



Asia-Pacific Network for Global Change Research

**Integrated Regional Studies of  
Global Change in Monsoon Asia:  
Phase 1: APN/SCOPE/START  
Rapid Assessment Project of  
Global Change in Monsoon Asia**

**Final report for APN project 2005-04-CMY-Snidvongs**

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**Final Report submitted to APN**

## Overview of project work and outcomes

### Non-technical summary

Monsoon Asia has been identified by the ESSP (IGBP, IHDP, WCRP and DIVERSITAS) as a priority region for integrated research studies. Changes to the regional climate, biogeochemical, and terrestrial and marine ecosystem functioning brought about by human driving forces such as increase in population, intensified land use, urbanization, industrialization, and economic development may have global as well as regional consequences. Similarly, effects of global change will have a significant impact on sustainable development at both regional and national levels. Together with the ESSP, START and its regional networks in East Asia, South Asia and Southeast Asia will undertake integrated regional studies of global change in Monsoon Asia. The integrated regional studies were preceded by a first phase of three sub-regional Rapid Assessment Projects for China/East Asia, South Asia and Southeast Asia that reviewed current knowledge regarding regional aspects of global change in Monsoon Asia. A series of book volumes primarily authored by regional scientists have been prepared and are being published both in book volumes as well as on-line on the website of the Monsoon Asia Integrated Regional Studies projects office.

### Objectives

The main objectives of the project were:

1. Systematically review and publish the state of global environmental change in three sub-regions of monsoon Asia
2. Use the reviews as input to develop the initial science plan of the Monsoon Asia Integrated Regional Studies (MAIRS) project
3. Engage and entrain regional scientists into collaborative partnerships to help develop and implement the MAIRS initial science plan

### Amount received for each year supported and number of years supported

US \$ 45,000 per annum for 2 years (2004/2005) – APN funding was specifically for the Southeast and South Asia rapid assessment exercises

### Participating Countries

Participants in the South Asia Rapid Assessment Workshop from the following countries were partially or fully funded by this APN grant:

India (8)	Bangladesh (2)	Pakistan (1)	Sri Lanka (2)
Nepal (1)	USA (1)	Australia (1)	

Participants in the Southeast Asia Rapid Assessment Project Coordinators Meeting from the were partially or fully funded by this APN grant:

Thailand (3)	Philippines (2)	USA (1)	Australia (1)
Indonesia (1)	India (1)	Singapore (2)	

### Work undertaken

During July 2005, workshops of lead coordinators and invited experts were held in Chiang Mai, Thailand (for Southeast Asia Rapid Assessment) and Colombo, Sri Lanka (for Southeast Asia Rapid Assessment). These workshops brought together key scientists engaged in ongoing research on Southeast and South Asia, including representatives from

START's program sponsors and APN SPG. Products from these meetings include a refined conceptual framework for national-level studies and agreements and action plans for writing chapters for the sub-regional book volumes. The tables of contents for the two volumes Southeast and South Asia are attached.

Early working drafts for various sections of sub-regional assessment book volumes were reviewed and decisions on the final structure, layout, and contents were finalized. Commitments for completion of written materials were secured from the lead coordinators. Updates were also provided to the MAIRS planning group meeting in Beijing during January 2006 and Kunming in May 2006 at which APN staff also participated.

The resulting chapters for book length volumes were reviewed, revised and further discussed at various fora, including the APN-supported October 2006 workshop in Darjeeling, India which involved scientists from South Asia as well as representatives of the MAIRS International Project Office

## **Results**

Three books summarizing current knowledge on regional aspects of global change in Monsoon Asia, and identifying gaps in knowledge, and priorities for new research are in hand. The first of the three books, 'Changes in the Coupled Human-Monsoon system of East Asia in the Context of Global Change', has been completed and is currently under final review. Publication is expected in early 2007. The second book, 'Global Environmental Change and the Southeast Asian Region: An Assessment of the State of the Science', is under preliminary review. The final book on the South Asia Rapid Assessment has been reviewed at the Darjeeling workshop (see above) and the South Asia START Regional Center intends to publish it in early 2007.

The ultimate outcome of this project provided input to the science plan for follow-up studies in Monsoon Asia and the establishment of an international network of scientists engaged in integrated regional analysis of regional environmental change, and the implications for sustainable regional development.

## **Relevance to APN scientific research framework and objectives**

### **Self evaluation**

The effort experienced some time delay due to slowness in submission by chapter authors and lead coordinators as well as in the review process. The active engagement of a number of authors and reviewers in the ongoing 4<sup>th</sup> Assessment of the IPCC contributed to this delay. Nevertheless, the effort was timely in helping define research themes and priorities for the Monsoon Asia integrated regional Studies program.

