CLIMATE IN ASIA AND THE PACIFIC:

A Synthesis of APN Activities

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Message from the Director

Work for the present Synthesis – Climate in Asia and the Pacific: A Synthesis of APN Activities began in November 2009 with a scoping workshop followed by an authors' workshop in August 2010. The work entailed summarizing over fifty scientific research and capacity building projects funded by the APN that had a climate-related element – whether natural climate variability and/or climate change. The contributing authors of the present synthesis report are leaders in their field and many of them are authors for the next Fifth Assessment Report of the Intergovernmental Panel on Climate Change (IPCCAR5). The present report will be a useful tool not only for the IPCC, but also for scientists, decision-makers and educators as it identifies both research gaps and future research activities for the Asia-Pacific region in the context of natural climate variability and climate change.

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Director, APN Secretariat

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Executive Summary

The adverse effects of climate change and natural climate variability pose a significant threat to humanity, with the poorest communities being the most vulnerable. Scientific understanding of our climate is advancing at a significant rate, with new information emerging about the likely impacts of climate change, the options to adapt to these changes, and new approaches to mitigation.

Through national and international fora, it is becoming clear that climate is one of the most pressing issues in the political arena today. This has been evident in government and stakeholder meetings such as the 34th G8 Summit (Japan, 2008) and the most recent United Nations Framework Convention on Climate Change (UNFCCC) 16th Conference of the Parties (COP) Meeting (Cancun, Mexico, 2010) and the Copenhagen Accord, where commitments to climate change have been underscored, particularly the need to support developing countries for financing and transferring knowledge and skills to respond effectively to climate change.

IPCC is the Intergovernmental Panel for Climate Change and its Fourth Assessment Report (AR4) states that "warming of the climate system is unequivocal" and that climate change will interact at all scales with other aspects of the global environment and aggravate existing concerns about the provision of natural resources including water, soil and air pollution, health hazards, disaster risk, and deforestation. Their combined impacts may be compounded in the future in the absence of integrated mitigation and adaptation measures [IPCCAR4 (SPM), 2007].

With this background, it comes as no surprise that the majority of projects funded by the APN since its inception have had a climate component.

The present synthesis report is part of the APN's larger aim to contribute, from the science perspective, to the development of policy options for appropriate responses to climate vulnerability and impacts, including adaptation and mitigation, which in turn will contribute to sustainable development. The timing of this publication also leads into three major activities of the "Planet Under Pressure: New Knowledge Towards Solutions Conference" and the "Rio+20 United Nations Conference on Sustainable Development," both taking place in the first half of 2012, and the work of the current IPCC fifth assessment with the report scheduled for release in 2014.

The present synthesis report indicates that, while there is much activity at the global level, there is a great need to intensify investigative research of climate change and climate variability and trends at the regional level, as these are still poorly understood. Consistent socio-economic data collection is

needed, as is the need for an interdisciplinary approach to solving complex climate change problems. The increasing frequency and severity of floods, droughts and extreme temperatures requires the use of appropriate indices to improve monitoring and prediction of extreme events.

The effects of climate on water resources have been studied in APN projects but many issues remain unclear. There is a need for models to better predict the effects of seasonal to inter-annual climate on water availability and quality. Coastal communities continue to be highly vulnerable to sea level rise and research is needed in identifying appropriate adaptation measures, strategies, and policies. Small islands are especially vulnerable and research is required into relocation options or alternatively, where relocation is not an option, into engineering solutions. APN has supported international workshops to reduce vulnerability and devise coping strategies for agriculture to climate variability and change. These have built the knowledge-base for developing predictive capacity to manage climate variability and climate change-related vulnerability, strengthen overall climate responses and build resilience to socio-economic and environmental shocks, which is one of the region's urgent development needs.

APN projects have contributed substantially to the building of regional capacity to include climate change in national sustainable development strategies and action plans. APN workshops on trends in climate extremes have provided a framework for international trend analysis in developing countries around the world. However, what is abundantly clear is that open access to climate data, including relevant socioeconomic data, will be essential for countries in the Asia-Pacific region to carry out risk assessments of their vulnerability to trends in climate within a regional framework. It is, therefore, in the interest of all countries of the APN to promote the open exchange of climate-related data.

The need for climate change adaptation is increasingly recognized by communities, with an initial focus on assessing vulnerabilities and identifying adaptation options. The complexity of adaptation due to the multidisciplinary nature of the required solutions and the lack of long-term data poses a great challenge. Approaches at the grassroots levels (including the identification of local champions) that involve communities and local governments to incorporate climate change adaptation practices into development planning will be needed, and Integrated Assessment Models (IAMs) will need to be customized for local to regional and sectoral levels.

Modelling the effects of climate on agriculture and fishery production needs to be refined. Critical to climate adaptation research, practice and policy are downscaled climate data. Developing Regional Climate Models (RCMs) in Asia has helped provide more detailed information on monsoon circulation; and high-resolution regional/local information from RCMs can be used in impact, vulnerability and adaptation studies. There is a need for further work on RCMs and statistical downscaling methods to help localize Global Climate Model (GCM) results and to quantify the uncertainties associated with these results. Especially problematic in the Asia-Pacific region are Small Islands States and areas with rough and steep terrain like the Himalayas.

The investments by APN in projects aimed at improving the Asia-Pacific region's understanding of climate in the region, at assessing the risks to society and nature from climate variability and change, and at raising awareness of these issues to decision-makers and the public are well justified in terms of need and benefits. Formal assessments and literature citations have demonstrated that these activities have been effective and of high quality.

Given the high quality of APN projects and the potential of many to yield longer-term benefits through the provision of marginal resources, there should be an investigation of innovative means to *sustain* such projects beyond the term of initial APN support.

Strategic planning of APN would benefit by ensuring that it maintains close contact with relevant international developments on indicators of the impact of research and capacity building. The APN should continue to recognize the benefits of applying appropriate models to assist in the integration of information in complex systems. The APN recognizes that effective application of climate knowledge to practical problems of societies across the Asia-Pacific region requires effective dialogue across the traditional boundaries of science, technology and policy.

The APN has a role to play in promoting research in the region that defines the strategies that lead to true sustainable development. The Asia-Pacific region has a rich variety of cultures, and the APN has been effective in promoting connections and alliances across all these cultures. This effectiveness comes from the recognition of cultural differences and not imposing a monolithic approach. These sensitivities to culture will be especially important as the APN continues to promote exchanges of knowledge on climate-related issues across disciplines and sectors.

Clearly, the most important aspect of interactions across a region is the human factor. The APN has been effective in promoting innumerable networks of participants in its projects related to climate. One potential element in the future development of sustained networks is through the engagement of early-career researchers who can carry their scientific and social networks into the future.

Finally, while substantial progress has been made by APN-supported projects on climate science, capacity building and policy outreach, much remains to be done in the Asia-Pacific region. Among the key trends impacting the region are rising population, increasing urbanization, rapid economic development, rising energy demand, massive land use and cover change, increases in temperature, heatwaves, floods and droughts, and globalization. APN may wish to invest in some of these areas in its future strategies and research agendas.

Michael Manton and Linda Stevenson

1 Background of APN

1.1. Introduction

Established in 1996, the Asia-Pacific Network for Global Change Research (APN) is a network of twenty-two member governments in Asia and the Pacific whose vision is to enable countries in the region to successfully address Global Change (GC) challenges through science-based response strategies and measures, effective science and policy linkages, and scientific capacity development.

Societies' ability to respond to GC depends on the resilience of human and environmental systems in the face of these changes. Improving understanding of the interactions and feedback of physical climate systems with human and environmental systems, improving predictions of longer-term causes and trends, and preparing nations for future events are grand challenges. The APN, now in its third strategic phase (2010-2015), continues its mission to enable countries in the region to address these challenges.

Financially sponsored by the Governments of Japan (Ministry of Environment [MOEJ] and Hyogo Prefectural Government), New Zealand (Ministry for the Environment), Republic of Korea (Ministry of Environment [MEV]) and the United States (National Science Foundation [NSF]; United States Global Change Research Program [USGCRP]), the twenty-two full member countries of the APN are:

- Australia
- Bangladesh
- Bhutan
- Cambodia
- China
- Fiji
- India
- Indonesia
- Japan
- Lao PDR
- Malaysia
- Mongolia
- Nepal
- New Zealand
- Pakistan
- Philippines
- Republic of Korea
- Russian Federation
- Sri Lanka
- Thailand
- USA
- Viet Nam

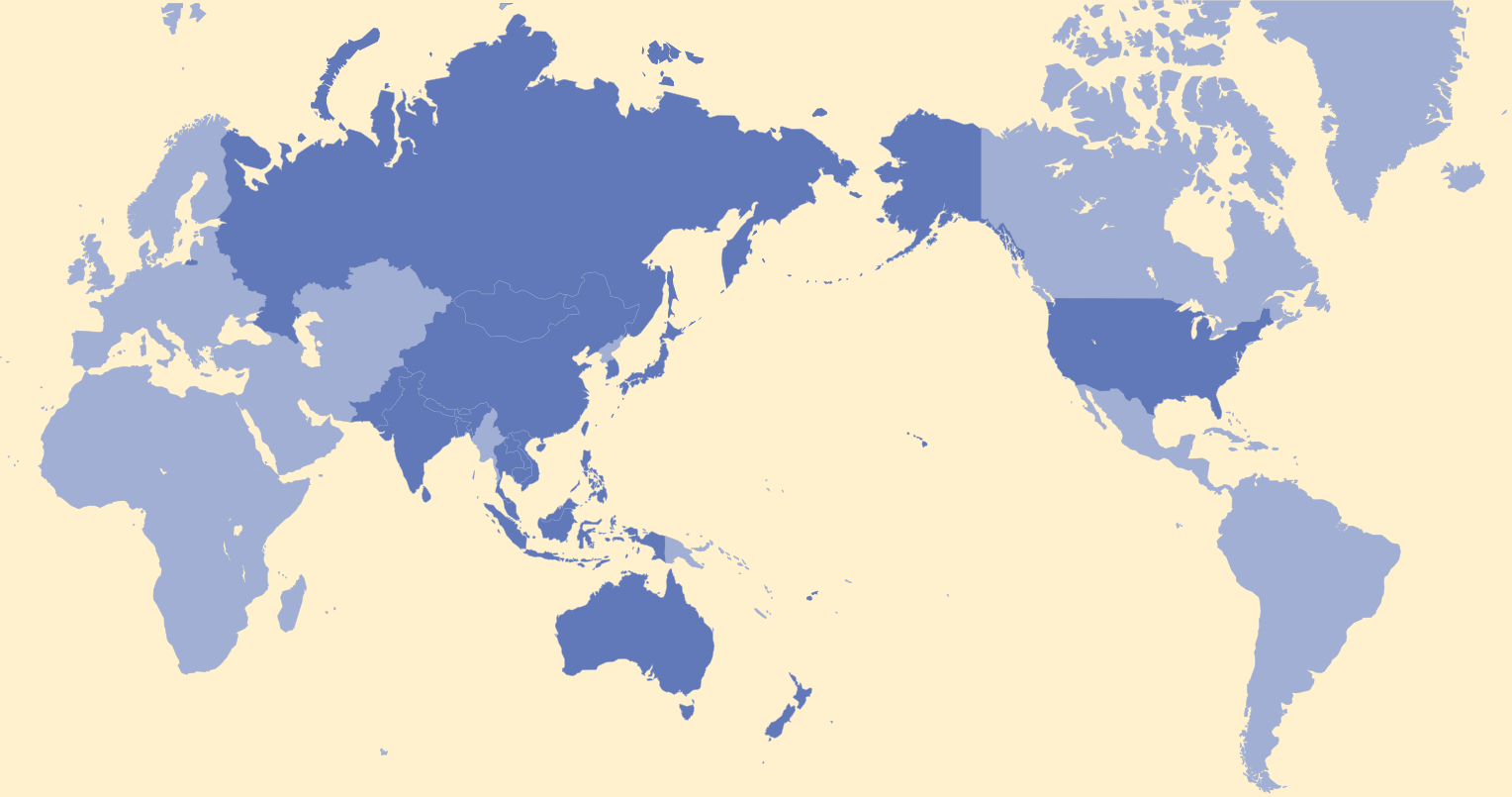


Figure 1: Geographic distribution of APN member and approved countries

The geographical distribution of current members of the APN is shown in ***Figure 1***. While the Pacific Island Countries (PICs) and Singapore are not member countries, they have "approved country" status allowing them to be actively involved in APN funding mechanisms and APN projects and activities.

The Secretariat of the APN is hosted in Japan by the Hyogo Prefecture Government and located in Kobe City.

1.2. APN Objectives

APN defines GC as the set of natural and human-induced processes in the Earth's physical, biological and social systems that, when aggregated, are significant at a global scale. In order to foster GC research in the region, APN implements three core strategies of: (i) Promoting and encouraging policy-relevant regional GC research; (ii) Promoting and encouraging activities that will develop scientific capacity and improve the level of awareness on GC issues specific to the region; and (iii) Identifying and helping address, in consultation with policy-makers and other end-users, present and future needs and emerging challenges. To this end, APN has four main goals:

Goal 1. *Supporting regional cooperation in GC research on issues particularly relevant to the region*

Goal 2. *Strengthening appropriate interactions among scientists and policy-makers, and providing scientific input to policy decision-making and scientific knowledge to the public*

Goal 3. *Improving the scientific and technical capabilities of nations in the region, including the transfer of know-how and technology*

Goal 4. *Cooperating with other GC networks and organizations*

1.3. APN Activities

The APN goals are achieved through a number of activities selected from the APN's two main programmes, which involve two annual open Calls for Proposals in which scientists based in APN member or approved countries can submit proposals for support. The two main programmes are the *Annual Regional Call for Research Proposals (ARCP)* and the *Scientific Capacity Development Programme (CAPaBLE)*. Particularly encouraged to submit APN proposals are researchers working in collaboration with the APN's four international core GC partners of the International Programme on Biodiversity (DIVERSITAS), International Geosphere-Biosphere Programme (IGBP), International Human Dimensions Programme on Global Environmental Change (IHDP), World Climate research Programme (WCRP) and their related core and joint projects, including the global change SysTem for Analysis, Research and Training (START) and the Earth System Science Partnership (ESSP). The APN has also established a strong partnership with the Group on Earth Observations (GEO) following the launch of its 10-year implementation plan in 2005.

Research and capacity building activities under the ARCP, CAPaBLE and other related initiatives of the APN focus on four scientific themes identified in the APN's Science Agenda. These are: (i) Climate Change and Climate Variability; (ii) Ecosystems, Biodiversity and Land Use; (iii) Changes in Atmospheric and Terrestrial Domains; and (iv) Resources Utilization and Pathways for Sustainable Development. Under these scientific themes, the APN supports activities that are interdisciplinary in nature and cut across natural, social, economic and political sciences.

Examples of the kinds of activities APN undertakes are:

- Promoting and strengthening GC research, including identifying gaps via syntheses and assessment work
- Identifying and developing existing methodologies and developing new methodologies and tools for effective transfer of scientific knowledge
- Strengthening the interface of policy- and decision-making processes and society in general for mainstreaming environmental concern
- Encouraging initiatives from developing countries for place-based, integrative research
- Aligning with programmes of the GC community

As APN is an inter-governmental network, a high priority goal is to produce sound scientific results that can be made available as a supportive tool for policy-making processes. Accordingly, the APN conducts regular synthesis and assessment activities of the projects it supports in order to identify important outcomes, research gaps and/or emerging issues that could be used to support policy development.

1.4. APN Climate Synthesis

It is with the above background that the present Climate Synthesis activity was undertaken. Of particular relevance is the IPCC Fifth Assessment Report (IPCCAR5) and the APN aims to ensure that the present report is not only relevant to the IPCC, but also published in time to be a useful resource for the fifth assessment.

The synthesis encompasses all of the APN-supported projects in which climate change and climate variability are featured as a major theme. This allowed the authors to identify knowledge gaps and help prioritize research goals and programmes relating to climate in the Asia-Pacific region as well as provide knowledge on climate issues for the policy- and decision-making communities at local, national, sub-regional and regional levels. In essence, the Climate Synthesis activity endorsed by the APN's 14th Inter-Governmental Meeting (IGM) in March 2009 had the following objectives and intended outputs:

Objectives

- » Address the relevance, achievements and present status of APN climate activities by synthesizing APN climate-related projects conducted under the ARCP and CAPaBLE programmes.
- » Highlight significant problems of climate change, including impacts and vulnerabilities, and identify urgent research needs and, in so doing, allow the APN to identify gaps between research needs and APN activities.
- » Identify a future research direction for climate change & climate variability that is relevant to the region.
- » Report the results to the IGM and Scientific Planning Group (SPG) Meeting to review and determine future APN policies and initiatives in the climate arena.
- » Disseminate the results to the global scientific community (via international journals, websites, relevant fora, etc.); the policy and decision-making community (via policy-briefs; a synthesis summary report and information exchange at relevant fora); and to the public (via social media and general publications).
- » Discuss the activity at relevant policy-related fora, and ensure relevance for policy processes including the IPCC (particularly AR5), UNFCCC/COP16 (and beyond) and UNFCCC SBSTA34 (and beyond).

