**Kushiro Workshop**

# The Asian Wetland Inventory as a tool for providing information on the effect of climate change on wetlands in Asia.

Max Finlayson[1], John Howes[2], Rick van Dam[1], George Begg[1] & Koji Tagi[3]

[1]National Centre for Tropical Wetland Research, Darwin, Australia

[2]Consultant, Kuala Lumpur, Malaysia

[3]Wetlands International-Japan, Tokyo, Japan

## Abstract

The environmental changes associated with climate change have serious implications for wetlands throughout the world. It is proposed that the Asian Wetland Inventory (AWI) has much to offer the Asian region assess and manage at least some of these implications. In particular it provides a method to get better data for climate change modeling and to assess whether the changes predicted are currently occurring or likely to occur.

The AWI is an Asia-wide program being developed by Wetlands International to encourage the adoption of an innovative and standardised approach to wetland inventory. The key features of the AWI is the use of a hierarchical, map-based approach defining the most appropriate land and resource management units at four levels of detail. The level of detail is related to the scale of the maps that are contained within a standardised Geographic Information System format. In essence, information about the geological, geomorphological, climatic, hydrological and biological features of entire river basins, as well as other information regarding wetlands within each basin, is collected and digitized in a standardised database system. The data will be provided for both international and national decision-making on watershed management and, amongst other things, will enable critical biodiversity hotspots to be prioritised for conservation. The inventory will also integrate information already collected in disparate analyses and programs.

With recent rapid population growth in Asia, there are serious water management problems throughout the region. These include diminishing water supplies, water contamination, accelerated erosion and sedimentation, groundwater depletion, flood damage and climate change. According to the Stockholm Environment Institute, 48 countries in the world will suffer from acute water shortages by 2025 and, with global warming starting to have a significant influence on large scale flooding of coastal plains in China and Bangladesh, improved water management is becoming increasingly essential for preventing or minimizing the downstream consequences. By supplying much of the information needed for climate change modelling the AWI is seen to be one of the best ways in which this can be achieved in a cost-effective and timely manner.

## 1. Introduction

The Ramsar Wetlands Convention promotes wetland inventory as a tool for identifying the functions and values of wetlands, including ecological, social and cultural values. Finlayson & van der Valk (1995) also emphasise the value of wetland inventory for establishing a baseline for measuring future change in wetlands, for identifying their functions and services, for locating where wetlands are and which of these are the priority sites for conservation. (Wetland inventory is also required for planning and managing wetlands at both practical and/or political levels and to enable comparisons between wetlands and management procedures to be made at different levels of government (local, national and international). In short, wetland inventory is not an end in itself, but rather an essential step in the decision-making process affecting land use, the conservation of natural resources and water allocation.

To assess the current global situation and need for wetland inventory the Ramsar Convention commissioned the preparation of a comprehensive "Global Review of Wetland Inventories" (GRoWI) in 1998/99. GRoWI showed that the existing wetland inventory base was inadequate for assessing the distribution and different types of wetlands, the extent of likely impacts and vulnerability, the role of wetlands in climate change and the loss of wetland related economic and ecological values (Finlayson et al 1999). The outcomes of this review led to renewed calls for standardisation of wetland inventory procedures whilst recognising the many purposes of inventory. The Asian Wetland Inventory is one response to this call.

## 2. The Asian Wetland Inventory

Although there is *A Directory of Asian Wetlands* that provided summary information on the status, threats and biodiversity significance of 947 wetland sites in 24 Asian countries (Scott 1989; Scott & Poole 1989), no updated regional information has been collected for the past 10 years. Without such information planning, development, management, training, education and public awareness in and around wetlands across Asia is unlikely to be effective (Watkins and Parish 1999; Finlayson 2000).

The Asian Wetland Inventory (AWI) has been designed as a program that addresses the needs of international conventions and other stakeholders in 42 countries in Asia. The origins of the program lies in the call of several international meetings, especially the 7$^{th}$ Conference of Parties of the Ramsar Convention (COP7) to collect standardised information on wetlands (Ramsar Convention Bureau 1999). Under resolution VII.20 from this Conference, Wetlands International, a leading international wetlands non-governmental organisation (NGO) was charged with leading this responsibility. With support from the Japanese Environment Agency Wetlands International the AWI is being undertake by the Wetland Inventory and Monitoring Specialist Group of Wetlands International in collaboration with the Japanese National Institute for Environment Studies (NIES).