### **Potential for further work**

The MAIRS Initial Science Plan describes research activities to be undertaken in 4 highly vulnerable zones in Monsoon Asia, including the coastal zone, urban zones, mountain zones and semi-arid zones. The scientific research to be carried out in each of these zones as well as integrative and syntheses across the monsoon Asia region to be conducted form the basis for further work building on the effort accomplished under this APN grant award. Specifically, two immediate activities have been proposed in the recent round of

APN ARCP: one for a scoping workshop for the semi-arid regions of monsoon Asia and another for an institute on Advances in Monsoon Science.

### **Publications**

On-line publication of the chapters from the Southeast Asia and South Asia rapid assessments will take place through the MAIRS website (with appropriate acknowledgement of APN support). The on-line material will be made public during early 2007.

A book volume of the East Asia rapid assessment is complete and due to be submitted to the publisher in India in early 2007 (initial negotiations with publishers such as Springer, Kluwer and Cambridge Publications were abandoned because of the extremely high costs of these publishing firms; instead, following advice of SARCS members, contacts have been established with Earthworm books in India for publication of the East Asia volume.

### **References**

Congbin Fu and F. P. de Fries, (Eds.) 2006: Initial Science Plan of the Monsoon Asia Integrated Regional Study, MAIRS Working Papers Series #1. Available from MAIRS IPO ([www.mairs-essp.org](http://www.mairs-essp.org)).

### **Acknowledgments**

Sincere thanks are due to the Asia-Pacific Network for Global Change Research for funding support for this effort. Participants from the monsoon Asia region as well as from USA and members of APN SPG contributed to the success of this effort.

# Technical Report

## Preface

Different regions of the world may manifest significantly different responses to various Earth-System dynamics, which may in turn produce considerable consequences for the global Earth System. Irreversible changes to the regional biogeochemistry, and terrestrial and marine ecosystem functioning brought about by increase in population, intensified land use, urbanization, industrialization and economic development may have global as well as regional consequences. Similarly, effects of global change have a significant impact on sustainable development at both regional and national levels. An assessment of environmental changes occurring in the monsoon Asia region is a prerequisite for developing a coordinated and integrated effort on regional scale global changes of particular importance to the global earth system.

## 1.0 Introduction

Different regions of the world interact with the Earth System in different ways. Some regions may function as choke or switch points (Figure 1.1) in larger biogeochemical processes. The monsoon Asia region has been postulated as important to the global climate system, for example, because the Tibetan Plateau exerts considerable influence on atmospheric circulation and the Himalayas are the source of most of the major rivers of Asia. An international, regional perspective is important to achieving a better understanding of both the Earth System and sustainable development (Tyson et al., 2002). Regions whether defined by common biophysical characteristics, by shared patterns of history, language, and culture, or by the strength of recent economic relations like trade and investment, are important complementary levels of analysis to focus on nation states and biogeographical zones for the study of environmental change. In the case of the monsoon Asia region, a long history of adaptation and transformation of landscapes has resulted in perhaps a greater co-evolution of bio- physical landscapes and social organization than most other locations in the world. This requires studies aimed at understanding both the region's role in the Earth System and, conversely, how societies in the region may be impacted and be vulnerable to changes largely beyond their control. For example, there have already been several important investigations at large spatial levels on the vulnerability of food systems (Aggarwal et al., 2004), identification of hotspots and syndromes of environmental degradation, environmental threats to security (Khagram et al., 2003) and consideration of regional strategies for managing these risks and impacts.



Figure 1: Potential choke points in the Earth System (Source: Steffen et al, 2004)

In this document monsoon Asia is defined as the contiguous region of Asia, including East, Southeast and South Asia, that is affected by the seasonally varying Asian monsoon circulation system. The monsoon Asia region supports the largest populations on earth, being home to 3.6 billion persons (FAO, 2006). Societies in Monsoon Asia are critically dependent on the variability of the monsoon circulation system. Seasonal flood regimes underlie agricultural land-use systems and the evolution of human-dominated landscapes. Floods also maintain ecosystems that support inland fisheries, but at the same time, constrain or make more costly, urban–industrial development in seasonal flood plains. Many of these relationships between the monsoon and human activities and well-being are once again, and even more rapidly, transformed in the current wave of industrialization and urbanization. Notably increasing intensities of energy and land use are contributing to increased levels of aerosols with implications for air quality and human health (Imura et al., 2005; Ezzati et al., 2004), as well as regional biogeochemistry.

The region is characterized by diverse geography that includes the world’s highest mountains and longest rivers. These rivers have been extensively modified by canals and dams to support irrigation systems, produce electricity and reduce risks of flooding in built-up areas. As in other parts of the world, riparian ecosystems, freshwater lakes and wetlands have been modified and transformed. The region has diverse habitats ranging from glaciers and deserts, extensive semi-arid zones to tropical rainforests. Significant fractions of these habitats are fragile for various reasons, including highly variable rainfall, frequent droughts and floods. Dust storms and soil erosion are endemic in the region. A long coastline with major deltas and ports includes most of the largest urban conglomerations.