Products

- » APN Synthesis Report: Climate in Asia and the Pacific: A Synthesis of APN Activities (Publication: Mid-2011)
- » Peer Reviewed Journal Paper (Publication: End-2011)
- » A Special Journal Edition and/or an Academic Book (Publication: Mid-2012)

The present Synthesis Report is the third APN synthesis activity. The two previous syntheses are on "Land-Use Cover Change: An Initial Synthesis (2003)" and "Global Change and Coastal Zone Management: A Synthesis Report (2004)". The latter synthesis resulted in a number of citations in the IPCC Fourth Assessment Report (AR4) as well as the publication of APN's first book on "Integrated Coastal Zone Management," published by Springer in 2006.

It is important to point out that the present synthesis provides a focus for climate-related research results, scientific capacity development and future directions identified from APN-supported projects. These are placed in the context of the extensive climate research that has already been conducted, or is currently being undertaken, in the Asia-Pacific region.

2 Overview of APN Climate Activities

2.1. APN Climate Activities

The present report is a synthesis of fifty-six (56) projects (***Table 1; Appendix 1***) funded by the APN since 1998, all of which can be grouped into eight main sections:

(I) Food, Agriculture and Climate (16 projects)
(II) Seasonal Climate Prediction and Applications (8 projects)
(III) Climate Variability, Trends and Extremes (6 projects)
(IV) Regional Climate Change Modelling (3 projects)
(V) Vulnerability and Adaptation to Climate Change (9 projects)
(VI) Climate Change Mitigation (5 projects)
(VII) Coastal Cities and Climate Change (2 projects)
(VIII) Climate Change Policy and Outreach (7 projects)

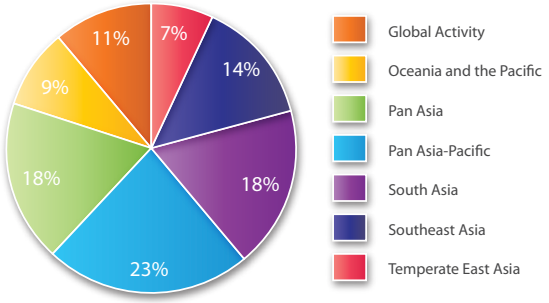
It should be noted that a number of APN projects that crosscut related issues were outside the scope of the present synthesis and have not been included. At the time of writing, the APN concluded a separate Biodiversity Gap Analysis Scoping Workshop for the potential synthesis of projects under the APN scientific theme *Ecosystems, Biodiversity and Land Use* to ensure that the APN continues to address gaps in this and other important areas.

The kinds of activities that the APN has focused on is reflected in its four goals (refer to ***Section 1.2***) in that it has supported climate projects that cover main issues of regional research; scientific capacity development, including training and transferring of knowledge; as well as communications and outreach activities at the science, policy, end-user and civil society levels. Many of the climate activities have focused on modelling and assessments for policy- and decision-making processes and have attempted to bridge the science-policy interface by producing science that underpins policy.

The research focus of the APN is regionally based and all of its climate research activities involve collaboration with a minimum of three countries, at least two of which are developing countries.

As the APN aims to develop and enhance the scientific capacity of mainly developing countries[1] in the region, all of APN's research proposals must involve developing countries as a fundamental criterion for APN funding. ***Figure 2*** shows the regional distribution of the climate activities conducted by the APN, highlighting the regional and collaborative nature of the work undertaken.

Figure 2: Regional distribution of APN climate activities



Having the capacity to conduct high quality research that provides *underpinning scientific support* for decision-makers and decision-making processes is vital for least-developed nations in the Asia-Pacific region and is recognized by the APN as crucial for improving the scientific and technical capabilities of these nations. This is the essence of the APN's scientific capacity development programme, CAPaBLE, and twenty-eight (28) of the projects included in the present synthesis were funded under the CAPaBLE programme.

At the time of writing, APN is undertaking seven (7) projects focusing on scientific capacity development for climate change impact and vulnerability assessments. As the synthesis considers only completed projects in the period 1998-2009, these activities are not included in the present report.

Figure 3 shows the outputs of the climate-related projects in terms of their major publications. Depending on the type of activity conducted, i.e. whether scientific research, scientific capacity development or communications and outreach, publications varied from peer reviewed journal papers, monographs and academic books to technical reports, assessments and various training materials to ensure the sustainability and transfer of technical knowledge, particularly for developing countries. The peer reviewed, special journal editions, books and monographs are cited in ***Appendix 3***.

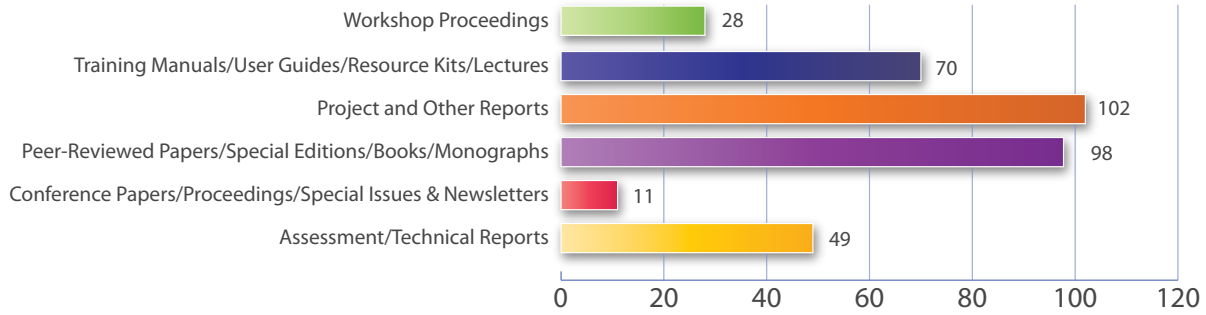


Figure 3: Major publications from APN climate-related projects

2.2. APN Evaluation: Significance and Impacts

APN has completed two significant phases since its launch in 1996 and many of the climate activities in the present synthesis were evaluated under two strategic periods that ran from 1999-2004 (1st Strategic Phase) and 2005-2010 (2nd Strategic Phase). Of the climate projects included in the present synthesis, thirty-two (32) were reviewed in Phase 1 and twenty-four (24) in Phase 2. The evaluations highlighted some significant developments and impacts. Both evaluations addressed the success of the projects in terms of relevance, efficiency, effectiveness, impact and sustainability against the APN goals. APN-funded activities have had some significant impacts and accomplishments, some of which are included here.

1 All of APN's member and approved countries with the **exception** of Australia, Japan, New Zealand, Republic of Korea, Singapore and USA are considered developing countries.

First Phase Evaluation (1999-2004)
Projects evaluated scored highly under the related goals of supporting regional collaboration on relevant issues such as facilitating the standardization, collection, analysis and exchange of relevant scientific data and information; and cooperation with international GC networks and organizations relevant in the region. Historically, meteorological services in the region have collaborated in sharing observations, methods and model results, since weather forecasts depend on regional as well as local developments. In this perspective, scientists and technical experts in the region had a good basis to build collaborative APN projects to work on climate issues, again depending on the sharing and understanding of regional and local data. Examples of such collaboration included regional climate model inter-comparisons and regional workshops to develop country-level information on climate trends and extremes and to synthesize this information at the regional level.

Evaluation Results - Gaps:
While a number of successes were noted, further efforts are needed to enhance activities that address the APN goals of strengthening interactions among scientists and policy-makers, and providing scientific input to policy- and decision-making processes, as well as scientific knowledge to the public. Participants of climate-related projects recognized the importance of science-policy interfacing, but noted that it is a difficult area for which appropriate mechanisms are often unclear, and for which resources are often limited.

Many of the projects funded by the APN involved partnerships with other organizations including the Global Climate Observing System (GCOS), IHDP, IGBP, Pacific Regional Environment Programme (SPREP), START, United Nations Development Programme (UNDP), United Nations Environment Programme (UNEP), WCRP and the World Meteorological Organization (WMO), among others.

Most of the climate projects under the first phase of the APN rated well against its goals of improving scientific and technical capacities in the region and facilitating the development of research infrastructure and the transfer of know-how and technology. Collaboration between developing and developed countries in most of the projects led to knowledge and skills transfer that was mutually beneficial. A strong training component was apparent in many of the projects. Results included the increased understanding, throughout the region, of the strengths and weaknesses of regional climate models, improved modelling and data analysis skills, and the sharing of experiences, particularly in terms of how knowledge developed through climate change and natural variability research can be used to benefit society.

Based on overall performance, climate projects were considered excellent in regional cooperation, data standardization[2] and exchange of scientific data, and cooperating with international GC networks and organizations. Projects were also considered good to excellent at improving scientific and technical capabilities and facilitating technology transfer, particularly in modelling technology. Science-policy interactions were generally rated poor, with some exceptions.

Second Phase Evaluation (2005-2010)
The evaluation concluded that APN-funded climate projects had very good overall success in terms of meeting the five goals stated in the APN Second Strategic Plan (2005-2010). Generally, the projects received above average ratings, although ratings of the individual projects varied in terms of effectiveness, impact and sustainability. The few projects rated as poor were either projects awarded seed grants to further develop a proposal but failed; or projects that did not meet their original objectives due to poor project implementation or collaboration.

For the most part, climate issues were addressed with excellent regional collaboration. Most projects were able to form strong regional networks of scientists. There were also genuine attempts to have policy- and decision-makers participate in mainstream climate-related activities; however, it was realized

2 Experts expressed the view that the APN can support this kind of work even if it does not do it itself. A number of targeted workshops turned data into something useful.

that more interactions are still necessary in this field. It is important to promote among policy-makers awareness of APN climate science activities and their potential value in policy-making.

The scientific and technical expertise was considerably increased through workshop and hands-on training. With some project initiatives, institutional units were formed and were able to sustain their functions after APN funding ended. Some projects communicated effectively at all levels, particularly at the grassroots level. Collaboration with other GC institutions facilitated projects to look at climate issues from a regional perspective and, at the same time, provided opportunities for scientists to communicate with their counterparts in the broader GC community; however, more interactions with the GC community are needed. The transfer of knowledge and methodologies were conducted well through training and workshops. Research infrastructure in the region is improving and some APN projects were able to help in establishing specific infrastructure.

Many of the research projects reviewed were policy-relevant, with successful and highly rated projects focusing on specific impacts on the environment and society. These projects identified relevant problems and proposed well-developed methodologies to achieve outcomes beneficial to either a scientific community or the public at large. The projects improved regional and national networking of scientists in specialized fields of research, which resulted in improved collaboration. The research outcomes resulted in better understanding of the impacts of climate change in the region and an increased awareness of these issues by policy-makers and resource managers. All projects were designed to meet the needs for scientific information relevant to regional issues.

The projects all had important policy considerations but the degree of science and policy interaction needs to be strengthened. Sustainability of project implementation (where sustainability was a project objective) also needs to be improved, particularly those with long-term support and not a one-time only activity. Projects classified under the "Crosscutting and Science-Policy Linkages" had the weakest ratings as it was difficult to assess outcomes when the criteria for determining success were not well defined. There is an increasing need to evaluate economic impacts; food, water and energy security; and financial consequences to facilitate science-policy interfacing. Without adequate metrics to determine a successful outcome, it is difficult to determine if a science-policy linkage has been made.

2.3. APN Evaluation: Highlights of Outstanding Projects

Nine of the fifty-six (56) projects were identified by the APN's first and second strategic phase evaluation teams (comprising independent reviewers, APN Scientific Planning Group [SPG] Members and the APN Steering Committee) as outstanding. Summaries and highlights of these projects are outlined here.

2.3.1. CSP01: Continuation of Regional Climate Modelling (RCM) Development

Regional climate modelling groups from throughout the region collaborated to compare their Regional Climate Models (RCMs) (*Figure 4*). This set the scene for comparing regional projections of future scenarios using these models, which was expected to provide vital information for policy-makers. Some of the science generated from this project fed into the IPCC Third Assessment Report (TAR). The evaluation of climate models from this project provided the scientific knowledge for decision-makers and other users in their appropriate settings to apply projected climate change information, as there are significant uncertainties in such projections. The project organized several workshops and an advanced workshop to build the scientific capacity to apply the climate models in developing countries. Several young scientists

Evaluation Results - Gaps: While a web-based platform of RCMs had been used by 13 countries and more than 30 scientists, which allowed them to access the RCMs; the website is no longer running. This is a common problem with other project-related websites that do not seem to be able to maintain websites long-term due to lack of funding, rapidly changing web-based systems, in-country regulations, lack of institutional memory, etc.

	China	Korea	Japan	China	Korea	Japan	
RIEMS	-2.59	-3.46	-3.36	0.51	2.29	1.37	RIEMS
CCAM	-1.25	-2.35	-1.52	-1.61	0.91	0.59	CCAM
DARLAM	1.40	-0.68	0.90	-0.04	1.29	0.76	DARLAM
SNU RCM	0.43	-4.03	-5.94	-2.93	-1.71	-3.76	SNU RCM
RegCM	-3.98	-7.57	-5.06	-1.02	-0.40	-0.44	RegCM
RegCM2a	-2.55	-3.96	-4.13	-3.53	-0.41	-0.89	RegCM2a
RegCM2b	-1.11	-5.90	-7.34	-2.31	-0.81	-0.28	RegCM2b
ALT MM5/LSM	0.11	-3.77	-3.85	-4.46	-2.96	-2.77	ALT MM5/LSM
MRI	0.82	4.76	5.06	-3.09	1.23	2.43	MRI
ENSEMBLE	-0.96	-2.99	-2.80	-2.05	0.01	-0.33	ENSEMBLE

>=6 5 4 3 2 1 0 -1 -2 -3 -4 -5 -6 <=-7

Figure 4: Model-simulated seasonal averaged temperature bias (°C) in 3 East Asia sub-regions for winter 1997 (left) and summer 1998 (right) [Source: Fu]

from the region also worked in the Temperate East Asia main centre (START node in the Asia-Pacific region) in using the RCMs for their research. This project was recognized as a model inter-comparison study at the international level by WCRP and IGBP.

2.3.2. CSP03: Asia-Pacific Workshops on Indicators and Indices for Monitoring Trends in Climate Extremes

This was a set of data analyses workshops in which participants from individual countries brought their own data and analyzed them for indicators and indices of trends in climate extremes. A series of papers were published enabling the IPCC to incorporate these results – which are of relevance to policy-makers and hazard managers – in its Fourth Assessment Report (AR4). Participants also brought the results to the attention of their own national policy-makers. The WMO used the series of workshops as a model for other regions and, since the APN's first phase evaluation (1999-2004), two other workshops were conducted in the Asia-Pacific region, one of which was considered outstanding in the APN's evaluation of its second strategic phase (see CSP20 below).

Figure 5: Hands-on data analysis in monitoring trends in climate extremes [Source: Manton]

APN has continued to demonstrate its commitment to addressing the most significant scientific and societal challenges associated with climate variability and change as well as the broader field of global change. I believe that their experience with early Pacific Island research and education projects (like the Training Institute: Project CSP09) helped APN see the need for/value of a targeted capacity-building programme like CAPaBLE and APN is to be applauded for this insight and leadership. I continue to be proud to be an APN Principal Investigator and look forward to a long, collaborative relationship.

2.3.3. CSP09: Training Institute on Climate and Society in the Asia-Pacific Region

The Training Institute on Climate and Society brought together participants from universities, research institutes, research institutions, NGOs, government agencies, and private sector enterprises from throughout the Asia-Pacific region. The training institute included presentations on several of the research projects supported by the APN and participants shared their experience on applying climate information for the benefit of society. Not only did the project significantly involve scientific capacity development of those who attended the Institute, but also made a substantial contribution to APN's third goal of strengthening interactions with scientists and policy-makers.

Perhaps one of the most important products of the Institute was the creation of a regional network of individuals actively engaged in the development and use of climate information to support economic development, community planning, resource management and practical decision-making in key sectors throughout the region. The Institute's specific focus on agriculture during the third week also provided an opportunity to expand regional awareness of and participation in the "Climate Prediction and Agriculture" project (CLIMAG), which APN considered as outstanding in its achievements during its second strategic phase evaluation; refer to CSP17 below.

Figure 6: Billboard highlighting an El Niño season and calling for water conservation [Source: Shea]

This project also contributed to the transfer of know-how and technology by providing participants with the latest scientific information on the nature and consequences of climate variability and change for the Asia-Pacific region as well as access to and familiarity with the use of state-of-the-art tools, techniques and technologies for climate forecasting and assessment. Through group sharing of individual experiences, participants and resource people developed a more detailed understanding of how climate affects the people, communities and resources of the region and how individual communities and governments are acting to address those challenges and opportunities.

2.3.4. CSP17: Applying Climate Information to Enhance the Resilience of Farming Systems Exposed to Climate Risk in South and Southeast Asia

APN stakeholders considered the project to have had major impact on the conduct of multi-disciplinary research, highlighting the importance of simulation modelling being the glue that connects several disciplines, thus providing a focus on outcomes relevant to end-users. (***Figure 7***) The project successfully addressed capacity development through staff training and the development of postgraduate scholarship opportunities. The science conducted was highly regarded and considered an excellent example of the value of international, inter-disciplinary research, as evident by the peer-reviewed publications arising from the project (***Appendix 3***). The project had tremendous positive impacts at the vulnerable grassroots level within the Asian region and established a network of scientists committed to providing useful climate information to stakeholders and end-users and building appropriate partnerships to reduce climatic risks. The commitment to having a consortium of partners to build and extend the existing pilot study areas is highly beneficial to farming systems. The fact that tools developed in this project are being used in decision-making in the community-level farming sector is testimony to the project's effectiveness, which has significantly impacted scientific capacity building to incorporate climate information in agricultural processes.