The AWI will provide a region-wide standard methodology for wetland inventory designed to:

- provide core data / information on Asian wetlands to support international conventions and treaties on wetlands, climate change, biodiversity, migratory species and desertification, and their implementation by Governments;
- analyse long term trends in the status of Asian wetlands and their natural resources;
- enable regular revisions and updates of information on wetlands of national and international importance in Asia; and
- disseminate these analyses for wider consideration and use in sustainable development and conservation of wetland resources.

The AWI will build on existing wetland surveys and collate and assess new and existing data on the fundamental features of wetlands, their values and threats. Unlike other programs the information bases will be compiled using a standard (core) data set suitable for analyses at the global and continental scale in addition to the local scale where most wetland activity is directed. In this respect it will also enable reporting to international conventions and for national and regional biodiversity and wetland use assessments.

The data will be shared, as appropriate, with environment-related international frameworks, such as the Ramsar Wetlands Convention, the United Nations Framework Convention on Climate Change (UNFCCC), the United Nations Convention to Combat Desertification (UNCCD), the Convention on Biological Diversity (CBD) and the Asia-Pacific Waterbird Conservation Strategy to assist in their monitoring programs and the management of water resources and wetland biota (Bergkamp & Orlando 1999). The AWI outputs will also be important for other interest groups, such as donors, for developing other sub-regional level projects and for making global assessments (e.g. Intergovernmental Panel on Climate Change and the Millennium Ecosystem Assessment).

A principal purpose of the AWI is to delineate and map the wetland resources of Asia, taking into account wetland habitats from the intertidal zone to the uppermost reaches of all major river basins, and to store this information on a GIS (Finlayson 2000). This exercise is to be undertaken at different scales with the amount of detail being dependent on the explicit purpose of the inventory and the size and importance of the wetland (fig. 1). The first two levels will provide the contextual basis for the inventory and provide the framework for further detailed wetland inventory and assessment. The third level will provide more information on core data attributes of wetland complexes and larger sites, while the fourth level will provide more information at the site/ habitat level. The hierarchy proposed is presented below.

- <u>Level 1</u>: Geographic regions with a map at a scale of 1:5 000 000

A broad-based geographical regionalisation of Asia developed on the basis of river basins. Region wide assessments of geology, land cover and climate will be included.

- <u>Level 2</u>: Wetland regions with maps at a scale of 1:1 000 000 to 1: 250 000

A broad, map-based, geographic inventory for each subregion of the identified river basin. On the assumption that wetlands within each subregion will share common characteristics, such as underlying geology, climate and rainfall, this will provide the baseline in which similar wetlands or "complexes" can be identified and categorised.

- <u>Level 3</u>: Wetland complexes with maps at a scale of 1:250 000 to 1:50 000

A detailed inventory of specific wetland "complexes" identified within each subregion. As each wetland complex will exhibit different hydrological features, such as rainfall, water flow, regulation and seasonality of inundation, similar information will be collected for all wetlands within a complex.

- Level 4: Wetland sites with maps at a scale of 1:50 000 to 1:25 000

A site specific wetland inventory designed to identify all discrete wetland areas within each complex. Wherever possible map-based representations will be compiled. Detailed information on each wetland will include ecological units (habitats and biodiversity usage), threats, conservation status, human uses and criteria fulfilled under Conventions.

The essential features of the AWI are that it is map-based with hierarchical and multiple scales of analysis that are connected through a standardised data set (the core or minimum data sets) that can be complemented by further data as needed. Whilst the hierarchy provides a geographic scale for data collection there is no *a priori* reason for undertaking inventory in the order given above. If the core data elements are collected and recorded in standardised or interchangeable data formats the data can be compared and combined as needed. We recognise that data needs will vary and the scale of data collection will be driven by the specific requirements of individual projects.