Humans have extensively modified the landscape, sometimes maintaining significant levels of biodiversity and other ecosystem functions, for example, in complex agro-systems with significant conservation value in their own right (Long et al., 2003; Xu and Wilkes 2004), and in other cases following conventional intensification approaches with their associated problems where inputs or land are not well managed. The region is also well-known for its biodiversity that supplies the inhabitants with essential ecosystem goods and services (Millennium Ecosystem Assessment, 2005). Several major zones appear to be highly vulnerable to the combination of global environmental changes and more locally wrought transformations of land and water use. In particular, mountain zones, coastal–urban corridors and semi-arid areas are under considerable stress generated by human activity and incipient global warming impacts (IPCC AR3, 2003).

The intensification of human activities, evident in per capita resource-use and emission levels well below those of the United States or the European Union, will in aggregate have a major impact on the global environment. How urbanization and industrialization unfold will be critical. The technologies used by firms can, and sometimes have, had major impacts on environmental performance (Rock, 2002; Rock and Angel, 2005). Urbanization creates substantial opportunities to improve energy efficiency in buildings and transport as well as reducing pressure on valuable agricultural land through higher densities of human settlement (McGranahan and Satterthwaite, 2003; Lebel 2005). Demographic trends are also likely to be hugely important for future landscape change. Very rapid declines in fertility rates in most countries across the region, combined with high levels of rural-to-urban migration are leading to scenarios of ageing populations and local de-population in rural areas, while massive increases in densities in others.

Nevertheless, there is substantial evidence of environmental degradation, in terms of

worsening air pollution in the larger cities, losses of biodiversity, desertification, disappearing wetlands, grassland overexploitation, water pollution, salinization and soil erosion. The need for further economic development underlines the prospect that many of these pressures are likely to continue rather than decline in the foreseeable decades, indicating the need for major changes in development trajectories if they are going to ever become sustainable. Decoupling social development gains from their adverse environmental impacts is going to be critical for the region and the globe.

Current scientific understanding suggests that global warming will significantly affect the variability of the monsoon system, especially the hydrological components. There are recent indications that anthropogenic impacts caused by enhanced greenhouse gas emissions and large-scale changes in land cover might be responsible, at least in part, for regional impacts such as attenuation of surface heating (Ramanathan et al., 2005), declining crop production (Chameides et al., 1999) and changes in precipitation (Fu et al., 2002, Endo et al., 2006). Extreme events, such as typhoons, may also be increasing in intensity (Emanuel, 2005). Monsoon circulation may also be important, because it transports aerosols, for example, from the urbanizing regions of Delhi through the Himalayas or out over the Indian Ocean.

The impacts of changes to the Asian monsoon are unlikely to be felt evenly across the region. Parts of society and some ecosystems are much more vulnerable than others. Mountains, arid regions and coastal zones appear to be particularly vulnerable. Urban zones may also be though they often have the political power and economic resources to protect, insure and repair themselves. However, at present there is still no strong direct evidence that the dynamics of the regional monsoon circulation system have been altered. Moreover, little is known about potential changes that might occur in the physical monsoon circulation system itself - including its variability and stability - due to global warming induced by anthropogenic activities, especially global-scale emissions and accrual of greenhouse gases in the atmosphere, regional landscape changes and associated aerosol generation. Hence, a comprehensive regional research effort is needed to understand the conjoined physical–biogeochemical–human interactions in monsoon Asia. Recent advances in modeling climate in the region (e.g. Fu et al., 2005) augur well for such investigations.

Clearly, a dedicated effort to understand and anticipate the interactions between regional development and the Earth System could be very valuable for developing decision tools, alternative policy options and sustainable development pathways for the region. In order to develop such a dedicated effort, it is essential to take stock of what is known about global change at regional and sub-regional scales and what scientific challenges must be met that could be embodied as essential thrusts of a concerted research program for the region.

Hence, a set of 3 sub-regional scale rapid assessments/syntheses exercises were proposed: one each for East Asia, Southeast Asia and South Asia, respectively to distil the available knowledge on the driving forces of change, current state of the system, impacts of changing driving forces and consequences for the region. The intent was to use such syntheses to develop a program of research, called Monsoon Asia Integrated Regional Study Program, to be fostered under the general umbrella of the Earth System Science Partnership (ESSP) and in close collaboration with ESSP's START program. ICSU funded a collaborative effort between START and SCOPE on East Asia and APN funded a part of this effort focusing on Southeast and East Asia. This report focuses on the



activities and outcomes under APN-funded effort.