2.3.5. CSP20: Development and Application of Climate Extreme Indices and Indicators for Monitoring Trends in Climate Extreme Indices and Indicators for Monitoring Trends in Climate Extremes and their Socio-Economic Impacts in South Asian Countries

The project was able to associate eminent scientists as resource persons in addition to excellent regional collaboration. The preparation of indices and indicators on climatic extremes was prepared for the first time exclusively for the region of South Asia and, at the same time, the project captured the essence of all APN goals. The project on the development of climate extreme indices enhanced the capacity building of scientists in developing countries to the extent that they now have the expertise to do meaningful research in the field of climate extremes. They are now in a position to contribute to the IPCCAR5, which would include a Special Report on Extreme Events and Disasters: Managing the Risks.

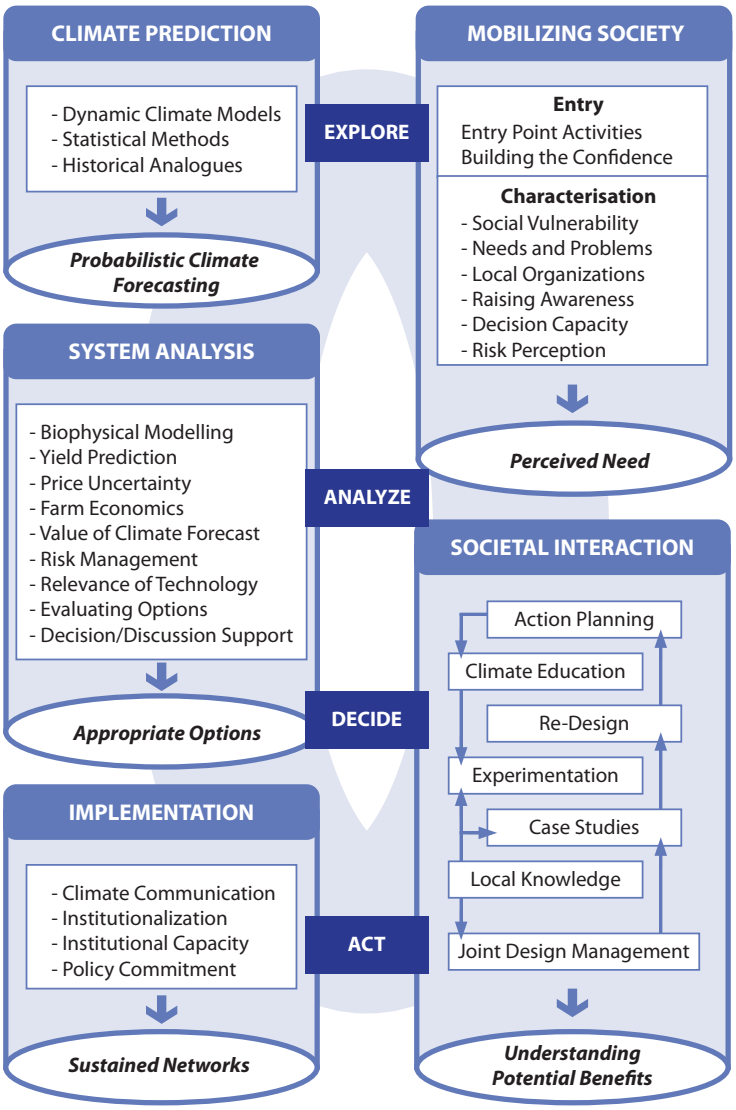


Figure 7: Framework showing the application of models and engagement of multiple stakeholders for climate forecasting in farming systems [Source: Meinke]

Policy-makers need appropriate adaptation measures to help minimize losses due to climate extremes. This project has generated new information on how climate extremes have changed in South Asia. The availability of this information to policy-makers will help them implement policy agendas in participating countries. The participating countries gained updated knowledge of software like *RClimDex* and *RHTest*, used them for analyzing daily meteorological data, and further developed expertise in working out trends in core climate extreme indices.

Rather than study event-based climate extremes, such as floods, droughts, severe cyclonic storms, tornadoes, etc., the project provided a capacity building component to study climate extremes in statistical terms such as cool nights, cool days, warm nights and warm days, which offers a meaningful picture of climate extremes in terms of their trends in a more understandable manner for decision-makers for determining appropriate adaptation measures across South Asia.

2.3.6. CSP37: Integrated Assessment Model for Developing Countries and Analysis of Mitigation Options and Sustainable Development Opportunities

The project was organized around three themes - i) development of national scenarios with a developing country perspective; ii) explicit recognition of developing country dynamics in the modelling, and iii) initiation of national modelling exercises and development of national databases in the three participating countries of China, India and Thailand.

The project provided an integrated modelling framework taking into account different aspects of climate change mitigation measures, policy changes and sustainable development. It also developed national databases of socio-economic data, demographic information and technological information as well as development scenarios in the context of national development plans and changes in GHG mitigation policies. Scientific capacity building was achieved by focusing on solutions rather than on tools and skills.

Project outcomes were interfaced with various international environmental assessments by project team members participating in the activities such as IPCCAR4, Global Environment Outlook 4 (GEO-4), Asia-Pacific Environment Innovation Strategy (APEIS), and Development and Climate project led by UNEP RISO Centre on Energy, Climate and Sustainable Development. A significant number and variety of materials (***Figure 8***) were produced from this project and papers from the project activities were cited in the IPCCAR4.

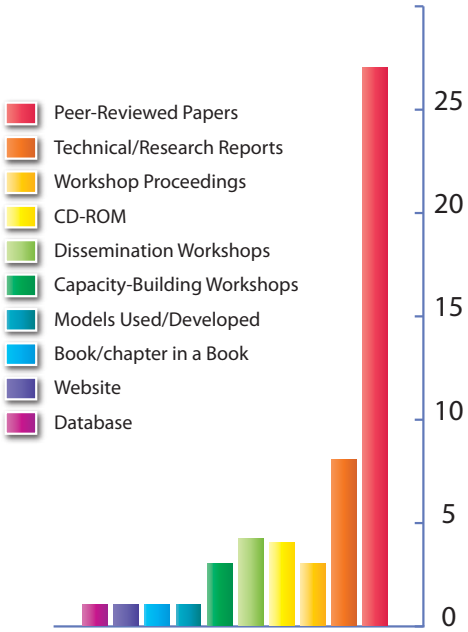


Figure 8: Outputs of CSP37 on Integrated Assessment Modelling [Source: APN Secretariat]

2.3.7. CSP51: Capacity Development for Greenhouse Gas (GHG) Inventory Development in Asia-Pacific Developing Countries

This project was considered a great success because it focused on a topic of importance to all of the Asia-Pacific region; resulted in *in situ* data for the region being collected and made available; led to the development of equipment and procedures that can be readily used in the region; involved strong developed country support and developing country interest and commitment and has the impetus for further related activities. In terms of key strengths, this project succeeded in the transfer and testing of portable field equipment in the developing countries involved, ultimately leading to the compilation of follow-up projects from within the developing countries. The availability of real data as opposed to international norms was one of the keys to success, as was the transfer of easy-to-use technology for determining CH_4 and CO_2 concentrations in rice paddies and the potential this creates for use in other developing countries. The creation of a GHG inventory that has real relevance to a country as opposed to the adoption of international norms provided key traction for policy development. In all, the expanded capabilities and experiences of young scientists will hopefully lead to greater benefits for the region.

2.3.8. CSP52: Greenhouse Gas (GHG) and Aerosol Emissions under Different Vegetation Land Use in the Mekong River Basin Sub-region

The project aimed to develop the capacity of scientists working in the Mekong River Basin to develop appropriate technology in GHGs and aerosols inventory and to provide scientifically sound decision support information to policy-makers to improve regional air quality. The project helped to provide technical skills and knowledge related to the estimation of GHG emissions from biogenic sources and aerosol emissions from biomass burning through onsite training in Cambodia and a hands-on-training workshop in Thailand. The project involved scientists from Lao PDR, Cambodia, Myanmar and Thailand, which enhanced interaction and regional cooperation to some extent. The main outcome was the transfer of science and technology to participating scientists. The project is a good start in terms of regional cooperation among scientists and policy-makers involved in the preparation of UNFCCC national communications. The project produced some excellent results regarding the extent and impact of biomass burning and standards for assessments were established. However, it is not currently clear

how future applications of the products will help change policy. Cooperation among the scientists was key to the success of this project.

2.3.9. CSP56: Water Resources in South Asia: An Assessment of Climate Change - Associated Vulnerabilities and Coping Mechanisms

Among the regions of the world, South Asia is one of the most sensitive to changes in climate. This region depends very heavily on the precipitation from the Asia regional monsoon as well as water derived from the snow and glacier melt in the Himalayas, also known as the Water Tower of Asia; both of which are affected by climate change. This three-year project focused on the following activities: i) Analyzing recent experience in climate variability and extreme hydrological events, and their impacts on regional water resources; ii) Assessing the impacts of projected climate change and variability and associated extreme hydrological events, and socio-economic changes on the water resources of Pakistan, India, Nepal, and Bangladesh; iii) Determining the vulnerability of regional water resources to climate change, identifying key risks to each sub-region and prioritizing adaptation responses; iv) Evaluating the efficacy of various adaptation strategies or coping mechanisms that may reduce vulnerability of the regional water resources; and v) Providing input to relevant national and regional long-term development strategies.

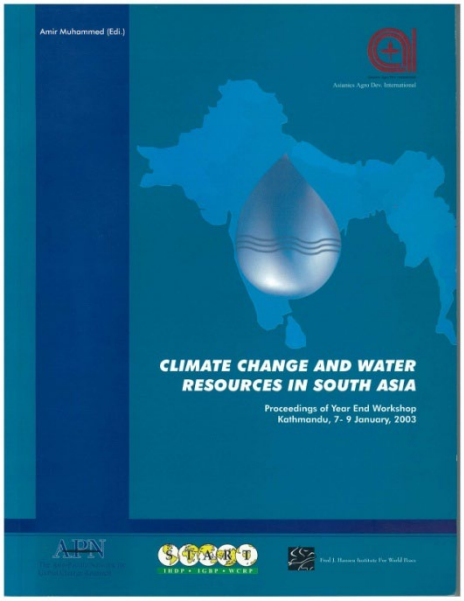


Figure 9: Publication from CSP56 on climate change and water resources in South Asia [Source: Muhammed]

The project brought together scientists from several disciplines, including meteorology, climate science, hydrology, economics and agriculture. Policy-makers demonstrated keen interest in the project because of its importance in planning the harnessing of future water resources in light of anticipated climate change. Use of multi-media techniques developed as a part of the project activities to disseminate the improved technology especially to illiterate farmers was expected to prove effective. Finally, for the flood prone regions, the project analyzed the incidence of past floods and trends for the future and discussed mitigation measures in order to forewarn threatened populations about the incidence of flood so they could prepare to minimize any damage.

2.4. CAPaBLE Phase One Evaluation: Highlights

An independent evaluation that looked at the outputs of CAPaBLE activities conducted in the first phase of the CAPaBLE programme, which ran from April 2003 to March 2006, provided excellent results and ultimately led to the CAPaBLE programme becoming an integrated pillar for capacity development within the APN framework. During this first phase, eighteen (18) projects were completed at community, local, national and regional levels.

Key messages from the evaluation, which are highlighted in the "CAPaBLE Phase I In Review – Climate Change" publication (***Figure 10***) was the success of the CAPaBLE programme, particularly in developing the capacity of individuals and institutions in significant areas:

- Developed research infrastructure and transfered expertise and technology through the provision of equipment and user knowledge, transferring and sharing of data, provision of information and methodologies to researchers and institutions.
- Strengthened regional collaboration for climate change research and development.
- Developed and enhanced scientific and technical capabilities of researchers.

- » Developed new and enhanced awareness of policy-makers and civil society on climate change issues.
- » Achieved success in science-policy interactions particularly in areas where they had previously been lacking.
- » Achieved success in development and better use of climate change tools for decision-making processes.
- » Provided unique and timely outputs that can be incorporated into future work on climate change.

Four of the eighteen projects were rated excellent – CSP26, CSP34, CSP36 and CSP37 (details of CSP37 are outlined in ***Section 2.3.5***). Brief highlights of the other three projects are provided in the following sections.

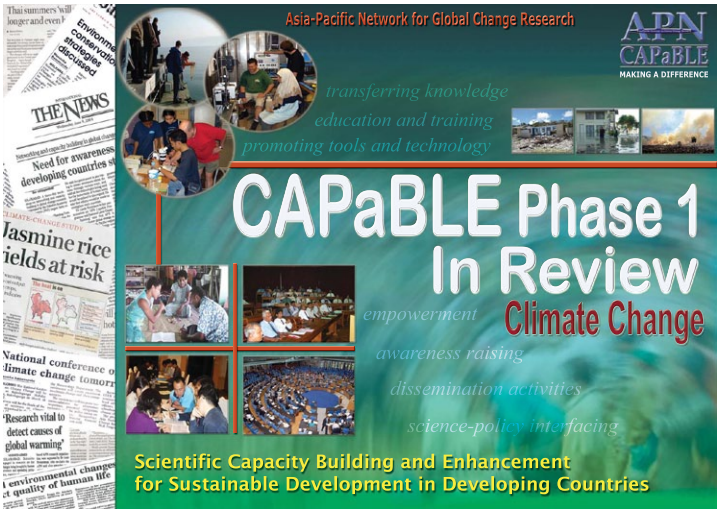


Figure 10: CAPaBLE Phase 1 In Review – Climate Change [Source: APN Secretariat]

2.4.1. CSP26: Training Institute on Climate and Extreme Events in the Pacific

The Climate and Extreme Events Training Institute was held in the Pacific in Fiji (2004), Samoa (2005), and Kiribati (2006). The institute addressed the need to create a regional network of scientists, decision-makers and institutions skilled in the use of climate information and services to support practical decision-making in key sectors such as agriculture, water resource management, public health and safety, tourism and community planning, and resource development within the Pacific Island Countries region.

Key impacts:

(1) The 70 participants trained are able to contribute to:
- » National local awareness building and climate planning and adaptation activities as part of National Adaptation Programme of Action (NAPA)
- » Regional climate projects such as Pacific Adaptation to Climate Change (PACC)
- » General sustainable development initiatives

(2) There is anecdotal evidence that trained personnel are using their skills in professional activities for mainstreaming climate to support policy formulation.

2.4.2. CSP34: APN Scoping Workshops on Global Earth Observation System of Systems (GEOSS) & the Capacity Building Needs of the Region: Focus Climate

The aim of the scoping workshops was to identify capacity building needs for research in global earth observations and climate change and its impacts; identify the role of the APN in such research; and underpin systematic observations and create road maps for designing ideas appropriate for capacity

building activities. Key impacts were determined for those vulnerable sectors identified as food and fibre; biodiversity; water resources; coastal ecosystems; human health and settlements; and land degradation.

Key impacts:

(1) The workshops identified the main constraints in the Asia-Pacific region, particularly for developing countries, which included:
- » Lack of observational data (meteorological, oceanographic, socio-economic, etc.);
- » Inaccessibility to existing data;
- » Scarcity of experienced scientists and lack of adequate scientific infrastructure; and
- » Lack of familiarity with relevant methods and models.

Figure 11: Participants of the GEO Scoping Workshops [Source: APN Secretariat]

(2) The workshops identified the overarching capacity needs of developing countries:
- » Continuous training and capacity development to advance efforts towards comprehensive and sustained understanding of the Earth's processes;
- » Research on climate modelling and socio-economic impacts and adaptation;
- » Collection, rescue and analysis of historical data; and
- » Linking earth observations and climate modelling.

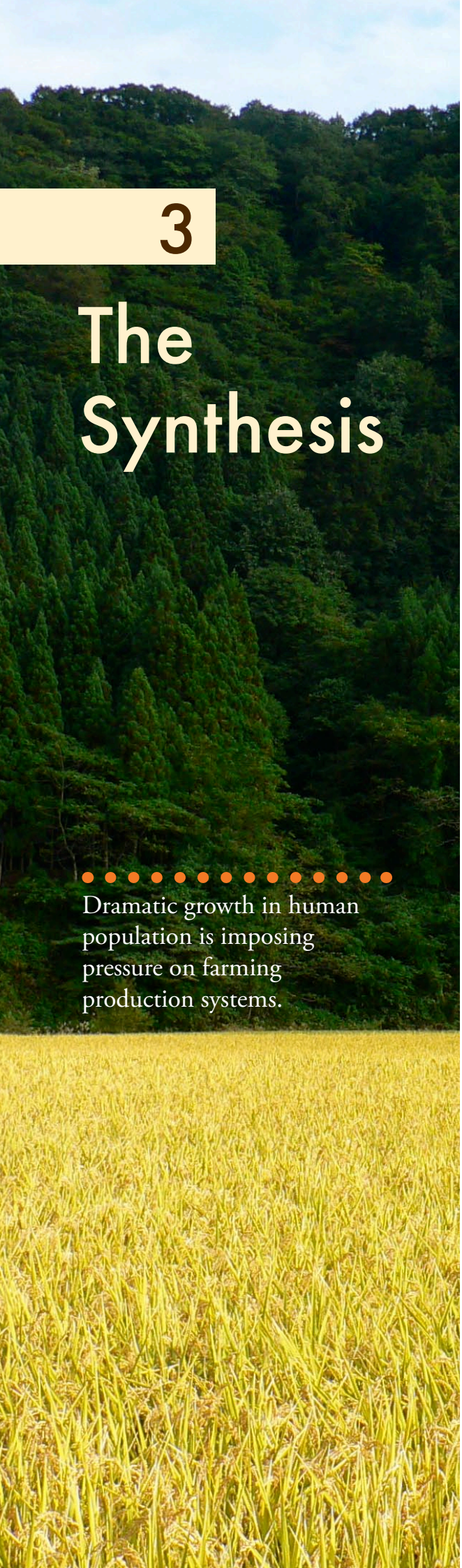
2.4.3. CSP36: Enhancement of National Capacities in the Application of Simulation Models for the Assessment of Climate Change and its Impacts on Water Resources and Food & Agricultural Production

This 3-year project conducted underpinning scientific research on regional climate change modelling in manifestations of temperature & precipitation changes, monsoon variability, floods, droughts and other extreme events; water and food security and melting of glaciers in three countries of Bangladesh, Nepal and Pakistan. In addition, extensive capacity building training workshops were conducted using various RCMs, Watershed Simulation Models and Crop Simulation Models.

