluated against the original objectives. Such evaluation can yield new insights and information, which could give rise to adjust the strategy as appropriate. Effective evaluation requires a reliable set of data or indicators, to be collected at some regular interval by means of an appropriate monitoring system. It is an ongoing process and the monitoring should be planned accordingly. Observations of the natural evolution of the coast allow trends to be estimated and hence the impact of human interventions on the coast to be evaluated.

The broader context

Technology by itself is not a panacea. It can make an important contribution towards the sustainable development of coastal zones, provided it is implemented within an enabling economic, institutional, legal and socio-cultural environment. Coastal adaptation technologies are therefore most effective as part of a broader, integrated coastal zone management framework that recognises immediate as well as longer-term sectoral needs. A successful adaptation strategy will comprise a mix of various adaptation approaches, tailored to the particular needs of the area at risk and aimed at reducing implementation constraints.

Many of the world's vulnerable coastal countries and communities do not have access to coastal adaptation technologies, nor to the knowledge that is required to develop or implement them. Effective coastal adaptation by these countries could benefit from increasing current efforts of technology transfer. Furthermore, climate change is but one of many interacting stresses in coastal zones. The importance of controlling non-climatic stresses in the quest to reduce vulnerability to climate change must not be underestimated.

Source:

Klein, R.J.T., R.J. Nicholls, S. Ragoonaden, M. Capobianco, J. Aston and E.N. Buckley, 2001: Technological options for adaptation to climate change in coastal zones. *Journal of Coastal Research*, 17(3), 531–543.

Determining the cause of a changing environment

Source: Anisul Kabir, Research Officer, Institution and Policy Support Unit (IPSU), Ministry of Environment and Forest, Bangladesh

In a developing country like Bangladesh, we need to determine the actual environmental change happening under a changing climate. It has been said that increasing salinity in the southern part of Bangladesh has been caused by the impact of the Farakka barrage on the River Ganges in India. At the same time, it has been said that climate change could increase salinity in the southern part of Bangladesh. Several similar issues are attributed to climate change as well as other causes. We need to determine the actual reasons for changing natural characteristics in areas vulnerable to climate change.

Climate change, coastal communities and development

Source: Dr Bob Pokrant, Associate Professor of Anthropology, Curtin University of Technology

A key research area for the future is climate change, coastal communities and development. As a project, I suggest the following objectives:

- What are the main ways in which coastal communities historically and at present deal with physical hazards such as flooding?
- What impacts do such events and processes have on coastal communities and are some affected more than others? Here one could examine gender, caste, class, ethnic, occupational impacts.
- What short-term measures in rehabilitation and recovery have been implemented to deal with such events and processes?
- What changes need to be made to international, national and local institutions to deal more effectively with such events and processes (Long-term disaster management and preparedness)?

Such a project could be carried out among selected coastal peoples anywhere in the world.

Coastal Erosion: A Major Concern for Pacific Island Communities

Source: Taito Nakalevu, Secretariat of the Pacific Regional Environment Programme (SPREP)

The main issue:
Coastal erosion is one of the major issues facing small island states of the Pacific now and into the future. It threatens lands that are of traditional and cultural significance to the Pacific people, dwellings and properties are lost and livelihood is seriously threatened in turn threatening the very existence of the people. Many of these impacts are familiar to the people but the rate at which erosion is happening now is alarming to many. While there is scientific and political interest in trying to distinguish between what is caused by climate change and what is due to variability, the reality on the ground is that communities will have to adapt to both.

Today, many Pacific islands are already facing damage to coastal infrastructures, coastal protection, destruction of agricultural crops such as pulaka and babai (giant taro) pits as a result of salt water intrusion and most low lying atoll islands are increasingly facing salt water intrusion to their underground water lenses due to erosion in particular and storm surges.