## **2.0 Methodology**

The PI and collaborators (called “coordinators” for various sections of the proposed syntheses/assessments) contacted well-known regional scientists and secured their participation in the effort. These scientists were persuaded to prepare written contributions on selected topics (see Appendix). Guidelines for the length, style (including number of figures and reference styles, etc.) were prepared and disseminated. While sufficient time was provided to prepare such written inputs, additional time was needed to consolidate the written sections.

During July 2005, workshops of lead coordinators and invited experts (including select APN SPG members and APN Secretariat staff) were held in Chiang Mai, Thailand (for Southeast Asia Rapid Assessment) and Colombo, Sri Lanka (for Southeast Asia Rapid Assessment). These workshops brought together key scientists engaged in ongoing research on Southeast and South Asia, including representatives from START’s program sponsors and APN SPG. Products from these meetings include a refined conceptual framework for national-level studies and agreements and action plans for writing chapters for the sub-regional book volumes. The tables of contents for the two volumes Southeast and South Asia are attached as Appendix.

Early working drafts for various sections of sub-regional assessment book volumes were reviewed and decisions on the final structure, layout, and contents were finalized. Commitments for completion of written materials were secured from the lead coordinators. Updates were also provided to the MAIRS planning group meeting in Beijing during January 2006 and Kunming in May 2006 at which APN staff also participated.

The resulting chapters for book length volumes were reviewed, revised and further discussed at various fora, including the APN-supported October 2006 workshop in Darjeeling, India which involved scientists from South Asia as well as representatives of the MAIRS International Project Office

Negotiations have been undertaken with various publishing companies to produce the books. In the meantime, the synthesized products were also provided to members of the Scientific Steering Committee of the monsoon Asia Integrated Regional Study Program in order to help develop a longer-term research effort on the most vulnerable zones in the Monsoon Asia region.

## **3.0 Results & Discussion**

The sub-regional rapid assessments identified two major challenges for global changes in the monsoon Asia region:

- Is the Asian monsoon system resilient to the human transformation of the region’s land, water and atmosphere?
- Are societies in the region becoming more or less vulnerable to potential changes in the Asian monsoon?

Through these sub-regional assessments several major gaps in knowledge were noted that require consideration of:

- The major demographic, socio-economic and institutional drivers for change, including the development of scenarios for changes related to urbanization and industrialization, energy production and biomass burning, land-use/cover change and water resource harvesting, including dam construction.

- The effects of these drivers on regional air quality, water quality and availability, coastal resources and natural land-based ecosystems and biodiversity.
- The impacts on biogeochemical cycles and the physical climate system, including its variability at different scales.
- The impacts of global and other feedback effects on the regional biospheric life-support system, including food systems, water resources and health.

The assessments noted that there are indications that human activities, especially those associated with economic development may be having a detectable impact on the monsoon system (Giorgi et al., 2001, Fu et al., 2002, Ashrit et al., 2003, Ramanathan et al., 2005). Examples of such activities are increasing emissions of greenhouse gases and aerosols and large-scale human-induced land cover changes. Increases in emissions of greenhouse gases and aerosols and shifts in their detailed composition are being driven by rapid urbanization and industrialization in previously low-input agriculture-dominated economies.

Our understanding of the implications of these major social transformations for environmental changes has progressed substantially in the last decade and there is now a real potential to address larger Earth System questions — is the Asian monsoon system resilient to this human transformation of land, water and air? Changes in the monsoon could have profound impacts on social development, ecosystem goods and services, human well-being and health. At the same time rapid economic and social development that is driving environmental changes might also reduce certain kinds of vulnerabilities. The range of technologies available to governments and communities has grown tremendously. Institutional innovations like insurance and better accountability, data and information systems, better communication infrastructure and better observation systems could further reduce key vulnerabilities or be the basis of adaptation to future changes in the monsoon in Asia and the global environment. But involuntary risks are also modified and shifted by development (Lebel et al., 2006).

The improved understanding of social change at multiple levels in the region needs to be directed at new questions — are societies in the region becoming more, or less vulnerable to potential changes in the Asian monsoon?