The enhanced capacity was effectively utilized to varying extents to pursue envisaged research on:

- » Implementation, validation and calibration of a variety of RCMs, WSMs and CSMs;
- » Development of coarse and fine resolution climate change scenarios;
- » Assessment of the impacts of expected climate change on annual and seasonal flows of main rivers and on the yields of major crops in different agro-climatic zones; and
- » Identification and evaluation of appropriate adaptation measures and coping mechanisms to counter the negative impacts of climate change.

The project outcomes were much appreciated by the heads of the Planning Commissions in Nepal and Pakistan, who emphasized that this type of research is highly relevant to the countries of South Asia whose water and food security are at great risk due to global climate change. Furthermore, there were notable changes in government and bureaucracy attitudes towards climate change issues. The project team have stipulated that governments are now much more attune to issues of climate change and are seeking further information as to its impacts and clarifying their vulnerabilities.



3 The Synthesis

Dramatic growth in human population is imposing pressure on farming production systems.

3.1. Food, Agriculture and Climate

3.1.1. Seasonal to inter-annual climate variability

3.1.1.1 Issues and significance

Farmers and farming communities throughout the world have survived and developed in most cases by mastering the ability to adapt to widely varying weather and climatic conditions. However, the dramatic growth in human population is imposing enormous pressure on existing farming production systems. In addition, farmers are expected to manage the ever more difficult effects of long-term climate change that may now be occurring at an unprecedented rate. Increased productivity can be associated with increased economic and environmental risk as farming systems become more vulnerable to weather and climate. More targeted climate information can increase preparedness and lead to better economic, social and environmental outcomes for farmers.

3.1.1.2 Scope of the activities

Important issues for APN support were activities that used climate information to improve food production. In this regard, the first stage of the present synthesis of activities under Food, Agriculture and Climate was to perform a "stock take" of the tools involved, including implementing crop/climate models to enhance the operational use of seasonal climate prediction in target APN countries. Issues also included the effective communication of these climate prediction tools for farmers and farming communities by climate and agricultural experts.

APN supported activities that established a network of teams with the capacity to apply agricultural systems analysis to evaluate options for managing climatic risk. Projects building from this documented the benefits delivered from mainstreaming climate information to agricultural decision-making, with the building of a large-scale system of support for the operational use of seasonal climate information for target countries India, Pakistan and Indonesia. Project CSP17 produced twelve (12) peer reviewed publications (***Appendix 3***), the most notable one entitled, "**Actionable climate knowledge – from analysis to synthesis**." This also included the development of environmentally friendly strategies for agricultural pest management, with papers published in the book "**Weather and climate risks in agriculture**" from CSP24. Further workshops used this research to promote the use of climate prediction tools for farmers and farming communities.

An international workshop on "Content, Communication and Use of Weather and Climate Products and Services for Sustainable Agriculture (CSP55)" was held, which evaluated climate products that can be used by farmers and farming communities. This workshop placed special emphasis on the communication of products to farmers and the development of new products to enhance interaction between climate services, farmers and farming communities. The workshop developed new methods, including interfacing climate tools via web-based technologies to farming communities, which were trialled in the Cook Islands at www.climatecookislands.com.

An APN workshop developed new methods to communicate climate information from climate and agricultural experts to farmers in the Pacific Islands.

3.1.1.3 Outcomes

Results

For agricultural management decisions, seasonal climate information and prediction offer a means for farmers to manage increasing climate variability. Currently, the skill of dynamical seasonal climate forecasting is improving. Reasonable seasonal predictions are now available from statistical and dynamic downscaling of GCMs over South Asia. Prediction skill is greatest when El Niño and La Niña events are occurring. Near-global analysis has demonstrated that the Madden-Julian Oscillation (MJO), a large-scale, tropical atmospheric anomaly that originates in the Indian Ocean and moves eastwards at intervals of 30–60 days, is a significant phenomenon that influences daily rainfall patterns even at higher latitudes. This also influences the onset and breakdown of the Asian-Australian monsoon system and is very useful in these longitudes. The ability to combine MJO forecasts improves tactical climate risk management. Work remains on improving dynamical forecasting of the Indian summer monsoon although good progress is being made.

APN built an international multi-disciplinary network of scientists providing "actionable climate knowledge" to farming groups in parts of South and Southeast Asia.

GCM outputs are too coarse in resolution for application to crop decision-making and therefore must be downscaled for use at the field decision-making level. Downscaling can be achieved by statistical or dynamical modelling. These techniques are being used in India, Pakistan and Indonesia to provide improved climate predictions and hence a better understanding of climate impacts.

Field experiments and data analyses have established important functional relationships for disease risk and climate for late "leaf spot" in peanut, "Sclerotinia rot" and "Alternaria blight" in canola and mustard. This has enabled the validation of the *Cropgro* and *Infocrop* climate and disease models for these crops in Bangladesh and Cambodia.

By using systems analysis and modelling, the best response to climate forecasts can be uncovered. This has been achieved for Tamil Nadu in India for groundnut, horsegram, sorghum and cotton; for pigeonpea and groundnut in the Pavagada region of India; drought costing in Bandung, Indonesia; on farm trials and wheat simulation in Pakistan; and whole farm optimization for Tamil Nadu. Examination of the value of climate forecasts in Tamil Nadu showed that the value of forecasts in smallholder systems depends on the prediction skill, Southern Oscillation Index phase, and types of decisions and their responsiveness to climate forecasts. Though the forecast skill for the summer monsoon is moderate, the value is greater for groundnut and cotton management. The winter monsoon rainfall forecasts are more skilful but have low value for sorghum management. The economic value of a forecast was found to be very sensitive to the response action; for example, modifying the groundnut planted could be ten times more valuable than modifying the amount of fertilizer applied to groundnuts.

From these approaches, it is necessary to establish a network of research teams for capacity building in the application of agricultural systems analysis to evaluate options for managing climate risk. This

has been established for Pakistan, India and Indonesia. Crop simulation modelling has been found to be essential as the bond that connects several disciplines providing a focus on outcomes and products useful to farmers and farming communities.

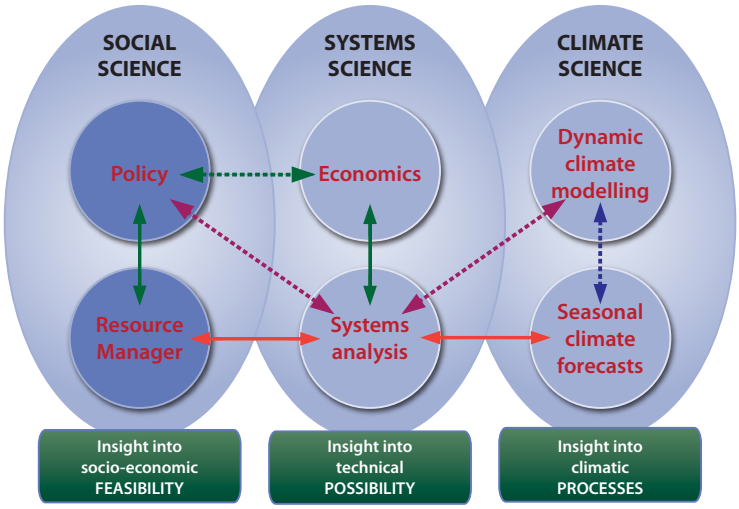


Figure 12: Disciplines, relationships and linkages for effective delivery of climate information for decision-making. Operational links are indicated by the solid arrows; dashed arrows indicate where an operational connection is still weak or does not exist [Source: Meinke]

By these and other means, a multi-national network of scientists working in different disciplines, has been established for the creation of useful climate knowledge by building partnerships with farmers and farming communities. This process is depicted in ***Figure 12***.

Considerable advances have been made in the past decade in the development of the collective understanding of climate variability and its prediction in relation to the agricultural sector and scientific capacity in this field. More sophisticated and effective climate prediction procedures are now emerging rapidly and finding increasingly greater use. By using crop simulation models in a decision systems framework, alternative decisions are being generated, but there is a clear need to further refine and promote the adoption of current climate prediction tools. Equally, it is important to identify impediments to the further use and adoption of current prediction products.

A comprehensive profiling of the user community in collaboration with social scientists and regular dialogue with users will assist in identifying opportunities for agricultural applications. Active collaboration between climate forecasters, agrometeorologists, agricultural research, and extension agencies in developing appropriate products for farming communities is essential.

Communication of climate information is an essential part of the process. Despite advances made in improving climate forecasts, the application of these products at the farm level has not been "up to the mark" because of the lack of effective contact between climate information and farming communities.

Capacity Building

The activities funded by the APN have created an international, multi-disciplinary network of scientists who support the mainstreaming of climate information to farmers in India, Pakistan and Indonesia. The work has improved the understanding of climate variability impacts and related vulnerabilities on farming communities. It has also provided a consortium of partners for extension and further pilot studies. Crop/climate and crop/disease models have been developed and enhanced.

Assessments have been made and published on the applications of seasonal to inter-annual climate variability to agricultural production. Capacity building has also occurred among scientists from developing and developed countries. Improvement in communication between climate and agricultural experts and a farming community occurred on a small island state.

3.1.1.4 Conclusions

The first decade of 2000 has shown great improvement in the skill and resolution of seasonal to inter-annual climate forecasts. In addition, there has been improvement in communicating climate information to farmers and farming communities. Farmers collectively have some knowledge of climate,

water and crop management. Assistance for farming communities, business and policy-makers to better cope with climate-related risks is improved by synthesizing information across disciplines to include end-users in the process. This includes control of climate-sensitive crop diseases. Climate information is valuable to farmers because agriculture is very climate sensitive. However, there needs to be greater interaction between the farming community and the national meteorological services in the communication of this information.

Changes in the frequency of climate extremes because of climate change will significantly impact agricultural production in those communities with the least resources and infrastructure to cope.

3.1.1.5 Recommendations

- Seasonal to inter-annual forecasts are critical to agricultural risk management. Further work is needed to improve the skill of forecasts and associated downscaling, so that better risk management decision-making can occur at the whole farm level.
- Identification of critical areas where agricultural production is sensitive and vulnerable to climate requires close monitoring of climate.
- Targeted climate synthesis and integration into applied risk management are required at the farm level. This requires new institutional arrangements and multidisciplinary partnerships especially between National Meteorological and Hydrological Services (NMHSs), ministries of agriculture and the whole farm level.
- The increasing frequency and severity of floods, droughts and extreme temperatures requires use of appropriate indices to improve monitoring and prediction of these extreme events.
- Formation of farmer groups and associations are needed to improve the dissemination of collective knowledge of farming communities on climate and crop management.
- Mainstreaming climate information to farmers is required from experts in meteorological services and agricultural ministries through improved communication via various media. This requires close collaboration with media organizations.

3.1.2. Long-term change

3.1.2.1 Issues and significance

Climate scenarios during the 21st century for the Asia-Pacific region indicate a drying of the subtropics, a more vigorous monsoon season, but with increases in extreme events such as high intensity rainfall, drought and heatwaves. During the past four decades, climate extremes such as droughts, floods, storms, tropical cyclones, heatwaves and wildland fires and windstorms have caused major losses in the agricultural sector. Communities that are most exposed to these risks are those with limited access to technological resources and with limited development of infrastructure. One of the most important strategies is the improved use of climate knowledge and climate risk technologies. Both structural and non-structural measures can be used to reduce the impacts of the variability (including extremes) of climate resources on crop production. Planning, early warning and well-prepared response strategies are the major tools for mitigating losses due to climate change. Hence, climate variability and climate change are considered in evaluating all environmental risk factors and coping decisions.

Currently, many opportunities exist that can assist in coping effectively with agrometeorological risks and uncertainties to long-term change. One of the most important strategies is the improved use of climate knowledge and technology, which includes the development of monitoring and response mechanisms to current climate. By providing new, quantitative information about the environment within which farmers operate or about the likely outcome of alternative or relief management options, uncertainties in crop productivity can be reduced. Quantification is essential and computer simulations can assist such information and may be particularly useful to quantitatively compare alternative management and relief options in areas where seasonal climatic variability is high and/or prone to

extremes. One of the most important strategies to cope with risks for long-term change for agriculture and fisheries includes the development of climate knowledge and technology for future climate change.

3.1.2.2 Scope of the activities

For fisheries, APN held two workshops: one to examine the consequences of climate-induced changes on pelagic fisheries in East Asia and the other to model the annual to inter-decadal variability of sardine and anchovy populations.

APN produced the first major assessment of climate change and its impacts on water resources and agricultural production for South Asia.

For rice and wheat production in South Asia, field visits by researchers to villages in the Indo-Gangetic Plain (IGP) have improved their understanding of climate change and water issues. APN also held a workshop of experts on rice pests, which established a regional network of scientists throughout South Asia for projecting pest damage impacts of climate change.

APN supported two major activities on climate change and its effects on water resources and food production in South Asia. CSP36 organized four regional capacity-building workshops for the training and application of RCMs with crop simulation models then two workshops to consider the model output for climate change. This was followed by research on the assessment of various climate trends in Bangladesh, Nepal and Pakistan over the past five decades; projections of climate in these areas to 2100 at high resolution; assessment of 21st century climate trends on yields of wheat, rice and maize in the three countries; as well as evaluating the impacts of climate change on annual and seasonal flows of three main rivers. The monograph "**Climate change: global and OIC perspective**" and many other publications were produced from this project (***Appendix 3***).

The work was preceded with the assessment of adaptation and coping mechanisms to cope with negative impacts of climate change on agriculture and water resources (CSP56). The regional activities, which included India, prepared regional maps of climate change risk to water and agricultural resources. These results were presented to end-users so that vulnerabilities and coping mechanisms could be assessed. A major publication "**Climate and water resources in South Asia**" was prepared from these activities.

APN supported international workshops to reduce vulnerability and devise coping strategies for agricultural impacts due to climate variability and change.

Two international workshops were held on reducing the vulnerability of agriculture and forestry to climate variability and change, and devising coping strategies. These reviewed the latest assessments of climate variability and change and likely impacts, and considered a range of adaptation options. The second workshop built on the first by considering coping strategies of which crop risk insurance was one main option. These workshops provided capacity building for scientists from developing countries with scientists from developed countries. From CSP13 the book "**Increasing climate variability and change: Reducing the vulnerability of agriculture and forestry**" was published.

One method of promoting climate change adaptation is to mainstream it in national sustainable development policies and programmes. This is founded on the notion that climate adaptation and sustainable development share common goals and determinants. APN supported a study in the Philippines, Indonesia and Viet Nam to assess how climate adaptation can be integrated into national plans and programmes especially in agriculture and water resource management.

3.1.2.3 Outcomes

Fisheries

Small pelagic fisheries such as sardine, anchovy, herring and mackerel constitute a large portion of the fisheries catch off the coasts of East Asia. Zooplankton biomass for the period 1965–1998 increased after the late 1980s corresponding to a warm regime of ocean climate. During the 1990s fish catches in the Chinese pelagic fisheries increased reaching the highest production in 1998, while many stocks showed low recruitment off Southwest Japan. The proportion of small pelagic fish increased off southern Korea during the 1980s. The multidecadal changes in stocks such as anchovy and mackerel in the Pacific showed a 55–65 year variability relating to climate indices such as the Pacific Decadal Oscillation (PDO). Further work on anchovy and sardine catch off California, Japan, Chile-Peru and in the Benguela region shows multidecadal variations with large changes in the mid-1940s and the mid-1970s when PDO phase changes occurred.

Agriculture and water resources

Rice and wheat production in the IGP is very important for food security in South Asia. Crop models, which are geo-referenced, are required to investigate management strategies to cope with climate change. An assessment of water resources and climate change in South Asia showed that air temperatures increased in all countries in the latter half of the 20th century. Pre-monsoon rainfall increased in northern Bangladesh, with increases also apparent in the southwest, and decreases in the southeast. No trends were observed in Nepal, but in Pakistan, rainfall was more extreme for both wet and dry anomalies. There were no changes in the All-India rainfall statistics. The Indus River simulations showed declining flows (***Figure 13***) but for the Ganges and Brahmaputra no trends were detected in runoff. The eastern parts of South Asia, especially Bangladesh, Nepal and parts of India are flood-prone.