In a vulnerability assessment carried out in four Pacific island countries (Cooks, Fiji, Samoa and Vanuatu) under a Canadian International Development Assistance CIDA funded adaptation project known by the acronym CBDAMPIC which stand for Capacity Building for the Development of Adaptation Measures in Pacific Island Countries, noted that coastal erosion ranked very high on the vulnerability of these communities. These especially true for Saoluafata and Lano in Samoa and Panita and Lateu community in Vanuatu, In Fiji most of the pilot communities investigated were in-land and for Cook Islands even though Coastal erosion was a major problem, water was considered a more immediate problem. In these communities coastal erosion are happening at a frightening rate of 2-10 meters per year, a very conservative estimate. People are already adapting to these changes but more do need assistance. In the case of the Lateu community in Vanuatu, the CBDAMPIC project has already started a relocation process that will see the community move into a new village site 200-300 meters away from the coast. In Saoluafata, Samoa people are already carrying out private adaptation and the CBDAMPIC project will assist those households that do not have the resources to adapt to the erosion problem they are facing.

Identify the most common problem/questions
Most common problem will include:
- new or accelerated coastal erosion
- more extensive coastal inundation which will negatively impact on crop land and also cause salt water intrusion into surface waters and underground water lenses;
- further encroachment of tidal waters into estuaries and coastal river systems;
- higher nearshore, lagoonal and groundwater temperatures.

Justify your choice
Most small islands and coastal zones of the Pacific are already under stress from human activities. Majority of Pacific island communities' leave near the shores and carry out hotel and other businesses developments along the coast. The eroding of coast lines do threaten these major businesses and while they may have the means to adapt they transfer the coastal erosion problems to communities close-by who do not have the necessary means and resources to be able to cope. For small low-lying atoll national such as Kiribati where land is a scarce commodity, with parts of the island only 400 m in width, there is need to so something about it or people will simply be displaced.

Key references:

- Vulnerability and adaptation assessment reports of climate change country teams for Cook Islands, Fiji, Samoa and Vanuatu. This work was carried out under a project funded by the Canadian international Development Assistance (CIDA) and implemented in the Pacific by the Secretariat of the Pacific Regional Environment Programme (SPREP);
- First National Communication funded by GEF and implemented through UNDP and SPREP;
- National Adaptation Programme of Action (NAPA) currently being prepared by five least developed countries (LDCs) – Kiribati, Nauru, Samoa, Tuvalu and Vanuatu. This programme is funded by the GEF and implemented through UNDP.
- World Bank Report. 2002. Cities and Storms
- Hay, J.E., Mimura, N., Campbell, J. Fifita,S., Koshy, K., McLean, R.F., Nakalevu, T., Nunn, P., and N. deWet. 2003. Climate Variability and Sea Level Rise in the Pacific Islands Region: A Resource Book for Policy and Decision Makers, Educators and other Stakeholders. Secretariat of the Pacific Regional Environment Programme, Apia, Samoa. This is a very recent publication funded by the Government of Japan working very closely with SPREP.

References

Adger, N.W., Social Vulnerability to Climate Change and Extremes in Coastal Vietnam *World Development,* Volume 27, Issue 2, February 1999, Pages 249-269

Chemane, D., H. Motta, and M. Achimo. Vulnerability of coastal resources to climate changes in Mozambique: a call for integrated coastal zone management *Ocean & Coastal Management,* Volume 37, Issue 1, 1997, Pages 63-83

Cooper, A.J., G. Cooper, and O.H. Pilkey. Sea-level rise and shoreline retreat: time to abandon the Bruun Rule *Global and Planetary Change*, Volume 43, Issues 3-4, November 2004, Pages 157-171

CZM-C (2002) Special Event on Coastal Adaptation Strategies Proceedings UNFCCC COP-7 Marrakech, Morocco 30 October 2001. The Coastal Zone Management Centre, The Hague, The Netherlands, in cooperation with the UNFCCC Secretariat, Bonn, Germany. The Hague October 2002.

Devoy, R.J.N., Sea-level applications and management *Progress In Oceanography,* Volume 18, Issues 1-4, 1987, Pages 273-286

Doornkamp, J.C., Coastal flooding, global warming and environmental management *Journal of Environmental Management,* Volume 52, Issue 4, April 1998, Pages 327-333

EEAC (2002) Reflection on the EU Integrated Coastal Zone Management Strategy Towards Sustainable Development of the European Coastal Zone. Working Group Paper. EEAC Working Groups on Coastal Zones, Marine Environments and Fisheries.