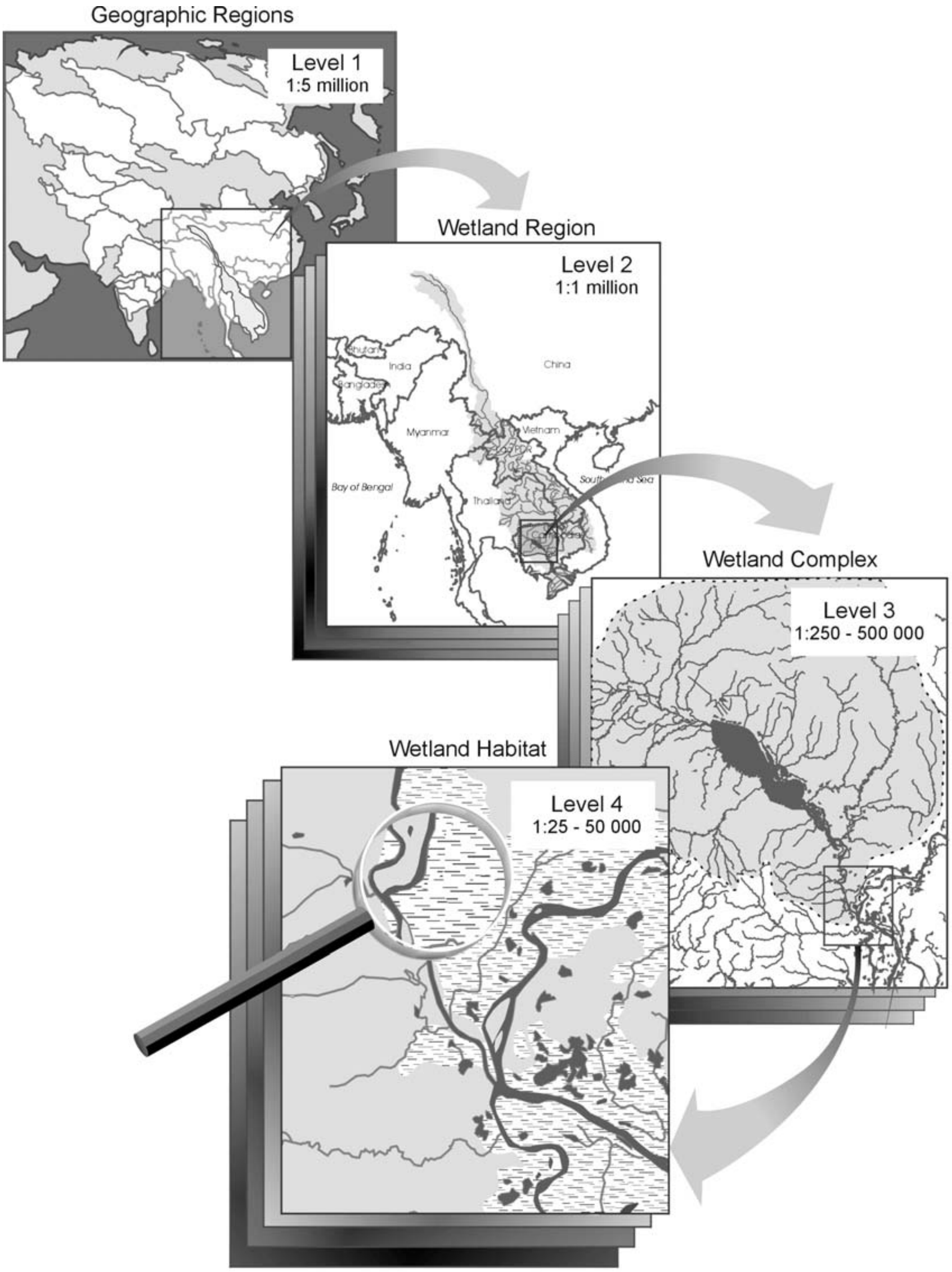


**Fig 1:** The four tiered landscape (or "top-down") approach of the AWI. The level of detail varies with spatial scale in a hierarchy from a continental level (1) to a site level (4). *Note: figures not to scale.*
Sources: Level 1 and 2 adapted from WRI (2001 a) and WRI (2001 b ), level 3 from ESRI (1993), level 4 from USGS, 2001.