Recent analysis suggests that the frequency of devastating floods in Bangladesh is on the increase, with four of the most severe occurring in the past 30 years. In northeast India, where the Brahmaputra drains, there has been significant erosion with problems owing to overbank spillage, drainage congestion, bank erosion and landslides. In the western region of India and adjacent Pakistan, rainfall is very erratic leading to extremely arid conditions interspersed with >90% of the annual mean rainfall in a single month causing devastating short-duration floods. For the Indus river system because of extensive deforestation in the Himalayas, this has led to major floods in Pakistan with seven of the ten worst floods in the last 100 years occurring in the last 25 years. These floods were caused by unprecedented melting of snow on glaciers due to an increase in temperatures. Five glacial lake outburst floods (GLOFs) occurred in Nepal over the period 1977–1998. Devastating droughts are common in Pakistan and northwestern India. The most severe drought occurred in Pakistan from 1998–2002, where surface water availability was reduced by 30%. In India, about one third of the country is drought prone. There are approximately 20 droughts per century.

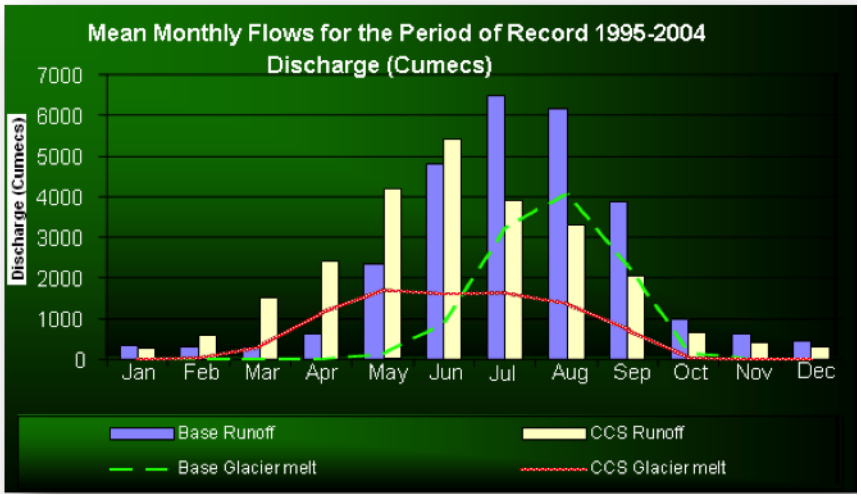


Figure 13: Simulated mean monthly flows of the Indus River under the baseline (1995-2004) conditions and under the influence of a hypothetical climate change scenario (CCS) [Source: Khan]

The impacts of floods and droughts are dramatic on agriculture in South Asia. Floods in South Asia have resulted in crop losses with the 1974 Bangladesh flood severely damaging the Aman crop, and the 1993 Nepal flood reducing agricultural production by 12%. The 2000–2001 drought in the Sindh and Balochistam provinces of Pakistan reduced overall agricultural production by 3%. Nine droughts in the pre-monsoon season in Bangladesh have occurred since 1951 affecting about half the country.

For water resources, the melting of mountain glaciers in the Himalayas is having several effects. More water will be supplied to glacier dependent perennial rivers. But this is likely to increase the chances of GLOFs; Nepal has 2315 glacial lakes and 26 are considered dangerous. On longer timescales, dry season flow in the upstream reaches will be greatly reduced. North Pakistan agriculture is becoming increasingly dependent on ground water irrigation. Prolonged drought and high temperatures between 1990 and 2000 significantly reduced recharge to the aquifer.

GCM-based coarse resolution climate scenarios show that increases in temperature on an annual as well as seasonal basis are comparable for Nepal and Pakistan, but lower for Bangladesh, and higher in winter than in summer (***Table 2***). There are clear indications of precipitation increases in summer, but decreases in winter. The impacts of these on agriculture and water resources have been investigated using crop/climate and watershed models. CERES-Wheat model simulations for Pakistan show that the growing season length decreases throughout the country with increases in mean temperature.

Precipitation Change (%), A2 Scenario			
	Pakistan	Nepal	Bangladesh
2020s			
Annual	2.79 ± 2.94	-3.60 ± 3.08	-1.02 ± 1.09
Summer	5.31 ± 4.13	-0.76 ± 4.07	-0.31 ± 1.15
Winter	-16.2 ± 2.84	-11.74 ± 2.69	-11.32 ± 4.17
2050s			
Annual	5.53 ± 4.63	1.81 ± 4.76	2.72 ± 1.79
Summer	12.55 ± 7.13	5.88 ± 6.67	3.09 ± 1.63
Winter	-1.62 ± 3.56	-10.93 ± 3.63	-9.58 ± 8.05
2080s			
Annual	3.48 ± 5.78	6.22 ± 6.56	8.39 ± 2.15
Summer	12.16 ± 8.91	14.98 ± 9.74	10.02 ± 1.48
Winter	-5.12 ± 4.78	-17.58 ± 2.53	-11.55 ± 6.46

Table 2: Projected changes in annual and seasonal prediction (%) in 2020s, 2050s and 2080s over Pakistan, Nepal and Bangladesh for A2 Scenario, based on 13-GCM Ensemble [Source: Khan]

Yield increases in Pakistan until about 4°C above the baseline then decreases. This reveals that yields will decrease in the order of 5% for IPCC-SRES A2 and B2 scenarios by the 2080s. Similar results for Pakistan occur using the CERES-Rice model, which reveals rice crop yields will decrease by 15 to 18% by the 2080s.

For Nepal, model-based studies show that a 4°C increase in mean temperature has positive impacts on all crops, except maize, where a 2°C increase results in decreases in yield in the mountain zone. Unfortunately, the impacts on water resources of climate model output could not be assessed because the watershed models could not be satisfactorily validated or had very demanding data input requirements, which were not available.

Perceptions of risk were carried out in Pakistan, India and Nepal. In Pakistan respondents observed that the intensity of drought had increased compared with the past, and in India the drier areas anticipate

drought where recovery usually takes 2 to 3 years. Drought causes hardship leading to migration. For Nepal, rainfall extremes were perceived as the main cause of floods. The 1993 event was the largest since 1954. The rise in river flows in Bangladesh was perceived as the major cause of floods, with the intensity and duration on the rise. Current coping strategies for drought in India and Pakistan include borrowing money, migration for alternative livelihoods and destocking. Flood coping strategies include migration, stock protection and crop insurance.

Reducing vulnerability

Changes in temperature have reduced the number of frost days and increased the length of the growing season. Land cover changes and other changes have led to changes in rainfall patterns and extremes. However, it should also be mentioned that the role of land-use change in modifying rainfall is often over-stated. These all increase the risk to long-term change. As well as seasonal to inter-annual forecasting, the development of multi-year climate forecasting will be an important tool. Old (radio) and new (internet and SMS) communication strategies when adapted to local applications assist the dissemination of useful information to farming communities. However, developed countries have the technology to adapt more readily. In many developing countries, agriculture is marginal and the ability to adapt in the tropics and subtropics and countries in transition will be difficult. Traditional knowledge, indigenous technologies and local innovations can also be used to improve farming systems.

Coping strategies include the use of seasonal climate forecasts to assist in alleviation of food shortages and to cope with drought and desertification; and the use of integrated agricultural management systems incorporating climate-forecasting systems together with crop simulation models. Improvements can be made in water-use efficiencies through surface irrigation, reduction in excessive groundwater utilization and increased efficiency in the rainfed areas, and crop diversification. Local indigenous knowledge provides coping mechanisms for change, as well as improved cultural and farming practices and crop diversification. Crop insurance spreads the risk for adverse periods of climate.

3.1.2.4 Linking climate change adaptation to sustainable development

APN-supported research has shown that current national plans and programmes do not adequately reflect a concern for climate adaptation. There is, however, strong perception that climate adaptation should be mainstreamed into national plans and programmes including agriculture and water resources. Options for doing this have been demonstrated in the Philippines, Indonesia and Viet Nam. For example, the critical role of Local Government Units (LGUs) in promoting climate change adaptation at the ground level in the Philippines has been shown. Neglecting climate risks could also imperil attainment of the Millennium Development targets on eradicating poverty as has been shown on the potential impacts of climate change on rice production in Indonesia and in agriculture in the Mekong delta in Viet Nam. Clearly, more intense efforts to link climate adaptation to development planning are needed.

APN supported a regional study on how climate change adaptation can be linked to sustainable development in Southeast Asia.

3.1.2.5 Conclusions

Small pelagic fishery stocks of anchovy and sardines in East Asia are related to multidecadal changes in ocean climate. These data sets have been used to model climate change effects on marine ecosystems to quantify the effects on fish growth and production of anchovy and sardines.

For wheat and rice crops in South Asia field research and crop simulation modelling improvements are needed for climate change research. Much better data are required to model rice pests. Simulation models of climate change have been used to assess impacts on agricultural production and water resources in Pakistan, Nepal and Bangladesh. Ultimately, with increased warming crop production decreases. However, because watershed modelling is complex, it has not been possible to simulate river flows in different watersheds.

Analyses reveal that the climate of three Indian subcontinents has been changing with increases in temperature and increasing rainfall variability in the eastern Himalayan region, and decreasing rainfall in the western Himalayas (Pakistan and Northwest India). As much of the food production is subsistence, these regions are more susceptible to climate extremes with change. Floods and droughts are common. Drought management through irrigation is only possible if enough water is available, particularly during the dry season. Dealing with floods is more complex as the existing levee banks on roads do not have adequate drainage infrastructure, with the channels of the major rivers, and their tributaries, heavily silted up. The intensity and duration of floods and droughts is on the increase recently and efforts need to be made for adaptation strategies and coping mechanisms.

APN work has developed approaches to characterize and manage risk, which includes risk scoping, risk characterization and evaluation, risk management and monitoring and review. This leads to preparedness planning with risk assessments, utilizing early warning systems so that vulnerability to society can greatly lessen climate risks to society and communities. With effective risk management, management and policy changes between climate hazard events are used so that the risk associated with the next event is reduced. This is through the implementation of well-formulated policies, plans and mitigation actions that are being utilized by farmers and others.

Farmers have a combination of strategies and tools for managing the risks they face. Approaches include taking action to reduce the likelihood of the risk event occurring, avoiding the risk, redistributing the risk and reducing the consequences. Actions can consist of enterprise diversification, contract hedging, having financial liquidity, use of crop yield insurance, crop revenue insurance and household off-farm employment or investment. Latterly weather derivatives and weather index insurance play a role in developing agricultural risk management strategies. However, there are requirements for the management of these risks by farmers and communities.

There has to be awareness that weather and climate extremes, their variability and climate change will impact farm operations. This requires an understanding of climate processes, including the causes of climate variability and change, which can operate over large spatial scales. Part of this requires a good knowledge of climate variability and extremes in the location of farm operations, and analytical tools to describe these. Forecasting tools and early access to early warning and forecast conditions on the multiseasonal timescale gives advance advice on the likelihood of extreme events and climate anomalies. However, the farmer must have the ability to apply these forecasts and warnings in the decision-making process. There is a range of risk coping strategies that can be utilized.

3.1.2.6 Recommendations

- Much work is required to link field data with climate conditions in South Asia so that crop simulation and disease simulation models can be refined and validated.
- Recent improvements in crop model simulations should be extended to all important crops in South Asia so as to better define the impacts of climate change.
- Watershed and water management models need to be used in conjunction with crop simulation models so use of available water under changing climate can be optimized for food production.
- The use of advanced remote sensing and GIS techniques should be further encouraged so as to provide ongoing monitoring of snow and water cover and temporal changes in the major glaciers of the Hindukush-Karakoram-Himalaya region, which feeds South Asia's major rivers, together with an emphasis on the forecasting of extreme events, especially floods and droughts, and the dynamics of the Himalayan glaciers, which play a crucial role in determining agricultural water resources for South Asia.
- Coping strategies to combat climate change involve the development of a proactive risk-based management approach to deal with adverse consequences of extremes and climate anomalies including risk scoping, risk characterization, risk management, and monitoring and review.
- Use of decision-support systems as risk management tools should be promoted as an effective means of providing outputs of integrated climate-agronomic information.

» Climatic risk zoning should be utilized to quantify climate-plant relationships and the risk of meteorological extremes for planning of changes in agricultural enterprises.
» Increased attention in many developing countries is needed to facilitate access by the rural poor to technical expertise and technological innovations.
» Because of climate change, an urgent review of drought contingency planning, drought preparedness and drought impact assistance policies is needed, and measures to reduce desertification must be vigorously pursued.
» Ways to accelerate mainstreaming or integration of climate adaptation into national development planning processes should be explored.

3.2. Seasonal Climate Prediction and Applications

3.2.1. Issues and significance

Developing predictive capacity to manage climate variability and climate change-related vulnerability, strengthen overall climate responses and build resilience to socio-economic and environmental shocks is one of our urgent development needs.

It is becoming increasingly clear that climate variability and climate extremes associated with El Niño and La Niña (El Niño–Southern Oscillation [ENSO]) cycles and Sea Surface Temperature Anomalies (SSTA) in the Pacific Ocean are adversely affecting the environmental and socio-economic aspects of Asia and Pacific Island Countries. For example, recent statistics show that due to the effect of the 1997/98 El Niño event, global and regional climate changed (relative to the observed long-term trends) and the associated large-scale natural disasters led to approximately 5 million people being made homeless resulting in a direct economic loss of approximately US$33.9 billion. However, while changes in ENSO activity are probably likely in the future, it is still unclear how the frequency and intensity of El Niño events will change as a result of global warming (IPCC 2007).

The monsoon system that dominates the climate of the Asia-Pacific region has been found to impact about 60% of the global human population by influencing lives and livelihoods, ecosystem goods and services, water resources, agricultural productivity and socio-economic activity. According to the IPCCAR4, as global warming accelerates, the magnitude and intensity of these impacts are most likely to increase. GCMs are used not only to simulate the overall behaviour of the climate system but also to produce projections of future climate variability and change. While these models are able to quite successfully reproduce large-scale climate processes, they have to be "downscaled" to produce results that are relevant at the regional level.

Skill development to downscale GCM outputs to produce locally relevant information and their application to climate proofing humans and ecosystems is a major priority for APN.

Although the Asia-Pacific region's vulnerability to climate variability and climate change is very high, the region's capacity to address sectoral impacts is relatively underdeveloped. *This situation calls for urgent intervention to enhance the skills of regional scientists, forecasters, disaster management officials, and resource managers* in the development and use of climate information relevant for improving human and ecosystem resilience.

3.2.2. Scope of the activities

Given the huge capacity constraints in the Asia-Pacific region to understand, anticipate and respond to climate and extreme events, APN has funded eight (8) research and capacity building projects in the region, four of which addressed computer model-based climate prediction, while the rest were intensive training for long-term capacity building at an advanced level. "Train the trainers" approaches were also designed to multiply training opportunities at the national and local levels of participants.

One of the projects resulted in a network involving nine countries sharing climate data from the Tropical Ocean Global Atmosphere-Tropical Atmosphere Ocean (TOGA-TAO) and South China Sea Monsoon Experiment (SCSMEX) buoys, and oceanic and satellite observations. Another focused on training participants from NMHSs to develop capacity using lectures and computer laboratory sessions at the Asia-Pacific Economic Cooperation (APEC) Climate Centre (APCC), using their Multi-Model Ensemble (MME). Seasonal climate forecasts were determined using meteorological data from fifteen prominent climate-forecasting centres (***Figure 14***).

These projects focused on vulnerable countries in the Pacific Islands, Southeast Asia and low-lying delta communities. A special feature of all training sessions was the emphasis placed on the science of climate

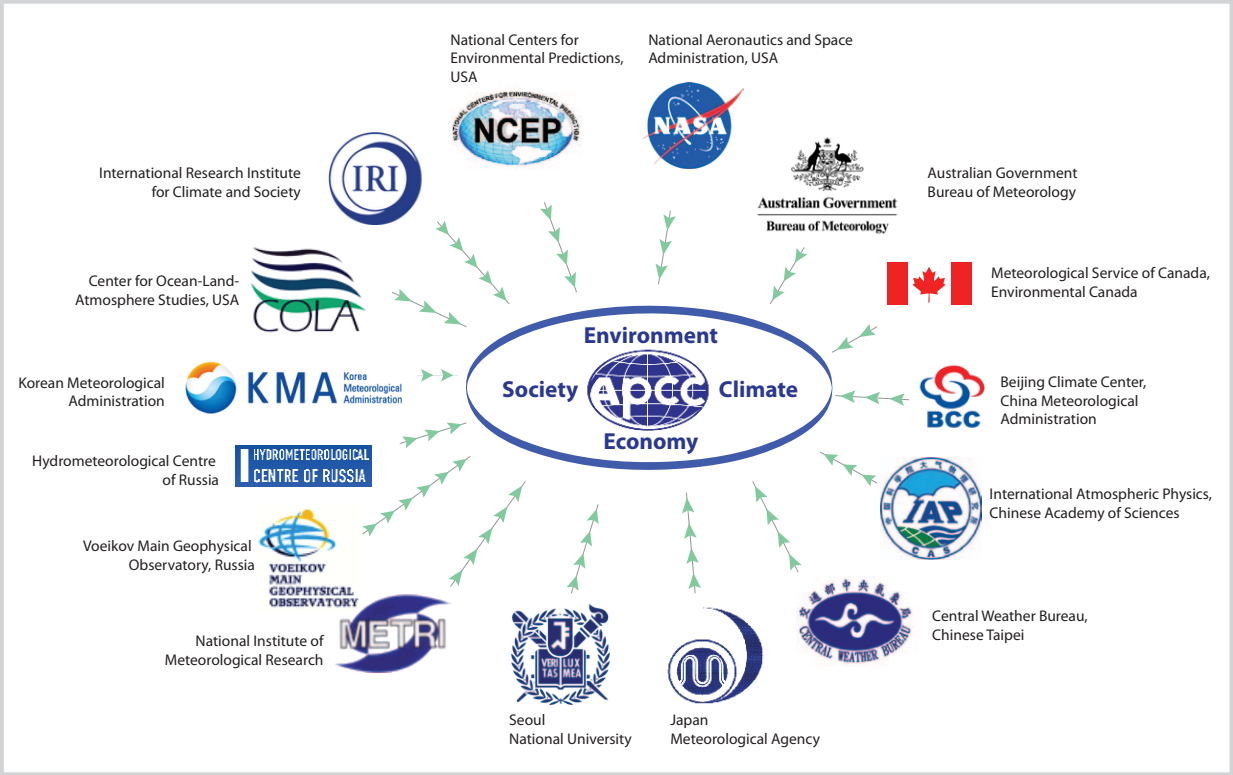


Figure 14: Multi-Institutional cooperation [Source: Ashok]

change and climate system functioning and the role of policy and governments in the implementation of mitigation and adaptation measures.