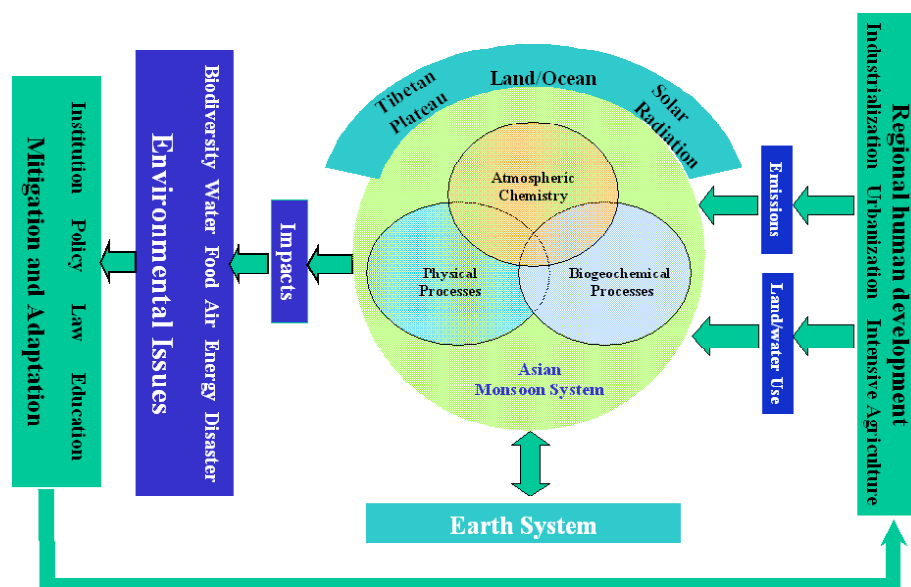
Environmental change in the monsoon Asia region is not independent of global changes, and vice versa. There is still little knowledge about how and how much the regional and global environmental systems are conjoined. The third overarching question is therefore: What are the likely consequences of changes in monsoon Asia on the global climate system?

The way societies in the monsoon Asia region use land, water and energy in the coming decades will make a difference. Hence, the sub-regional assessments provided inputs to development of the Monsoon Asia Integrated Regional Study Program that will focus its research efforts on four research themes. These were selected because they cut across resource management issues directly and are potentially impacted by changes in the monsoon system and other global environmental changes (Table 1). The research themes are:

- Rapid transformation of land and marine resources in the coastal zones.
- Multiple stresses on high mountain ecosystems and biophysical resources.
- Degradation of land and water resources in semi-arid regions as a result of changing climate and use.
- Changes in resource use and emissions resulting from rapid urbanization.

**Table 1: The key issues for environmental change in monsoon Asia**

<b>Zone</b>	<b>Coastal Zone</b>	<b>Mountain Zone</b>	<b>Semi-arid Zone</b>	<b>Urban Zone</b>
<b>Issue</b>				
Water	<ul style="list-style-type: none"> <li>•Saline intrusions</li> <li>•Reduced river outflow</li> <li>•Eutrophication</li> </ul>	<ul style="list-style-type: none"> <li>•Increased vulnerability of “water towers” monsoon Asia</li> </ul>	<ul style="list-style-type: none"> <li>•Larger variability in precipitation</li> <li>•Decline in Pollution</li> </ul>	<ul style="list-style-type: none"> <li>•Urban and industrial pollution</li> </ul>
Energy	<ul style="list-style-type: none"> <li>•Flooding of coastal oil and gas fields</li> <li>•Destruction by oil and gas platforms</li> <li>•Reduced mangrove area and other woody fuel biomass</li> </ul>	<ul style="list-style-type: none"> <li>•Deforestation for energy use</li> </ul>		
Food security	<ul style="list-style-type: none"> <li>•Red tides and harmful algal blooms</li> <li>•Declining fish catches</li> <li>•Less farmland</li> </ul>	<ul style="list-style-type: none"> <li>•Increased vulnerability of subsistence farming</li> </ul>	<ul style="list-style-type: none"> <li>•Reduced crop production</li> </ul>	<ul style="list-style-type: none"> <li>•Competition for prime agriculture land</li> </ul>
Air quality and health	<ul style="list-style-type: none"> <li>•More heat related and tropical diseases</li> </ul>	<ul style="list-style-type: none"> <li>•Urbanization in isolated areas</li> </ul>	<ul style="list-style-type: none"> <li>•Damaged by dust aerosols</li> </ul>	<ul style="list-style-type: none"> <li>•Air pollution from transportation, manufacturing</li> </ul>
Disasters	<ul style="list-style-type: none"> <li>•Sea-level rise</li> <li>•Land subsidence</li> <li>•Coastal erosion</li> <li>•Stronger typhoon</li> </ul>	<ul style="list-style-type: none"> <li>•Risk of glacial lake outburst floods</li> </ul>	<ul style="list-style-type: none"> <li>•Drought</li> <li>•Dust storms</li> <li>•Snow storms</li> </ul>	<ul style="list-style-type: none"> <li>•Increased vulnerability; protection cost;</li> <li>•Modified flood regimes</li> </ul>
Biodiversity	<ul style="list-style-type: none"> <li>•Hypoxia and anoxia</li> <li>•Dams blocking migration of aquatic biota</li> <li>•Loss of ecosystem functions and services</li> </ul>	<ul style="list-style-type: none"> <li>•Vulnerability of ecosystems to climate change</li> </ul>		



*Figure 2 The conceptual framework of MAIRS*

The conceptual framework for the MAIRS program takes into account the complex relations between development pathways and their impacts on key resources (land, air, food and water) and consequences for the regional monsoon and global climate systems. It highlights that environmental change in the region is due to both natural forcing and to anthropogenic forcing