El-Raey, M., Vulnerability assessment of the coastal zone of the Nile delta of Egypt, to the impacts of sea level rise *Ocean & Coastal Management,* Volume 37, Issue 1, 1997, Pages 29-40

Holdgate, M., Sir The need for international co-operation in the management of coastal environments *Marine Pollution Bulletin, Volume 29, Issues 6-12,* 1994, Pages 601-608

Huang, J.C.K. Climate change and integrated coastal management: a challenge for small island nations *Ocean & Coastal Management,* Volume 37, Issue 1, 1997, Pages 95-107

Huang, J.C.K. International workshop: planning for climate change through integrated coastal zone management Taipei, Taiwan, 24–28 February 1997 *Ocean & Coastal Management, Volume 37, Issue 1,* 1997, Pages 149-152

IPCC (1990) Strategies for Adaptation to Sea Level Rise. Report of the Coastal Zone Management Subgroup. Intergovernmental Panel on Climate Change. Originally published in the IPCC Response Strategies Working Group.

Jansen, M., 1990. "The Role of Coastal Zone Management in Sea Level Rise Response". In: J.G. Titus (ed.) *Changing Climate and the Coast*. Report for the IPCC from the Miami Conference on Adaptive Responses to Sea Level Rise and Other Impacts of Climate Change.

Klein, R.J.T., E.N. Buckley, J. Aston, R.J. Nicholls, S. Ragoonaden, M. Capobianco, N. Mizutani and P.D. Nunn (2000), Coastal adaptation. In: Methodological and Technological Issues in Technology Transfer, B. Metz, O.R. Davidson, J.-W. Martens, S.N.M. van Rooijen and L.L. Van Wie McGrory (eds.), Special Report of Working Group III of the Intergovernmental Panel on Climate Change, Cambridge University Press, Cambridge, UK, pp. 349-372.

Klein, R.J.T. and R.J. Nicholls (1998), Coastal zones. In: Handbook on Climate Change Impact Assessment and Adaptation Strategies, J.F. Feenstra, I. Burton, J.B. Smithand R.S.J. Tol (eds.). Version 2.0, United Nations Environment Programme and Institute for Environmental Studies, Vrije Universiteit, Nairobi, Kenya, and Amsterdam, The Netherlands, pp. 7.1-7.35.

Klein, R.J.T. and R.J. Nicholls (1999), Assessment of coastal vulnerability to climate change. Ambio, 28(2), 182-187.

Klein, R.J.T., R.J. Nicholls, and N. Mimura (1999), Coastal adaptation to climate change: can the IPCC Technical Guidelines be applied? Mitigation and Adaptation Strategies for Global Change, 4(3-4), 239-252.

Klein, R.J.T., R.J. Nicholls, S. Ragoonaden, M. Capobianco, J. Aston and E.N. Buckley (2001), Technological options for adaptation to climate change in coastal zones. Journal of Coastal Research, 17(3), 531-543.

Klein, R.J.T., R.J. Nicholls and F. Thomalla (2003), Resilience to natural hazards: how useful is this concept? Global Environmental Change Part B: Environmental Hazards, 5(1-2), 35-45.

Lakhan, C.V., Planning and development experiences in the coastal zone of Guyana *Ocean & Coastal Management,* Volume 22, Issue 3, 1994, Pages 169-186

Ledoux, L., et al. Towards sustainable flood and coastal management: identifying drivers of, and obstacles to, managed realignment *Land Use Policy,* In Press,

Corrected Proof, Available online 12 May 2004

Lewsey, C., G. Cid, and E. Kruse. Assessing climate change impacts on coastal infrastructure in the Eastern Caribbean *Marine Policy,* Volume 28, Issue 5, September 2004, Pages 393-409

McFarlane, G.A., et al. Have there been recent changes in climate? Ask the fish *Progress In Oceanography,* Volume 47, Issues 2-4, October 2000, Pages 147-169

Nicholls, R.J. and S.P. Leatherman (eds.), (1995), The potential impact of accelerated sea-level rise on developing countries. Journal of Coastal Research, special issue 14, 1-324.