## 3. Projected climate change and impacts on wetlands in Asia

### 3.1 Projected climate change

Lal et al (2001) detailed the projections for future climate change in Asia. The projected area-averaged annual mean warming by the 2080s is approximately 3.8±0.5°C. Projected warming will be greater over the Boreal Asia region (northern margins of the Eurasian continent, between 50°N and the Arctic Circle, consisting mostly of Russia, including Siberia), and least in Tropical Asia (from central India in the north-west, to Papua New Guinea in the south-east), particularly south-east Asia. Precipitation is projected to increase over Asia, with the change being greatest over Boreal Asia (+19%) and least in Tropical Asia (-0.1 to +5.1%). Seasonal changes in precipitation are also expected, particularly over central Asia, where rainfall is projected to increase in winter and decrease in summer. Mean sea level is also projected to rise, with global estimates ranging from 2 – 29 cm by 2050 and 9 – 88 cm by 2100 (McCarthy et al 2001).

Much of Tropical Asia is intrinsically linked to the annual monsoon cycle, and thus, projected changes to the monsoon carry great significance. A range of studies suggests an increase in both the intraseasonal and interannual variability of daily precipitation in the Asian summer monsoon. Projections for tropical cyclones are variable, ranging from no appreciable long-term changes, to increased variability in tropical cyclone frequency, and an increase in tropical storm intensity with $CO_2$-induced warming. Similarly, effects on ENSO are uncertain, although as global temperatures increase, the pacific climate may tend towards a more El-Niño-like state. In the Tropical Indian Ocean region, it is likely that the intensity of precipitation extremes associated with ENSO events will increase such that extremely wet areas become wetter and extremely dry areas become drier.

### 3.2 Impacts on wetlands

Rivers and lakes will be affected in various ways by changes in temperature, precipitation and evapotranspiration. For example, by 2050, increased runoff due to higher rainfall in Siberian river systems is expected to cause difficulties with seasonal inundation and flooding, and associated management of these problems (Lal et al 2001). As another example, perennial rivers in semi-arid Asia will experience short- to medium-term increases in summer flows as a result of glacial melting in the Himalayas, followed by flow reductions as the glaciers disappear. In addition, increased temperature will also increase the likelihood of water quality problems in lakes, while it may also promote the invasion or range expansion of exotic species (e.g. water hyacinth, salvinia) (Kadono 2000). Overall, it is likely that changes to runoff and river discharge as a result of climate change will place further pressure on water resources that are already under increasing demand due to population growth, urbanisation, industrialisation and in particular, agriculture (McLean et al 1998).

Other inland wetlands will also be affected by climate change. The expected large-scale shrinkage of permafrost in Boreal Asia is likely to result in reductions to the overlying boreal peatlands, and subsequent release to the atmosphere of large amounts of $CO_2$ and $CH_4$ (Lal et al 2001). Similarly, projected increases in evapotranspiration and projected rainfall variability are likely to have negative impacts on the viability of tropical peatlands (McLean et al 1998).

Coastal wetlands in Asia will be susceptible to accelerated sea level rise, sea-surface temperature rise, and more frequent and intense severe storm events (Lal et al 2001; Watson et al 1996). The major deltas of Asia are likely to experience changes in water regimes, saltwater intrusion of both fresh and ground waters, siltation and land loss. In Tropical Asia, the Ganges-Brahmaputra (Bangladesh), Irrawaddy (Myanmar), Choo Phraya (Thailand), Mekong and Song Hong (Vietnam) deltas are amongst the most vulnerable to sea level rise. In Temperate Asia, the Yangtze and Huang He (Yellow River) deltas are amongst the most vulnerable to sea level rise. Where runoff is projected to decrease, reduced sediment discharge will alter delta progradation, while sea level rise and more intense storm events could further erode the low-lying coastlines (Lal et al 2001; Peiying et al 1999). Where runoff is projected to increase, higher sea level and storm surge could act to reduce discharge, thereby resulting in flooding of the low-lying deltaic plains (Peiying et al 1999). For example, in the event of a 48 cm rise in sea level (by 2050) and a 2-3 m storm surge, approximately 40% of China's Yellow River Delta could be inundated (Peiying et al 1999). Many deltas in Asia play important roles as stop-over sites for migratory birds, and habitat alterations through sea-level rise and other climate-related factors could threaten the presence of these birds and other wildlife populations (Lal et al 2001; Peiying et al 1999).