#### **4.0 Conclusions**

Three books summarizing current knowledge on regional aspects of global change in Monsoon Asia, and identifying gaps in knowledge, and priorities for new research are in hand. The first of the three books, 'Changes in the Coupled Human-Monsoon system of East Asia in the Context of Global Change', has been completed and is currently under final review. Publication is expected in early 2007. The second book, 'Global Environmental Change and the Southeast Asian Region: An Assessment of the State of the Science', is under preliminary review. The final book on the South Asia Rapid Assessment has been reviewed at the Darjeeling workshop (see above) and the South Asia START Regional Center intends to publish it in early 2007. Logo of APN will appear on the final book volumes.

The ultimate outcome of this project provided input to the science plan for follow-up studies in Monsoon Asia and the establishment of an international network of scientists engaged in integrated regional analysis of regional environmental change, and the implications for sustainable regional development.

#### **5.0 Future Directions**

The Monsoon Asia Integrated regional Study program is one of the products resulting from this APN-funded activity. This program released its initial science plan at the ESSP Conference held in Beijing during November 2006. This initial science plan is now being implemented and several proposals have been submitted to APN for specific activities related to the plan.

## References

- Ashrit, R. H. Douville & K. Kumar**, 2003: Response of Indian summer monsoon and ENSO-monsoon teleconnection to enhanced greenhouse effects in CNRM coupled model, *J.Meteo.Soci.Japan*, 81, 779-803.
- Chameides, W.L., H. Yu, S.C. Liu, M. Bergin, X. Zhou, L. Mearns, G. Wang, C.S. Kiang, R.D. Saylor, C.Luo, Y. Huang, A. Steiner, F. Giorgi**. 1999. Case study of the effects of atmospheric aerosols and regional haze on agriculture: An opportunity to enhance crop yields in China through emission controls? *PNAS* 96(24): 13626–13633.
- Emanuel, K.** 2005. Increasing destructiveness of tropical cyclones over the past 30 years. *Nature*, 436: 686–688, doi:10.1038/nature03906.
- Endo, N., T. Kadota, J. Matsumoto, Ailikun & T. Yasunari** 2006: Climatology and trends in summer precipitation characteristics in Mongolia for the period 1960-98. *J. Meteor. Soc. Japan*, 84–3, 543–551.
- Ezzati, M., Bailis, R., Kammen, D.M., Holloway, T., Price, L., Cifuentes, L.A., B. Barnes, A. Chaurey & K.N. Dhanapala** 2004. Energy management and global health. *Annu. Rev. Environ. Resour.*, 29: 383–419.
- Fu, C.B. et al**, 2002: Regional-global interactions in east Asia. Pp 109-150 in *Global-Regional Linkages in the Earth System*. P. Tyson, editor, Springer Verlag, Germany.
- Fu, C.B, S. Wang, Z. Xiong, W.J. Gutowski, D.-K. Lee, J.L., McGregor, Y. Sato, H. Kato, J.-W. Kim & M.-S.Suh** 2005. Regional climate model intercomparison project for Asia. *American Meteorological Society*, 257–266.
- Giorgi, F. et al.** 2003. Indirect vs. direct effects of anthropogenic sulfate on the climate of East Asia as simulated with a regional coupled climate-chemistry/aerosol model. *Climatic Change*, 58: 345–376.
- Lebel, L.** 2004. Transitions to sustainability in production-consumption systems. *Journal of Industrial Ecology*, 9:1–3.
- Lebel, L.** 2005. Carbon and water management in urbanization. *Global Environmental Change*, 15: 293–295.
- Lebel, L., Nikitina, E. & Manuta, J.** 2006b. Flood disaster risk management in Asia: an institutional and political perspective. *Science and Culture*, 72: 2–9.
- Long, C.-l., Li, H., Ouyang, Z., Yang, X., Li, Q. & Trangmar, B.** 2003. Strategies for agrobiodiversity conservation and promotion: a case from Yunnan, China. *Biodiversity and Conservation*, 12: 1145–1156.
- McGranahan, G. & D. Satterthwaite.** 2003. Urban centers: an assessment of sustainability. *Annual Review of Environment and Resources*, 28: 243–274
- Millennium Ecosystem Assessment.** 2005. *Ecosystems and human well-being: synthesis*. Washington, D.C. Island Press.

**Rock, M.T.** 2002. Pollution control in East Asia: lessons from newly industrializing economies. *Resources for the Future*, Washington, DC.