Nicholls, R.J., S.P. Leatherman, K.C. Dennis and C.R. Volonté, (1995), Impacts and responses to sea level rise: qualitative and quantitative assessments. Journal of Coastal Research, Special Issue 14, 26-43.

Nicholls, R.J. and N. Mimura (1998), Regional issues raised by sea-level rise and their policy implications. Climate Research, 11,5-18

Nicholls, R.J. and F. M. J. Hoozemans. The Mediterranean: vulnerability to coastal implications of climate change *Ocean & Coastal Management,* Volume 31, Issues 2-3, 1996, Pages 105-132

Paw, J.N. and C. Thai-Eng. Climate changes and sea level rise: Implications on coastal area utilization and management in South-east Asia *Ocean and Shoreline Management*, Volume 15, Issue 3, 1991, Pages 205-232

Peerbolte, E.B., J.G. de Ronde, L.P.M. de Vrees, M. Mann and G. Baarse (1991), Impact of Sea-Level Rise on Society: A Case Study for The Netherlands. Delft Hydraulics and Ministry of Transport, Public Works and Water Management, Delft and The Hague.

Pernetta, J.C., Impacts of climate change and sea-level rise on small island states: National and international responses *Global Environmental Change, Volume 2, Issue 1,* March 1992, Pages 19-31

Pernetta, J.C., and D.L. Elder. Climate, sea level rise and the coastal zone: Management and planning for global changes *Ocean & Coastal Management,* Volume 18, Issue 1, 1992, Pages 113-160

Pethick, J., Coastal management and sea-level rise *CATENA,* Volume 42, Issues 2-4, 20 January 2001, Pages 307-322

Sagdahl, B.K. (1999) Integrated Coastal Zone Management: From sector policy to integration and devolution? Coastman Working Paper No 8. Presented at the Circumpolar University Association (CUA) Conference, University of Aberdeen, Aberdeen, Scotland, 24 – 27 June 1999.

Shea, E.L. and MF. Dyoulgerov. Responding to climate variability and change: opportunities for integrated coastal management in the Pacific Rim *Ocean & Coastal Management,* Volume 37, Issue 1, 1997, Pages 109-121

Sterr, H., R. Klein, and S. Reese. (2000) Climate Change and Coastal Zones: An Overview of the State-of-the-Art on Regional and Local Vulnerability Assessment. eem.it/NR/rdonlyres/45FC96F3-06F7-4DA5-B356-A2B554CAD74E/864/3800.pdf

SUCOZOMA (2001) Annual Report: Research programme Sustainable Coastal Zone Management. www.sucozoma.tmbl.gu.se/pdf/rapport02EN.pdf

Taylor, M. (2004) "Climate Change and Coastal Zone Management Processes, the Great Lakes, North America." In In A. Fenech, *et al. Building the Adaptive Capacity: And International Conference on Adaptation Science, Management and Policy Options*. May 17-19, 2004 in Lijiang, Yunnan, China. Published by Environment Canada, Toronto, Canada.

Timmerman, P. and R. White. Megahydropolis: coastal cities in the context of global environmental change *Global Environmental Change,* Volume 7, Issue 3, October 1997, Pages 205-234

Tol, R.S.J., S. Fankhauser and J.B. Smith. The scope for adaptation to climate change: what can we learn from the impact literature? *Global Environmental Change,* Volume 8, Issue 2, July 1998, Pages 109-123

Uncles, R.J. From catchment to coastal zone: examples of the application of models to some long-term problems *The Science of The Total Environment,* Volumes 314-316, 1 October 2003, Pages 567-588

Vellinga, P. and R.J.T. Klein Climate change, sea level rise and integrated coastal zone management: An IPCC approach *Ocean & Coastal Management, Volume 21, Issues 1-3,* 1993, Pages 245-268

Zeidler, R.B. Continental shorelines: climate change and integrated coastal management *Ocean & Coastal Management,* Volume 37, Issue 1, 1997, Pages 41-62