Nicholls et al (1999) predicted that by the 2080s, 22% of the world's salt marshes and mangrove forests could be lost due to sea level rise alone. However, responses of mangroves to sea level rise may vary from little adverse impact to collapse (McLean & Tsyban 2001). In Tropical Asia, large changes in species composition and zonation in mangrove forests are expected due to sea level rise, and changes in precipitation and runoff (Lal et al 2001). Such changes may leave other coastal wetlands (e.g. salt marshes, lagoons) exposed to the impacts of sea level rise and wave and storm surge (Lal et al 2001; Mapalo 1999). Peiying et al (1999) identified salt marshes in the Yellow River Delta, as being at risk from climate change and sea level rise, primarily due to coastal erosion and landward retreat. Many mangrove and salt marsh communities support important populations of wildlife, which could be threatened by sea level rise. For example, the mangrove forests of the Sunderbans of Bangladesh, which provide habitat for a range of important wildlife could be destroyed by a 1 m rise in sea level (Lal e al 2001).

Agricultural productivity associated with wetlands will also be impacted by climate change. Of these, rice cultivation is by far the most important, being central to nutrition in Asia (Lal et al 2001). Rice yields are expected to increase in northern and north-central Japan, but decrease in the southern regions of the country. In tropical Asia, rice crops may be vulnerable to increased minimum temperatures, while water shortages in India will probably outweigh the benefits of increased $CO_2$, and net declines in rice yield could be expected. Associated with changes to the area of rice paddies in Asia will be a corresponding change to $CH_4$ emissions, of which rice paddies contribute significantly (Cao et al 1998).

**4 Relevance of AWI to climate change prediction and mitigation**

As identified above, the environmental changes associated with climate change may have serious implications for wetlands. However, we contend that it is here that the AWI has much to offer because the challenge is to get better data (Finlayson 1999; Finlayson & Mitchell 1999). With such data natural resource managers will be better placed not only to assess whether the changes outlined in section 3.1 above are currently occurring or likely to occur, but also to use this information to better manage wetlands and offset the climate change impacts foreseen.

To begin with, the AWI has the potential to supply much of the information that is currently needed for climate change modeling. The Asian region contributes to global climate change in a major way and, although the role of wetlands in climate change is not yet fully understood, they are known to play at least two critical but contrasting roles in mitigating the effects of climate change. One is in the management of greenhouse gases (especially carbon dioxide) and the other is in physically buffering climate change impacts (Ramsar Bureau 2001; van Dam & Finlayson 2001). Wetlands, such as peatbogs and marshes, are important reservoirs of carbon, representing the largest component of the terrestrial biosphere carbon pool (Bolin and Sukumar 2000; Dixon & Krankina 1995). Disturbance, modification and/or loss of these wetlands (e.g. conversion to agricultural land), can result in significant changes in the exchange of carbon (as the greenhouse gases, $CO_2$ and $CH_4$) between the wetlands and the atmosphere. Hence, any information on the location, size and ecological character of wetlands in a river basin is extremely useful for modeling purposes. For example, the delineation and characterisation of marshes and swamps in each of the major drainage basins of Asia will help estimate the amount of global terrestrial carbon stored in wetlands. The AWI would help distinguish between the different roles of inland and coastal wetlands and would help elucidate the effects of changing rainfall patterns, rising sea-levels, warmer sea-temperatures and the increasing frequency of storms.

Secondly, it is widely recognised that global change research cannot succeed without a high level of intergovernmental co-operation and networking. In this respect the AWI is seen as an ideal collaborative project which not only lends itself to being implemented at a transnational (or cross-border) scientific level but also serving as a focus for underpinning national and international policy making needs.

From a resource management and landuse planning viewpoint the AWI has the potential to supply much of the information that is currently needed for determining the feasibility of buffering climate change impacts. Where intense economic activities or densely settled areas in Asia may be vulnerable due to increased flooding for example, better information about upstream wetlands could well lead to regional land use authorities putting in place the activities or measures necessary to bring about the prevention of further wetland destruction and conversion. Similarly, the financing of activities associated with the restoration, rehabilitation and creation of wetlands could well be forthcoming. Therefore, if only to serve as a means of buffering climate change impacts and increase the sequestering of carbon in a particular region, the AWI would help provide the data needed for wetlands to receive the proper political and economic attention that they deserve. In short, the AWI is seen by Wetlands International to be a potentially important tool that could assist Asian countries prepare for and mitigate the effects of climate change. In this respect the AWI has been endorsed by the Standing Committee of the Ramsar Wetlands Convention and in turn has heavily influenced decisions taken by the Convention's Scientific and Technical Review Panel in developing an international protocol for wetland inventory.