**Rock, M.T. & D.P. Angel** 2005. *Industrial transformation in the developing world*. Oxford, Oxford University Press.

**Steffen, W., A. Sanderson, P.D. Tyson, J. Jager, P.M. Matson, B. Moore, F. Oldfield, K. Richardson, H.J. Schnellhuber, B.L. Turner & R.J. Wasson** 2004. *Global change and the earth system: a planet under pressure*. The IGBP Book Series, Berlin, Springer-Verlag, New York, Heidelberg. 336 pp.

**Xu, J. & A. Wilkes** 2004. Biodiversity impact analysis in northwest Yunnan, southwest China. *Biodiversity and Conservation*, 13(5): 959–983.

## **Appendix**

See attached

### Funding sources outside the APN

Co-funding and in-kind support for the rapid assessment exercises was received from ICSU, SCOPE and START. ICSU provided funding support for the East Asia rapid Assessment. SCOPE provided services of two SCOPE representatives who helped edit the East Asia Rapid Assessment book chapters. START helped with arrangements of coordinators meetings, and representatives of START participated in the meeting of coordinators. START also helped promote the rapid assessment products with the MAIRS SC as well as the START regional Committees in monsoon Asia region.

## Glossary of Terms

APN: Asia-pacific network for Global Change Research

ARCP: APN's Annual Regional Call for proposals

DIVERSITAS: International research programme on Global Change and Biodiversity

ESSP: Earth System Science Partnership

IHDP: International human Dimensions of Environmental Change Programme

IGBP: International Geosphere-Biosphere Programme

IPCC: Intergovernmental Panel on Climate Change

MAIRS: Monsoon Asia Integrated Regional Study

SPG: APN's Science Planning Group

START: Global Change System for Analysis, research and Training

SCOPE: Scientific Committee for the Problems of the Environment

WCRP: World Climate Research Programme

## **Attachment 1: Table of contents of the Southeast Asia Rapid Assessment book volume**

### **Global Environmental Change and the Southeast Asian Monsoon Region**

1. Introduction: the global environmental change and sustainable development nexus in Monsoonal Southeast Asia *Louis Lebel*
2. Underlying societal drivers and responses to environmental change *Ooi Giok Ling, Louis Lebel*
  - 2.1. Governance and the Environment in Southeast Asia *Ooi Giok Ling*
  - 2.2. Urbanization and urban transformation: driving towards a carbon future? *Louis Lebel, Antonio Contreras, Ooi Giok-ling, Rodel Lasco, Nguyen Hoang Tri, Agus Sari*
  - 2.3. Energy production and use *Sardar Islam, Matthew Clark, Sammy Choi, Ainsle Jolley, Peter Sheehan*
  - 2.4. Public policy processes, decision-making and risk management *Ben Malayang*
  - 2.5. Institutional Challenges in South East Asia: Environmental Cooperation In Context *Simon Tay*
  - 2.6. Local Institutions at the Crossroads of Environmental and Natural Resources Governance in Southeast Asia: State-Civil Society Interfaces and Tensions in the Context of Regionalism *Antonio P. Contreras*
3. Climate change and air quality *Shaw S. Liu*
  - 3.1. Climate variability and change *Huang-Hsiung Hsu, Cheng-Ta Chen, Chih-wen Hung*
  - 3.2. Atmospheric changes and regional biogeochemistry *Shaw S. Liu, Julius Chang, Neng-Huei Lin, Zifa Wang, Hajime Akimoto*
4. Land transformation and its consequences *Daniel Murdiyarso*
  - 4.1. Land transformation and its consequences *Daniel Murdiyarso, Rodel Lasco, Doug Sheil, Upik R. Wasrin and Erik Meijaard*
  - 4.2. Land cover change dynamics in Southeast Asia *Jay H. Samek, Do Xuan Lana, Iwan Gunawanb, Asep Karsidic, Sharifah Mastura S. A.d, Sithong Thongmanivong, Hartanto Sanjayac*
  - 4.3. Measuring intensity of land use in tropical forest-agriculture mosaics with the ILUI index *Meine van Noordwijk and Suseno Budidarsono*
5. Alteration of hydrology and regional hydrological cycles *Anond Snidvongs & Lu Xi Xi*
  - 5.1. Regional hydrological cycle in response to climate variability and change *Yongquin David Chen*
  - 5.2. Impacts of land surface changes on regional hydrology – mainland Southeast Asia *Matti Kummu, Olli Varis, Juha Sarkkula and Jorma Koponen*
  - 5.3. Impacts of land surface change on regional hydrology in Insular Southeast Asia *Wang JJ et al.*
  - 5.4. Soil erosion and sediment yields *Lu Xi Xi*
  - 5.5. Human impacts on river ecosystems *Yixin Zhang, David Dudgeon*
  - 5.6. Natural vs. human factors controlling dissolved and particulate river loads of tropical Asia (Tim) *T.C. Jennerjahn*
6. Changes in coastal and marine environments *Arthur Chen, Liana Talue-McManus*