3.2.3. Outputs and outcomes

The projects considered under this section have all helped to bridge two major gap areas, namely: (i) the lack of reliable local climate predictions at seasonal to annual scales; and (ii) the lack of capacity to apply prediction tools to generate region and sector-specific climate information and products relevant for implementing adaptation and mitigation measures. Such model-based outputs are critical for national climate negotiators to be effective at international fora as they develop multilateral climate agreements. At the national level, such capacity building has resulted in the development of climate frameworks and large-scale climate adaptation projects through bilateral (AusAID project in Fiji) and multilateral (GEF and EU projects in the Asia-Pacific region) assistance.

The climate prediction project teams established networks with access to climate data archived in research centres of Hawaii, Japan and the Republic of Korea and mentoring support from senior scientists from these laboratories and user-friendly climate modelling software such as SimCLIM from the International Global Change Institute (IGCI) for Pacific Island users and CLIK software from APCC for Asian users. The Pacific Island Training Institute in particular (***Figure 15***) helped train media groups to produce accurate climate information and awareness materials, especially during cyclones, floods and drought-related disasters.

APN projects have contributed substantially to building regional capacity for mainstreaming climate change into national sustainable development strategies and action plans.

Figure 15: APN-CAPaBLE Training Institute on Climate and Extremes. Institute participants discussing climate change adaptation. Kiribati, July 2006. [Source: Koshy]

All of the projects produced peer reviewed publications, technical documents, awareness materials in both English and local languages, seminar presentations, new follow-up projects and web-based resource materials. Also, in a number of the capacity building activities, some of the networks created have been sustained. One example is the Alumni of Young scientists who attended the Advanced Institute on the Asian Monsoon (CSP41) through START's Alumni Network.

3.2.4. Conclusions and recommendations

Conclusions

- » Regional networks are an effective means to address the shortage of climate monitoring and prediction needs.
- » Without long-term commitment on the part of network partners and donor agencies, effectiveness will be short lived.
- » Without structured follow-up, it will be hard to determine how developed capacity is being used at individual and institutional levels.
- » As an effective sustainability approach for the Pacific Island Climate and Extreme Events Training (CSP26), a formal course was introduced at the University of the South Pacific in 2007, which attracts about 25 participants each year. This course is available through distance and flexible mode with "mature entry" provisions.
- » "Train the trainers" exercises should include training for the development of new proposals. This skill is critical to sustain skills developed.

Recommendations

- » Climate variability predictions are needed for different temporal scales – months to seasons and inter-annual.
- » There is a need for a series of advanced training courses on climate prediction, monitoring and capacity building.
- » Training workshops on downscaling need to be replicated in the region.
- » Community-based climate adaptation, as well as reducing vulnerability and building resilience, requires *much more attention* as this is where most adaptation activities in *developing countries* will take place in the future.
- » Climate change and disaster risk management must be mainstreamed into national development strategies and brought under appropriate ministries for budgetary support and to secure substantial international support.

3.3. Climate Variability, Trends and Extremes

3.3.1. Issues and significance

It is clear that the frequency and intensity of extremes in weather and climate have profound impacts on societies and the natural environment. For example, about 20% of the land area in Pakistan was flooded in 2010, resulting in the death of approximately 2000 people and the displacement of 20 million people. Despite universal recognition of the importance of understanding the nature of climate variability and extremes, in 1996 the IPCC recorded in its Second Assessment Report (SAR) that the data on climate extremes and variability at that time were inadequate to support any statement on global changes in climate extremes. Consequently work commenced in the mid-1990s to coordinate the analysis of climate data to detect trends in extreme events in temperature and rainfall in many developed countries. To complement this work, there was a need for capacity building in developing countries to enhance their capability and interest in managing and analyzing their climate records for trends and variability in extremes. This need was recognized by the APN in 1997 and a substantial investment was made in supporting relevant activities in the following years.

Extreme climate events have profound impacts on societies and the natural environment.

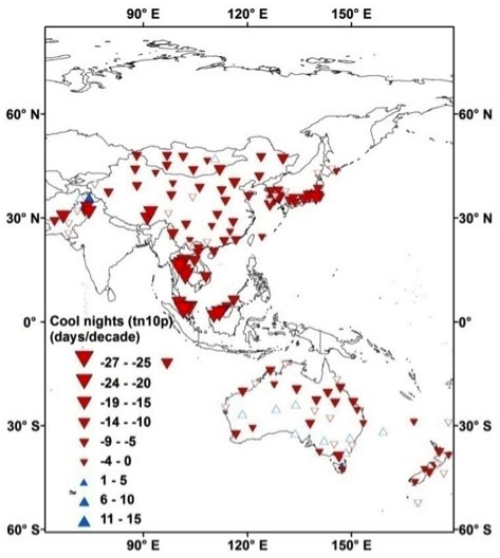


Figure 16: Trends (days/decade) in the frequency of cool nights over the period 1955–2007 across ten APN countries; colour-filled symbols indicate trend is significant at 95% level; the frequency of cool nights is decreasing across the region [Source: Kwon]

The regional need for capacity building has posed particular challenges in the Pacific where climate variability is largely owing to the influence of ENSO and where such influences have specific impacts on the many Small Island States. South Asia also has specific challenges associated with data access and capabilities in detailed climate analysis in some countries. Moreover, strategies for capacity building in the Asia-Pacific region need to be sensitive to differences in culture and institutional responsibilities. The APN-supported projects aimed at accounting for these regional issues.

The reconstruction and analysis of paleoclimate data are important contributions to the overall climate record because those data provide the context for the more recent instrumental climate record. Paleoclimate data also allow us to understand past climate regimes and to test models, used for projections of future climate, in quite different past regimes. The APN supported activities to raise the awareness of paleoclimate data across the Asia-Pacific region.

The Global Earth Observation System of Systems (GEOSS) was established in 2005 to provide a framework for earth observations to support societal needs for the whole world. The APN recognized the need to promote regional activities that followed on from the global planning.

3.3.2. Scope of the activities

In order to enhance the capabilities to quality control and analyze the climate record for trends in extreme events in Southeast Asia and the Pacific, the APN supported a series of workshops involving experts from more than a dozen countries. The first five workshops were held in Australia and the sixth was held in the Republic of Korea. The first workshop in 1998 identified issues of data quality and accessibility, and agreement was reached on appropriate indicators of potential trends in climate based on daily temperature and precipitation data. Further workshops brought together experts from each country to analyze their national data in order to identify trends both nationally and regionally, to

investigate links between the trends and the large-scale factors that influence climate across the region, and to address issues of data quality and accessibility. The work was linked to the international activities of the WCRP on global change detection.

APN workshops produced the first regionally consistent analyses of trends in temperature and precipitation extremes across Southeast Asia and the Pacific.

Initially the analyses used climate data since 1970, but by the sixth workshop, it was found that the time period could be extended back to the mid-1950s in most countries. The early workshops also analyzed data from only about six high-quality sites from each country, but the number of sites was extended for the sixth workshop as countries made progress in data digitization and rehabilitation. A key result of the analyses is that the trends found at the early workshops have persisted as the period under consideration has been extended. There are trends in temperature extremes, such as increases in the number of hot days and decreases in the number of cold nights each year, across the whole region (***Figure 17***). On the other hand, trends in precipitation extremes are more localized.

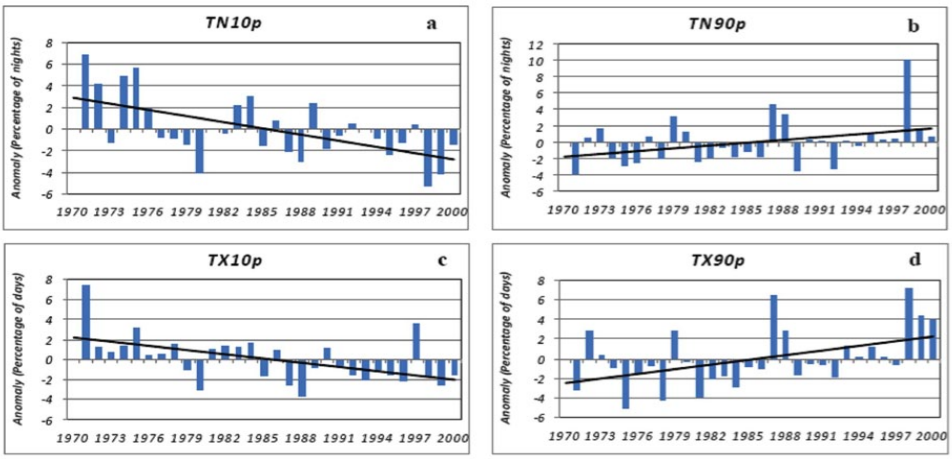


Figure 17: Trends in (cool nights) TN10P, warm nights (TN90P), cool days (TX10P) and warm days (TX90P) averaged over South Asia [Source: Sheikh]

The APN also supported three workshops on climate trends and variability for the Pacific Islands and fourteen (14) countries were involved. The activities included collaboration on data stewardship, regional analyses of climate trends across the Pacific and consideration of large-scale drivers of climate in the region and their impacts on the trends.

Other workshops were supported in South Asia to promote regional cooperation in analyzing climate data for trends in extreme events in a consistent manner. These workshops, which involved experts from Bangladesh, India, Nepal, Pakistan, Sri Lanka, USA and Australia (***Figure 18***), built on experience from the earlier APN workshops and from similar activities supported by international agencies such as the WMO.

Recognizing the relevance of paleoclimate reconstructions for the Asia-Pacific region, the APN supported the Open Science Conference of the international PAGES (Past Global Changes) programme in Beijing, China in 2006. Scientists from fourteen (14) APN countries participated in the conference.

Following the establishment of GEOSS in 2005, the APN supported two workshops in Japan in 2006 and Thailand in 2007, aimed at determining the regional actions required to implement GEOSS. Sixteen (16) countries from the Asia-Pacific region participated in the workshops, which included presentations and break-out sessions to identify regional observational needs, and capacity building requirements to support vulnerability assessments.

3.3.3. Outcomes

By supporting a sustained programme of workshops across the Asia-Pacific region, the APN established a network of experts in more than a dozen countries who continue to collaborate to collate and analyze national climate records at the regional level. The activities facilitated enhancements in the national infrastructure required for quality control and analysis of climate

APN workshops on trends in climate extremes provided a framework for international trend analysis in developing countries around the world.

data. Thus, the APN activity has been very effective in building scientific capacity across the entire Asia-Pacific region.

Figure 18: Participants and resource persons of the APN Technical Meeting for the finalization of research publications on climate extremes, Kathmandu, Nepal [Source: Sheikh]

The scientific capacity building activities of APN have led to improved data stewardship and to substantial scientific progress on the analysis of climate trends. The observed trends in temperature and precipitation extremes from the early workshops fed directly into the Third Assessment Report (TAR) of the IPCC, and subsequent results were included in the IPCCAR4. The advancement in climate science since 1996 has allowed the IPCC in its third and fourth reports (IPCCTAR & IPCCAR4) to make authoritative statements on trends in extremes in temperature and precipitation on a global scale.

The format of the early APN workshops was taken up by other international groups, such as the WMO and applied in other regions, including the Caribbean, Africa and Central Asia. Moreover, the APN-supported workshops in the Pacific provided the basis for further activities across the region under the auspices of GCOS and other regional bodies. These activities included vulnerability assessments in agriculture and forestry.

The APN focus in South Asia led to the development of consistent analyses of climate extremes across that region through direct collaboration between all the involved countries. Indeed, the activities have created a collaborative network across the countries of South Asia, which is working to link the observed trends in extremes to large-scale climate drivers.

Support for the PAGES conference ensured that 14 countries in the Asia-Pacific region were able to participate in this event of the GC community, and the GEOSS workshops in Japan and Thailand brought together 16 countries to identify regional observational needs as well as associated requirements for capacity building.

3.3.4. Conclusions and recommendations

It is clear that the APN has played a fundamental role in establishing the process for scientific capacity building for the analysis of climate extremes on a regional basis and within a globally-consistent framework. Moreover, the pioneering APN activities provided the first regionally-consistent analysis of trends in climate extremes across Southeast Asia and the Pacific.

Open access to climate data, including relevant socio-economic data, will be essential for countries in the Asia-Pacific region to carry out risk assessments of their vulnerability to trends in climate.

Progress on the application of the results of trend analyses in climate extremes to societal issues will depend upon the extension of systematic data collection, analysis and access to socio-economic data. Thus, there is a need for regional policy action to support international efforts to *promote open access to all climate data*, as agreed under the UNFCCC. Increased access to relevant environmental and socio-economic data will enhance regional and national capabilities to use climate data for vulnerability studies, especially related to disaster management, and for integrated assessments of the impacts of climate change and the development of management strategies.

3.4. Regional Climate Modelling

3.4.1. Issues and significance

GCMs have advanced significantly in recent decades, and the Earth Simulator Centre (ESC) in Japan is now running GCMs at resolutions of 3.5 km. However, at the same time, RCMs are being widely used by researchers as a complementary research method, allowing more detailed process studies and simulation of regional/local climate. High resolution information about climate change, variability and extremes is required to develop regional/local climate change projections, which are used in impact, vulnerability and adaptation studies.

Developing RCMs in Asia has helped provide more detailed information on monsoon circulation. High-resolution regional/local information from RCMs can be used in impact, vulnerability and adaptation studies.

The Asia-Pacific region is a hotspot for climate change because of its significant regional monsoon climate, interaction with the global climate system and greater economic activity in recent decades. The simulation and prediction of the Asian monsoon at higher resolution and lower uncertainty under the background of climate change and rapid regional development is not only a crucial scientific research issue, but also a key sustainability issue for both national and local decision- and policy-makers.

Significant requests have come from countries within the Asia-Pacific region for capacity building activities that develop the skills required to master and run RCMs, develop tailored RCMs, and improve downscaling methodologies and application of RCMs for future climate projection and for vulnerability and impact assessment studies.

3.4.2. Scope of the activities

Through support from the APN, an "Asian RCM network" was developed that supported scientists from the region and fostered collaboration with other RCM/GCM modellers under the flagships of WCRP, IGBP and START. APN promoted the development of RCMs tailored for Asian projections in order to improve the understanding of the Asian monsoon system and develop skills for predicting future climate change in the Asia-Pacific region. The capacity to develop and use RCMs has been improved through workshops, training schools and fellowships.

A network of RCM scientists was built through APN projects, workshops and fellowships; and a regional model inter-comparison project (RMIP) was undertaken in the Asia-Pacific region.

From 1999 to 2002, the APN's research programme, the ARCP, provided continuous funding for an Asian Regional Climate Modelling project by supporting the development of RCMs in Asia and promoting the "Regional Climate Model Inter-comparison for Asia (RMIP-Asia)" project and its activities. This aided the development of RCMs at the START Temperate East Asia regional centre and at Nanjing University. Nine (9) regional models from Australia, China, Japan, Republic of Korea, and the USA collaborated in the RMIP-Asia activities in Phase One of the project (***Figure 19***) and the ten (10) subsequent peer reviewed papers from these activities are listed under CSP1 in ***Appendix 3***. A number of these were picked up by the IPCC for their TAR and AR4 reports.

The APN's goal of transferring technology and expertise was supported by an APN-funded 5-week training course hosted by the Commonwealth Scientific and Industrial Research Organisation (CSIRO) Atmospheric Research on "Analysis of Climate Change Simulation of Southeast Asia," using the DARLAM (Division of Atmospheric Research Limited Area Model) high resolution model for Southeast Asia. Participants from Southeast Asia and the Pacific Islands were represented and a high-resolution simulation was conducted over Samoa.