## 5 Conclusions

By now there is a wide agreement that wetlands are critically important ecosystems that provides globally significant social, economic and ecological services. Under the auspices of the Ramsar Convention and Wetlands International, the AWI represents a mechanism by which a comprehensive wetland inventory database for Asia can be developed. Outputs will focus on the inventory database and map products.

The AWI would also go a long way towards providing the data needed for climate change modeling and decision-making about the conservation and wise use of wetlands in the region. As with the Ramsar Wetlands Convention, the AWI is also seen as an effective tool for other conventions such as the UNFCCC and the UNCCD. The AWI would help assess the extent of likely impacts of wetland ecosystems to climate change, help evaluate the role of different wetland types in global cycles and help appraise future losses of socio-economic and ecological values on humans and biodiversity.

**Acknowledgements**:

The authors wish to convey their genuine gratitude to the Japanese Ministry of the Environment (formerly - Japanese Environment Agency) for providing the initial financial support required for the AWI. The authors are similarly indebted to Wetlands International, the Japanese National Institute for Environment Studies and the Ramsar Convention's Wetland Inventory Monitoring Specialist Group for their encouragement, guidance and assistance in reviewing initial drafts of the AWI manual. The assistance of Ben Bayliss (eriss) in drafting figure 1 is also gratefully acknowledged.

**References**

Bergkamp G and Orlando B. 1999. *Wetlands and climate change* : exploring collaboration between the Convention on Wetlands (Ramsar 1971) and the UN framework Convention on Climate Change, October 1999.

Bolin B & Sukumar R 2000. Global Perspective. In *Land Use, Land-Use Change and Forestry* (eds RT Watson, IR Noble, B Bolin, NH Ravindranath, DJ Verardo & DJ Dokken). A Special Report of the IPCC. Cambridge University Press, Cambridge, UK, pp. 23-51.

Cao M, Gregson K & Marshall S 1998. Global methane emission from wetlands and its sensitivity to climate change. Atmospheric Environment 32(19), 3293-3299.

Dixon RK & Krankina ON 1995. Can the terrestrial biosphere be managed to conserve and sequester carbon? *Global Environmental Change* 33, 153-179.

ESRI (1993), Digital Chart of the World for use with ESRI Desktop software, Environmental Systems Research Institute, Inc. United States of America.

Finlayson C.M. 1999. *Coastal wetlands and climate change: the role of governance and science*. Aquatic Conservation: Marine and Freshwater ecosystems **9**, 621- 626.

Finlayson CM. 2000. *A mechanism for developing a comprehensive wetland inventory database for Asia; background and methodology*. Information paper submitted to Ramsar STRP meeting (STRP9), 27-30 June 2000.

Finlayson CM & van der Valk AG (eds) 1995. *Classification and Inventory of the World's Wetlands*. Advances in Vegetation Science 16, Kluwer Academic Publishers, Dordrecht. 192 pp.

Finlayson CM, Davidson NC, Spiers AG & Stevenson NJ 1999. *Global wetland inventory – status and priorities*. Marine and Freshwater Research 50, 717-727.

Finlayson CM, & Mitchell DS 1999. *Australian wetlands: the monitoring challenge*. Wetlands Ecology and Management 7, 105-112.

Kadono Y 2000. Aquatic plants at risk. In *A Threat to Life: The Impact of Climate Change on Japan's Biodiversity*, eds A Domoto, K Iwatsuki, T Kawamichi & J McNeely. Tsukiji-Shokan Publishing Co., Ltd, Japan and IUCN, Gland, Switzerland and Cambridge, UK, pp. 52-56.

Lal M, Harasawa H & Murdiyarso D 2001. Asia. In *Climate Change 2001: Impacts, Adaptation and Vulnerability* (eds JJ McCarthy, OF Canziani, NA Leary, DJ Dokken & KS White). Contribution of Working Group II to the Third Assessment Report of the Intergovernmental Panel on Climate Change, Cambridge University Press, Cambridge, UK, pp. 533-590.