- 6.1. Water masses and circulation of the Southeast Asian Seas *Arnold Gordon, Tetsuo Yanagi*
- 6.2. Sediment delivery, sea-level rise, and coastal evolution in the past and the future: natural and anthropogenic changes *Yoshiki Saito*
- 6.3. Mangroves *Ong Jin Eong*
- 6.4. Managing beyond boundaries: The management of coastal fisheries in the south east Asia by *Ablan, Ma. Carmen A Ma Carmen Menchie*
- 6.5. Integrated zone coastal management *Wen-Yan Chiau*
- 6.6. Acidification and potential dissolution of  $\text{CaCO}_3$  in the sediments of the South China and Sulu Seas *Chen-Tung Arthur Chen*
- 6.7. Synthesis *Arthur Chen et al.*
7. Vulnerabilities and Adaptations to global environmental changes *Lilibeth Acosta-Michlik and Mark Rounsevell*

## **Attachment 2: Table of contents of the South Asia Rapid Assessment book volume**

1. Introduction: Global Environmental Changes in South Asia: A regional perspective (Dr. Mitra)
2. Underlying Drivers and responses to environmental change (Joyashree Roy et al)  
Chapter Summary (including past/recent and future perspectives)
  1. Key Drivers: Supply Side and demand
  2. Population Demographics and Urbanization
  3. Energy
  4. Industrial Transformation, Technological Change and Innovation
  5. Public Transportation
  6. Globalization and Trade
  7. Development Pathways
  8. Gaps and Research Needs
3. Climate Change and Variability (Singhvi et al)  
Chapter Summary (including past/recent and future perspectives)
  1. Past Changes (Holocene and pre-Holocene)
  2. Recent Changes (Instrumental records-based)
  3. Tropical Cyclones, Storm Surges and Extreme Events
  4. Modeling
  5. Gaps and Research Needs
4. Land Transformation and its Consequences (Rajan et al)  
Chapter Summary (including past/recent and future perspectives)
  1. Forest Biomass and Carbon Estimates
  2. Soil Carbon
  3. The Indo-Gangetic Plains
  4. Mountains
  5. Urbanization and Urban Heat Islands
  6. Gaps and Research Needs
5. Atmospheric Composition Change and Air Quality (Jayaraman et al)  
Chapter Summary (including past/recent and future perspectives)
  1. Natural and Anthropogenic Aerosols, Sources and Sinks
  2. Direct and Indirect Radiative Forcing by aerosols
  3. GHGs, Sources and sinks
  4. Transport of Aerosols
  5. Stratospheric-Tropospheric Exchange
  6. Ozone and Precursor Gases
  7. INDOEX and ABC
  8. Air Quality
  9. Acid rain
  10. Gaps and Research Needs
6. Alterations to Hydrology and Regional Hydrological Cycles (Mirza et al)  
Chapter Summary (including past/recent and future perspectives)
  1. Monsoon Variability and Sediment Transport by Rivers
  2. ENSO and Stream Flows in the greater GBM Basins
  3. Floods and Droughts, including forecasting
  4. Water Quality
  5. Snow and Glaciers
  6. Ground Water
  7. Diversions and Storage
  8. Climate Change and Future Water Availability

- 9. Impacts of Land Surface Changes on Hydrology
- 10. Gaps and Research Needs
- 7. Changes in Coastal and Marine Environments (de Sousa et al)
  - Chapter Summary (including past/recent and future perspectives)
  - 1. Biogeochemistry (Indian coast, Northern Indian Ocean)
  - 2. Air-Sea Fluxes
  - 3. Land-Sea Interactions and Material Fluxes (APN project)
  - 4. Deltas
  - 5. Sunderbans, including coastal resource use (Box)
  - 6. Mangroves, Corals, Sea Grasses, etc., including resource use
  - 7. Impacts of Sea Level Rise, Changes in SST
  - 8. Gaps and Research Needs
- 8. Key Vulnerabilities of human society in South Asia to Global Environmental Change and Adaptation/Coping Mechanisms (Sumana, Shrestha, and et al)
  - Chapter Summary (including past/recent and future perspectives)
  - 1. Climate Change Scenarios and Implications
  - 2. Impacts of Climate Variability/Change on agriculture (CLIMAG, AIACC; boxes?)
  - 3. Health Effects: Heat Stress, Respiratory Diseases, Water-borne Diseases, Malaria, UV-B, etc.
  - 4. Water Resources (APN-funded project; others?)
  - 5. Mountain Regions (APN-funded project; others?)
  - 6. Biodiversity, Ecosystem Changes and Goods and Services (MEA Box)
  - 7. Tools for vulnerability assessment
  - 8. Economic Valuation of Welfare Loss
  - 9. Gaps and Research Needs

Conclusions including Cross-Cutting Issues and Way Forward (Mitra)