Properties of participating RMIP models for phase one									
Model	RIEMS	DARLAM	CCAM	JSM_BAIM	RegCM	RegCM2a	RegCM2b	ALT.MM5/lsm	SNU RCM
Group leader	C. Fu	J. McGregor	J. McGregor	Y. Sato	J. Kim	M. Suh	H. Kato	W. Gutowski	D. Lee
Country	China	Australia	Australia	Japan	Republic of Korea	Republic of Korea	Japan	USA	Republic of Korea
Vertical levels	σ-17 levels	σ-18 levels	σ-18 levels	σ-23 levels	σ-15 levels	σ-15 levels	σ-14 levels	σ-23 levels	σ-23 levels
Dynamic process	Hydrostatic	Hydrostatic	Hydrostatic	Hydrostatic	Hydrostatic	Hydrostatic	Hydrostatic	Nonhydro-static	Nonhydro-static
Lateral boundary condition	Linear relaxa-tion	Exponential relation	Exponential relation	ER+spectral coupling	Exponential relaxation	Exponential relaxation	Exponential relaxation	Linear relaxa-tion	Exponential relaxation
Convective scheme	Kuo-Anthes	Arakawa-Gordon	Arakwa-Gordon	Moist convec-tive adjust-ment	Grell	Kuo-Anthes	Kuo-Anthes	Betts-Miller	Grell
Land surface	BATS	Kowalczyk	Kowalczyk	BAIM	BATS	BATS	NCAR/LSM	NCAR/LSM	NCAR/LSM
Planetary boundary layer scheme	Holtslag	Louis	Louis	Yamada level 2 louis scheme	Holtslag	Holtslag	Holtslag	MRF	MRF
Longwave radiation scheme	CCM3	GFDL	GFDL	Sugi	CCM3	CCM2	CCM3	CCM2	CCM2
Shortwave radiation scheme	CCM3+ Aerosol	Lacis and Hansen	Lacis and Hanse	Lacis and Hansen	CCM3+ Aerosol	CCM2	CCM3	CCM2	CCM2

Figure 19: Properties of participating RMIP models for Phase One [Source: Fu]

APN also co-funded the WCRP regional-scale climate modelling workshop in June 2004 in Baltimore, USA in collaboration with CLIVAR/WCRP groups, thus ensuring the active participation of developing countries from the Asia-Pacific region.

3.4.3. Outcomes

The Regional Integrated Environmental Modelling System (RIEMS), which is an integrated RCM for the Asian monsoon region, was developed at the Institute of Atmospheric Physics, Chinese Academy of Sciences, with climate-vegetation and climate-aerosol coupling, and has become one of the leading regional models in China.

An Asian RCM group was formed to share the knowledge and experiences of regional model simulations. To support the modelling inter-comparison (RMIP Asia) activity, a data network on *in situ* and modelling outputs was established and a ten-year databank (1989–1998) of meteorological observations and six RCM simulation outputs in the Asian region was built through the APN projects.

APN supported the development of RCMs in the Asia-Pacific region by improving the simulation of the Asian monsoon system and applying RCMs at national and local levels.

Training workshops on the application of regional climate simulations at national and local scales for climate change impact and assessment studies helped scientists in Asia to develop their own RCMs. From the APN-funded regional modelling research project, ten (10) peer review papers were published and contributed to WCRP and IGBP modelling activities and IPCC reports.

3.4.4. Conclusions and recommendations

RCM activities in the Asia-Pacific region should have more interaction with APN climate change impact/ assessment studies in future.

- With APN support, a strong Asian RCM network has been established and the RMIP project is moving into its next phase. To respond to the requests for climate change impact studies in Asia, this group still needs leadership, coordination and support from APN.
- Based on current regional climate/environmental models in Asia now, promotion of studies on monsoon processes in the region is needed, including studies of the monsoon intraseasonal and seasonal cycles at local scales. These activities will also help to improve GCM simulation of the Asian monsoon system.
- Further work is needed to demonstrate the application of RCMs in climate change impact/ assessment studies such as agriculture, water resources and land/water management at local scales. This will require greater interactions across the APN communities, including the Asian Water Cycle Initiative (AWCI) who is supported by the APN.
- Training and strengthening the capability of scientists in the Asia-Pacific region in techniques and applications of downscaling climate change projections needs to be continued. This can lead to better understanding of the strengths and limitations of GCMs and downscaling, which will be of value to those who are involved in policy-making processes. Specifically, strengthening the simulation capacity in Southeast Asia, Small Island States and high altitude areas of the Asia-Pacific region is especially needed.
- There is a need to effectively communicate the uncertainties of climate modelling and the methodologies used to reduce these uncertainties.
- More emphasis should be placed on testing these models against observations.

3.5. Vulnerability and Adaptation to Climate Change

3.5.1. Issues and significance

Climate change may lead to more intense typhoons and more frequent extreme weather events such as wave surges, acute heatwaves, floods in some areas, drought and/or shortage of water supplies. This may also trigger the occurrence of more frequent natural disasters, such as landslides, forest fires, disease outbreaks, etc. The models used by the IPCC predict that by the end of this century (2099), the global average sea level may rise between 0.18 and 0.59 m above the 1980–1999 average, thus threatening regions at or below this predicted rise in sea level, especially the Pacific Island Countries and the coastal regions of Asia [IPCCAR4, 2007]. Global warming and related instances of drought are significantly affecting water resources at high altitudes and the survival of wetlands in the region.

Climate change is often viewed as a gradual, progressive, and long-term phenomenon, however, past climate and disaster history will no longer be an adequate benchmark and future changes could be non-linear and abrupt. Changes might be manifested not just in terms of a change in average temperature and precipitation, but also in terms of increasing variability that will lead to increased vulnerability of social-ecosystems in the Asia-Pacific region and compound the difficulties faced by the region to adapt.

Climate change has significantly impacted the Asia-Pacific region, especially Small Island States and Asian developing countries.

It is expected that climate change impacts will further exacerbate current environmental stress factors in developing countries, whose economies are closely tied to climate-sensitive sectors like agriculture, and who are already facing multiple stresses due to population growth, urbanization, industrialization, and globalization.

Developing countries also lack the financial mechanisms and technical resources to effectively defend themselves against natural disasters. Thus, regions and communities that are unable to cope with current climate hazards are also likely to be the most poorly equipped to cope with the adverse impacts of climate change.

3.5.2. Scope of the activities

In order to transfer knowledge to developing countries in the Asia-Pacific region and develop science and technology for vulnerability assessments as well as explore methodologies for adapting to climate variability and change, APN supported nine (9) projects during its first and second phases (1998–2010). Five of the nine (9) projects dealt with vulnerability assessments while the other four (4) focused on adaptation.

For vulnerability assessments, APN supported the following activities:

- Vulnerability assessment of two important coastal wetland sites to climate change and sea level rise.
- Integrated Assessment Model (IAM) Workshop in East Asia to exchange information on recent developments of IAMs in climate change and to explore and apply the methodology and experiences to use IAMs, to strengthen the capacity of the countries involved to develop and apply IAMs and achieve better understanding between researchers and policy-makers.
- Training course partnered with the Pacific Island Climate Change Assistance Programme on vulnerability and adaptation assessments for Pacific Island Countries using a prototype IAM – PACific CLimate Impacts Model (PACCLIM) developed by IGCI.
- Vulnerability assessment of carbon stores to land use and climate change relating to the extent and carbon content of peatlands in Southeast Asia and associated GHG fluxes using the PEAT CO_2 model combining two approaches for a global analysis using existing datasets, new process understanding, land use and climate change scenarios.

» Assessment of "climate risks" associated with changes in surface water quality as a function of changes in hydro-climates and land use, with translation of scientific data into practical information for the development of an integrated system.

For adaptation, APN supported the following activities:

» Initiated research on community relocation as an option for adaptation to the effects of climate change and climate variability in Pacific Island Countries through both literature search for information on the occurrence of environmental extremes and community relocation in Pacific Island communities and participatory community-based fieldwork in the village of Biausevu in southern Viti Levu (the largest island in Fiji).

» Built sub-region and country-specific knowledge base for assessing, facilitating and removing barriers to adaptation and resilience to climate change in the LDCs of South and Southeast Asia, and co-sponsored by UNFCCC and UNITAR, an up-scaled workshop convened under the New Asian African Strategic Partnership (NAASP) framework so that benefits would be increased to a much wider group extending to Africa.

» Identified priorities, requirements and existing gaps in available information among policy-makers and practitioners to enable the integration of climate change action in all policies, driving co-benefits in the long term and to develop web-based learning package (including relevant information like current state of knowledge, latest climate change science findings, disaster trends and unanticipated changes, strategic opportunities, etc.) for pilot testing and refinement.

» Developed capacity of LGUs, communities and regional universities to effectively respond to climate change for sustainable development in five vulnerable municipalities in four provinces in the Philippines, namely Kawit and Rosario, Cavite, Guagua, Pampanga, San Juan, Batangas and Ilagan, Isabela.

3.5.3. Outcomes

Vulnerability

Climate change will have strongest impacts in developing countries whose economies are closely tied to climate-sensitive sectors. The tropics and sub-tropics of the Asia-Pacific region, where rain-fed agriculture dominates, are faced with multi-dimensional challenges as some crops are already near their maximum temperature tolerance and yields are likely to decrease with even small changes in climate. Often the poorest in rural areas occupy the most marginal lands and this forces people to rely on highly vulnerable livelihoods in areas prone to drought, floods and other hazards.

Extreme weather events have already been observed and are making an impact. For example, in the Philippines, (in Kawit and Rosario, Cavite, Guagua, Pampanga, San Juan, Batangas and Ilagan provinces) people are experiencing larger impacts from increased frequency and intensity of typhoons since the 1990s. Rainfall distribution has changed with rain patterns shifting to more concentrated pockets from what used to be evenly spatially distributed patterns. Coastal communities have observed sea levels at high tide going beyond historical levels inundating some areas with longer flooding times. Vulnerability to climate change also differs by sector. ***Figure 20*** shows the levels of vulnerability by sector to different manifestations of climate change in sample communities in the Philippines.

For Small Island States, hydrology and topography are the critical parameters that determine vulnerability to livelihoods and ecosystems due to climate change. Vulnerability assessment through participatory measures have been developed and applied in the Olango Islands in the Philippines. This study can serve as a template for similar studies.

The effects of climate change are also observed in less obvious sectors such as water quality. In many parts of southern China, lower precipitation with large year-to-year variations has been observed in recent years. This appears to have had a substantial influence on year-to-year variations in acidity and

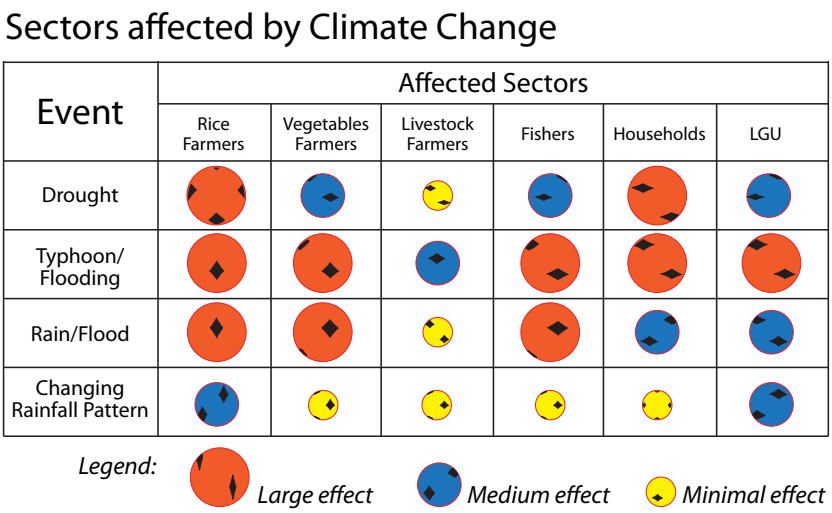


Figure 20: Levels of vulnerability experienced by climate change-related events in sample communities in the Philippines [Source: Peñalba]

nutrient fluxes in forest soils and headwater streams under increasing levels of acid deposition. Intense and extreme rainfall can pose a threat to surface water quality in vulnerable areas such as steep mountainous watersheds, with climate impacts often amplified by land-use change.

Climate change can also be accelerated by positive feedback from ecosystem responses, exacerbated by anthropogenic activities. Current management practices in peatlands combined with climate change and variability are having a major negative impact on peatland carbon pools. Peatlands cover approximately 31 million ha in South East Asia and store an estimated 47 Gt of Carbon. Peatland carbon pools in the region are being severely impacted by drainage (affecting over 6 million ha) and fire (affecting over 3 million ha). Approximately 3 million ha of peatland in the region have been drained for agriculture or logging and then abandoned. These areas are particularly susceptible to peat fires. Drainage may release 100 tonnes h^{-1} of CO_2 per year while a single fire event may release up to 2,400 tonnes h^{-1} of CO_2 . Peatlands in the region are emitting up to 1.5 Gt of CO_2 per year because of anthropogenic activities such as land clearance and conversion, drainage and fire. This represents a major global source of GHG emissions. Slight drainage is able to stop carbon sequestration in apparently healthy forests – turning important carbon sequestering systems into significant carbon emitters.

Adaptation

Adapting to change is not new. Climate extremes, prolonged droughts and seasonal changes have forced communities to adapt to changed conditions. Learning from past experiences is extremely important to prepare and plan for future adaptation needs. A case study of community relocation in the Pacific Islands has demonstrated this approach by establishing generic characteristics of relocation and aspects to be taken into consideration in relocation planning. Categorization based on whether it is a local relocation within land tenure boundaries, local relocation beyond land tenure boundaries, relocation within national boundaries and relocation beyond national boundaries has proved to be useful in such design. The difficulties associated with relocation are also associated with the distance from the origin (***Figure 21***), although the association is not linear as, for example, even where a community may relocate within its own boundaries, its members may have to travel further to get to their gardens and/or water supply, and children may have to walk further to school, etc.

The important steps in relocation are identified as: deciding to relocate, identifying destination, identifying economic costs, identifying other non-economic costs such as social, cultural and spiritual costs, and deciding on the time taken for relocation and the timing of relocation efforts. Such frameworks can be used to identify the resources needed to adapt to future climate change.

Raising awareness among civil society and policy-makers about climate change and its probable impacts is an important step towards developing appropriate adaptation strategies. Information and Communication Technology (ICT) can play a valuable role here through web-based information and tools repositories. Adapting to climate change also requires multi-disciplinary approaches involving a range of stakeholders to identify those issues that need to be addressed in a particular ecosystem or sector. Multi-disciplinary workshops supported by APN have addressed this important need.

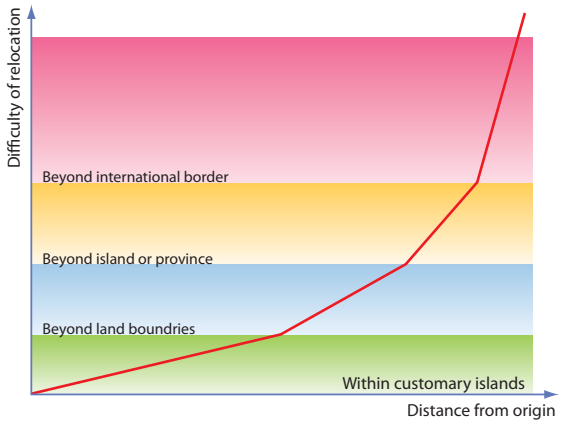


Figure 21: Difficulty of relocation increases when boundary thresholds (land, island, international borders) are exceeded [Source: Campbell]

LGUs are key institutions involved in managing climate risk. Disruptions caused by climate anomalies adversely affect LGUs in terms of revenue loss, increased expenditure for rescue, relief and recovery, and loss of potential investment. A study in the Philippines demonstrated that even without detailed precise vulnerability assessments, participatory approaches to vulnerability assessments through stakeholder meetings can still lead to development of useful indicative climate change adaptation plans by LGUs. However, there is little capacity or preparedness within LGUs for long-term anticipatory planning. Appropriate capacity development programmes should be developed for successful implementation of various national-level decisions taken with regards to climate change adaptation.

Integrated Assessment Models (IAMs)

Adaptation planning needs to be done based on comprehensive assessment of how future climate will alter ecosystems, their services as well as social systems and their interactions. IAMs are used for this purpose and their use has become a key process for policy-making in the recent decade. Developing countries play an increasingly important role in climate change pathways and their understanding and involvement in the use of these models as well as their development is critical. Capacity development workshops have been carried out to introduce different types of IAMs such as:

- Large-scale IAMs that analyze in detail the entire process of social activities and climate change and their impacts on the social economy. These have included models such as AIM, developed in Japan, and IMAGE2, developed in the Netherlands.
- IAMs that focus on the natural phenomena and mechanisms of climate change, its impacts and damage, such as MAGICC, PAGE, etc.
- IAMs that especially analyze the schedule for future countermeasures and the best way for economic development during the process of climate change damage analysis, such as DICE, MERGE, etc.
- IAMs that focus on system development, such as TARGETS, etc.

Feedback from these endeavours have identified the need to extend the simulation from energy and pollutants emission to agriculture, land use, territorial ecosystems, biological diversity, water resources and other fields. PACCLIM is a system that has been developed towards this end and a capacity development workshop for the Pacific Island Countries (PICs) has shown that the model's scenario generators and impact assessment models for different sectors are very well geared towards meeting these needs.

3.5.4. Conclusions

By supporting and encouraging the activities mentioned above, APN has played a leading role in facilitating knowledge transfer to developing countries on vulnerability assessments and adaptation in the Asia-Pacific region. These efforts have even extended to Africa with the collaboration of other related international organizations and institutions.

In the Asia-Pacific region, APN has facilitated the promotion of communication between modelling researchers and policy-makers with the assistance of IAMs. IAMs have supported policy-making through vulnerability assessments for the development of adaptive response strategies to climate change impacts in the Pacific Island region. This was demonstrated in an APN project in the Pacific

Islands where PICs overwhelmingly supported the prototype PACCLIM model and expressed support for its further development to assist in linking science with the policy-making process in PICs.