Mapalo A 1999. Vulnerability assessment of Olango Island to predicted climate change and sea level rise. In *Vulnerability assessment of two major wetlands in the Asia-Pacific region to climate change and sea level rise*, eds RA van Dam, CM Finlayson & D Watkins. Supervising Scientist Report 149, Supervising Scientist, Darwin, Australia, pp. 75-161.

McCarthy JJ, Canziani OF, Leary NA, Dokken DJ & White KS (eds) 2001. 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, UK, 1032 pp.

McLean RF & Tsyban A 2001. Coastal Zones and Marine Ecosystems. In *Climate Change 2001: Impacts, Adaptation and Vulnerability* (eds JJ McCarthy, OF Canziani, NA Leary, DJ Dokken & KS White). Contribution of Working Group II to the Third Assessment Report of the Intergovernmental Panel on Climate Change, Cambridge University Press, Cambridge, UK, pp. 343-379.

McLean RF, Sinha SK, Mirza MQ & Lal M 1998. Tropical Asia. In *The Regional Impacts of Climate Change: An Assessment of Vulnerability* (eds RT Watson, MC Zinyowera, RH Moss & DJ Dokken). A Special Report of IPCC Working Group II, Cambridge University Press, Cambridge, UK, 381-407.

Nicholls RJ, Hoozemans FMJ & Marchand M 1999. Increasing fllod risk and wetland losses due to global sea-level rise: regional and global analyses. *Global Environmental Change* 9, S69-S87.

Peiying L, Jun Y, Lejun L & Mingzuo F 1999. Vulnerability assessment of the Yellow River Delta to predicted climate change and sea level rise. In *Vulnerability assessment of two major wetlands in the Asia-Pacific region to climate change and sea level rise*, eds RA van Dam, CM Finlayson & D Watkins. Supervising Scientist Report 149, Supervising Scientist, Darwin, Australia, pp. 7-73.

Ramsar Convention Bureau. 1999. Seventh Conference of the Parties to the Ramsar Convention (San Jose, Costa Rica, May 1999). Ramsar Convention Bureau, Gland, Switzerland.

Ramsar Convention Bureau. 2001. *Wetland values and functions: climate change mitigation.* Folder commemorating 30th anniversary of Convention on Wetlands, World Wetlands Day, 2 February 2001. Ramsar Convention Bureau, Gland, Switzerland.

Scott DA (compiler). 1989. *A Directory of Asian wetlands*. IUCN, Gland , Switzerland and Cambridge, UK.

Scott D & Poole C. 1989. *A status overview of Asian wetlands*. AWB publication (53), Kuala Lumpur, Malaysia.

United States Geological Service 2001. Earthshots: Satellite Images of Environmental Change, www.edc.usgs.gov/earthshots/slow/PhnomPenh/PhnomPenhmap, United States Geological Survey, 1st August 2001, map image originally derived from Operational Navigation Chart K-10, Defense Mapping Agency, 1973.

van Dam RA & Finlayson CM 2001. Draft Report on Climate Change and Wetlands: Impacts and Mitigation. Ramsar STRP/10 Working Paper 2, 46 pp, Ramsar Convention Bureau, Gland, Switzerland.

Watkins D and Parish F. 1999. *Review of wetland inventory information in Asia*. In: Finlayson CM and Spiers A (eds.) Global review of wetland resources and priorities for inventory, SSR 144, Canberra. 201 – 244.

Watson RT, Zinyowera MC and Moss RH (eds). 1996. *Climate change in 1995: impacts, adaptations and mitigation of climate change: scientific-technical analysis*. Cambridge University Press, Cambridge.

World Resources Institute 2001 (a). Water resources and freshwater ecosystems, Watersheds: Asia Profiles, www.wri.org/watersheds/ww-asia.html, World Resources Institute, 1st August 2001.

World Resources Institute 2001 (b). Water resources and freshwater ecosystems, Watersheds: Asia Profiles, Mekong Watershed, www.wri.org/watersheds/ww-asia.html, VVG4V6B8.pdf] World Resources Institute, 1st August 2001.