Adapting to climate change is gaining increasing attention in recent years. At this early phase the major focus is on assessing vulnerabilities and identifying adaptation options for various sectors and/or ecosystems. The complexity of adaptation due to its multidisciplinary nature and challenges in seeking holistic solutions covering multi-sector multi-stakeholder interests make designing optimum adaptation strategies extremely difficult. The difficulties are increased by lack of long-term data pertaining to natural as well as socio-economic parameters. To address these issues it is necessary to develop participatory bottom-up approaches that involve communities and local governments to incorporate climate change adaptation practices into development planning. At the same time, IAMs need to be customized for particular regions and sectors of interest to reduce uncertainties in climate projections and assess impacts at the local level.

The development and application of IAMs in the field of climate change research have great significance in vulnerability assessments in PICs, East Asia and high altitude land in the Asia-Pacific region. The research field and process of integrated assessment are based on modelling, which has turned out to be a key process for policy-making in the recent decade through APN-funded projects and related research.

Finally, developing countries play an important role in climate change research in the Asia-Pacific region. The capacity improvement of developing countries to develop and apply IAMs through expanded international collaboration supported by APN will assist in establishing and implementing global climate change mitigation and adaptation mechanisms.

3.5.5. Recommendations

- Increase emphasis on community-based adaptation approaches, and encourage ground level consultations and multi-stakeholder analyses to disseminate tools and technologies for vulnerability assessments, thus complementing the APN Science and Policy Agendas on global change research.
- Encourage APN member countries to increase the capacity to formulate national strategies on adaptation, to share perspectives on the significance of integrating adaptation strategies with national planning for sustainable development, and establish useful networks to share experiences, and useful contacts with resource personnel for relevant guidance in the future.
- Develop programmes to enhance the capacity of major players in adaptation planning and implementation; local universities and academic institutions, communities and local governments, in an integrated framework to effectively mainstream adaptation into development planning.
- Develop localized climate change impact assessment tools, especially IAMs, as these promise to enhance the capacity to identify policy options and measures for climate change adaptation at local and national levels.
- Increase cooperation between governments, researchers, the private sector and local communities to enhance the management of peatlands to provide sustainable livelihoods and decrease CO_2 emissions from fires and drainage and, as far as possible, protect intact peatlands for their carbon sequestration and storage functions.

3.6. Climate Change Mitigation

3.6.1. Issues and significance

APN has supported five (5) climate change mitigation projects under its scientific capacity development programme, CAPaBLE. These projects can be classified into two major themes:

(1) Appropriate use and adoption (uptake) of environmental technologies for amelioration of emissions from point sources and to enhance the capacity of developing countries in the use of IAMs for climate change mitigation options.
(2) Building inventories for GHG emissions and other aerosols from a range of landscapes and land use activities.

An integrated, non-specific approach to combating climate change is required.

The generation of emission scenarios and the technological approaches used to reduce emissions are largely dependent on a range of country-specific development characteristics, which can differ significantly from one country to the next. In the past, many models used for climate change assessment at the global, regional and national levels did not take into account specific developing country conditions such as differences in socio-economic dynamics and sustainable development issues and priorities. Therefore, there was a need to apply a multi-disciplinary approach to account for a broad range of country-specific dynamics, which could be achieved with IAMs. Similarly, the diffusion of technologies to the developing world is also subject to a range of national factors that may not necessarily be suitable for a particular technology, particularly in light of the cultural and social divide that exists between the developed and developing world.

The development of GHG inventories has also featured as a significant issue over the last decade. Under the UNFCCC, countries must publish a national inventory of their GHG emissions in accordance with IPCC guidelines. These guidelines contain "default" emission factors and activity data to assist countries to construct their inventories. However, there are a range of factors that can affect GHG inventory compilation and the resulting accuracy of emission inventories with respect to both time and space. Therefore, in order to accurately reflect a country's circumstances and conditions, individual countries are encouraged to develop inventories based on their own set of emission factors as opposed to those stipulated in the IPCC guidelines.

3.6.2. Scope of the activities

The development of inventories and effective technology transfer described in the previous section requires the appropriate capabilities and expertise often lacking in many developing countries. APN-supported activities addressed these issues through the delivery of scientific capacity building workshops, training programmes and seminars. These activities have enhanced the scientific capacity in a number of developing countries including India, Thailand, China, Bangladesh, Sri Lanka, Viet Nam and Cambodia.

APN has supported workshops and training on i) GHG inventory compilation ii) sustainable technology transfer for climate change mitigation and iii) measuring GHG emissions from landscapes.

3.6.3. Outcomes

A majority of these activities have essentially focused on i) delivering methods for assessing country specific requirements for determining point sources of GHG emissions from landscapes; ii) the development of emission inventories; and iii) strategies for the effective transfer of environmental technologies for climate change mitigation. One particular project conducted a comparative assessment of sampling

techniques for measuring GHG emissions from rice fields. Another project undertook a detailed assessment and measurement of GHG emissions and aerosols from a range of agricultural landscapes and land use activities across the Mekong River Basin Sub-region. Another outstanding APN project (CSP37) conducted a series of training and workshop activities to enhance the capacity of developing countries in the use of IAMs for climate change mitigation options.

APN has significantly improved the capacity of developing countries to measure and assess their GHG emissions and has assisted in the delivery of strategies to enhance the mitigation effort.

The introduction of IAMs to APN participating countries has led to an improvement in the accuracy of assessing emission pathways and their energy demands. These capacity-building projects have also provided end-users with more informative carbon emission abatement options based on a range of scenarios, which reflect their country's social and economic status. The training outcomes have also demonstrated significant progress with respect to the methodology used to assess the extent of GHG emissions from various land use activities under a range of different field conditions (***Figure 22***).

Figure 22: Know-how transfer on experimental procedures for measurement of GHGs from forest and paddy fields [Source: Towprayoon]

Capacity development

Although accurate and informative GHG inventories are an essential planning tool for policy-makers, APN project leaders identified a number of problems that could be addressed in follow-up activities, particularly with respect to capacity building and the need for appropriate model validation with respect to IAMs. For example, it has been identified that a number of developing countries have not satisfactorily adopted the use of UNFCCC software/manuals/guidebooks to assist their inventory development. A number of APN-funded projects also identified a deficiency in the ability of some project managers to effectively manage staff and projects as well as coordinate a range of technical tasks, suggesting a lack of trained personnel with the necessary management skills required to train and manage others within their institutions. The key to successful human capacity building is the ability of individuals to effectively liaise and develop strong collaborative links with other individuals from institutions working on similar issues. Furthermore, the overwhelming consensus originating from a majority of these APN-funded projects is the need to improve knowledge-sharing capabilities on information such as activity data, emission factors, estimation methodologies, etc.

Science

APN-funded field projects have made an important contribution to our understanding of the relationship between GHG emissions and land-use changes, which has led to a number of peer reviewed papers. Data analysis derived from these APN activities has revealed that a major contributing factor to the overall GHG emissions from developing countries is from biomass burning and biogenic GHG emissions from agriculture. Biogenic and biomass burning in the Mekong River Basin constitutes a major source of air pollutants as well as GHG emissions. In Southeast Asia, around 42,000 billion tonnes of carbon is stored in the tropical peatlands but much of this captured carbon store is increasingly being released to the atmosphere through drainage and burning of tropical peatlands associated with logging and palm plantation activities. Current projections point towards a 50% increase in GHG emissions by 2030 if the predicted expansion of palm oil production continues (***Figure 23***). The drainage of peatlands for palm oil production is driven by the increasing global demand for food and biofuels.

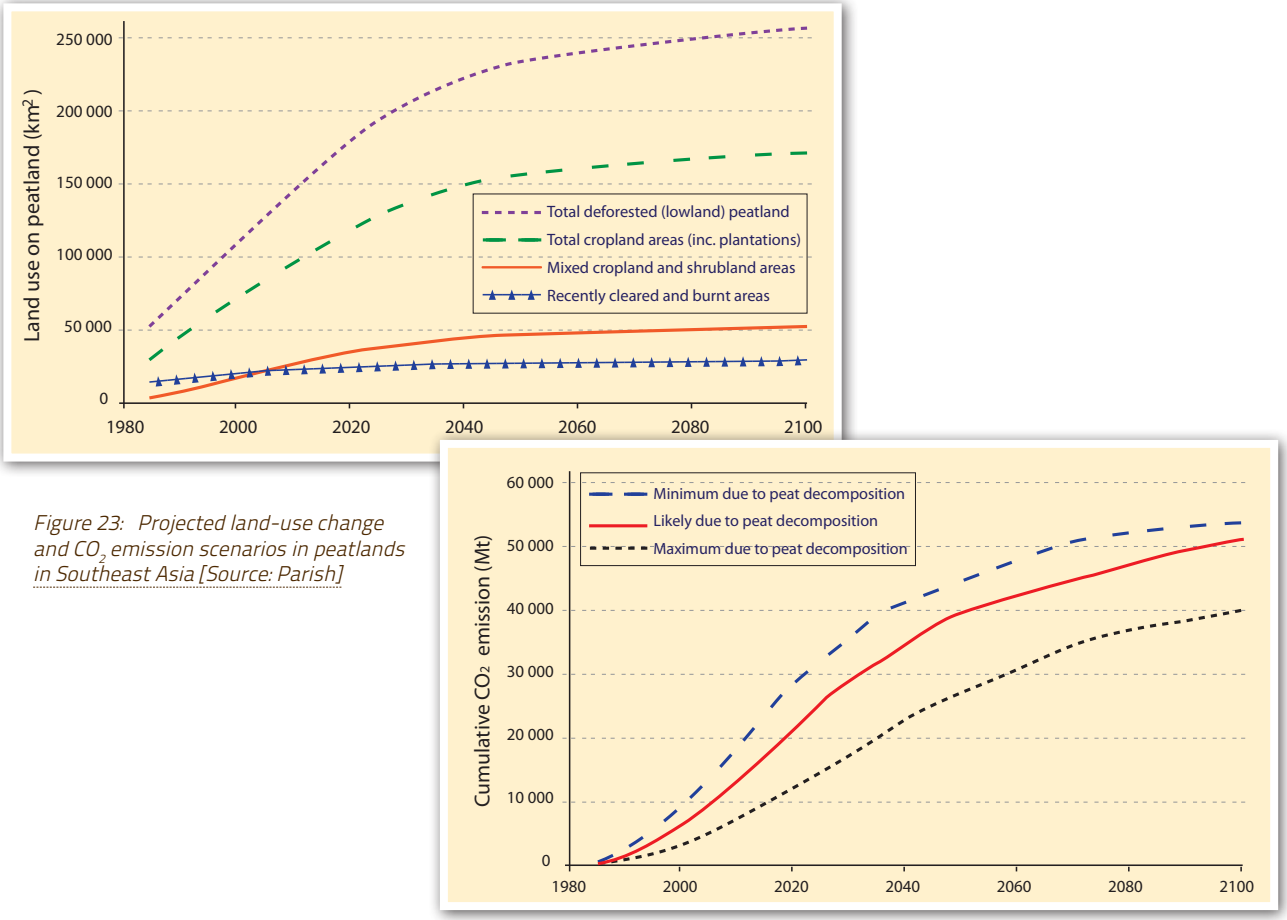


Figure 23: Projected land-use change and CO_2 emission scenarios in peatlands in Southeast Asia [Source: Parish]

Raising awareness of these issues is seen by many researchers as a way of reducing environmental degradation and associated GHG emissions from a range of landscapes. Apart from biomass burning, basic agricultural production is also a contributor to global GHG emissions; for example, rainfed rice cultivation contributes to around 68% in methane emissions.

Given the success of these GHG monitoring programmes, consideration should be given to their expansion to other countries and jurisdictions in the region.

Several peer reviewed papers were published on the effects of land clearing on the production of GHG emissions and on the importance of IAMs in assisting the capacity of developing countries to apply these models for developing climate change mitigation options.

Communication/policy and outreach

In 2004, an APN CAPaBLE-funded training programme, conducted in Japan, China and Nepal, helped raise awareness of the role of locally-owned technologies in contributing to the mitigation effort. A series of workshop lectures emphasized the impediments to effective technology transfer and the benefits associated with locally-owned and manufactured technology using local materials. They also highlighted the importance of encouraging the users of environmental technologies to play a greater role in technology development. These activities also demonstrated the effectiveness of locally-owned technologies for climate change mitigation with particular emphasis on issues relating to the social acceptance of new technologies in the community.

"Train the trainer" models should be supported by educational institutions that have the capacity to provide ongoing support either face-to-face or web-based. There is a need for improved alignment between sustainable development and climate change mitigation efforts.

Finally, the dissemination of information on technology best practices is still an effective mechanism for technology uptake by the developing world. Work has also shown that the uptake of so-called

"intermediate" technologies in association with lowering energy consumption can make a substantial contribution towards reducing GHG emissions. However, it has also been emphasized that in order to achieve greater energy efficiency, a wide-ranging multi-policy approach is required rather than countries adopting a one-size-fits-all policy approach to reducing their increasing reliance on fossil fuels. Most project participants agreed that there was still an ever-increasing need to effectively bridge the gap between policy-makers and scientists.

3.6.4. Conclusions and recommendations

- "Train the trainer" models should be considered in future capacity building activities involving the development of GHG inventories. However, such capacity building activities need to be actively supported by ongoing training programmes. These programmes should operate within the framework of existing tertiary institutions with the capacity to provide ongoing support either via the internet or face-to-face. In addition, training, including the development of country specific training manuals and materials, should be targeted where there is a specific need for further personnel development, rather than on delivering broadly focused training workshops.
- Over the last couple of years, problems associated with the development and use of GHG inventories have emerged. Some inventories still do not reflect country-specific conditions and others require further attention in relation to issues such as inaccessible or inaccurate datasets in some sectors[3]. Although many countries are making progress in the area of GHG inventories, the institutional capacity to undertake this work could be improved. In order to ensure a much smoother transition from a high to a low carbon society, APN project participants identified a need to develop a comprehensive integrated framework or road map that aims to provide better alignment between sustainable development and climate change mitigation efforts. Assistance for the development of a strategic technology database to support IAMs should be considered. Similarly, there is a need to develop stronger coordination and cooperation between institutions throughout the region. The establishment of comprehensive research and development database of research institutions and scholars working in the area of sustainable technology development would help in this process.
- As the population of major cities continues to grow through migration from rural regions, there is an urgent need for more comprehensive and sustainable city planning.
- There should be a strong focus on educating farmers on sustainable farming practices (better water management and fire control strategies in the case of peatlands) that will lead to a reduction in GHG emissions from agricultural land. Emerging carbon markets can also provide opportunities for landowners to divert their attention away from so called "traditional slash and burning practices" to more sustainable land management practices (combined plantings) that offer financial incentives through new economic instruments such as an international carbon pricing scheme.

3 Sectors investigated included energy, industrial processes; agriculture; land use; land-use change and forestry; and waste.

3.7. Coastal Cities and Climate Change

3.7.1. Issues and significance

The frequency of flooding in the coastal areas of Asia has tripled in the last thirty years, with the problems exacerbated by increasing urbanization and population growth. Based on the IPCCAR4, by 2100 sea level rise may be in the order of 0.18 to 0.67 m when polar ice sheet dynamics are included. However, a sea level rise of between 0.5 to 1.4 m above the 1990 level by 2100 cannot be ruled out [Rahmstorf *et al.* 2007].

The vulnerability of coastal cities of Asia to flooding will be exacerbated by sea level rise associated with climate change.

In parallel with increasing sea levels, the coastal zone is expected to become home to 75% of the population of Asia by 2025. Bangkok and Dhaka are already facing severe flooding problems owing to substantial amounts of activity in low-lying urban areas. Indeed, the growing number of mega-cities along the coasts of Asia are increasingly vulnerable to the impacts of severe weather events such as storm surges.

Figure 24: Flooding in Bangkok in October 2006 [Source: www.thaiphotoblogs.com]

3.7.2. Scope of the activities

Recognizing the need for action to assess the socio-economic impacts of flooding on the coastal cities of Asia, the APN has supported a project aimed at gathering and analyzing data for a GIS database of hydrologic characteristics and socio-economic conditions for a number of cities across Asia. The data was used in existing tools for simulating the impacts of and vulnerabilities to flooding under climate change conditions. The activity also aimed at building capacity in flood risk management within a network of researchers, to support policy-making on strategies to mitigate and adapt to flooding, and also to raise public awareness of the issues associated with flooding. The project involved seven (7) countries and there was a focus on the Maghna Delta in Bangladesh, the Mahanadi Delta in India, Karachi in Pakistan, Matara in Sri Lanka, Bangkok in Thailand, and Hue City in Viet Nam (***Figure 25***).

The APN has supported activities aimed at promoting effective interactions between scientists and local decision-makers on strategies for flood risk management.

In addition to the impact assessment project, the APN supported an international workshop in 2009 on "Cities at Risk" focusing on mega-cities in coastal areas of Asia. The activity involved a review of the science of climate change impacts on these coastal cities, and consideration of the vulnerabilities and risk management strategies associated with those impacts. The meeting brought together scientists, urban planners, disaster management experts and development agencies to promote interaction between the range of experts relevant to the issues. Reviews were carried out on activities in Bangladesh, China, India, Indonesia, Pakistan, Philippines Manila, Thailand and Viet Nam.

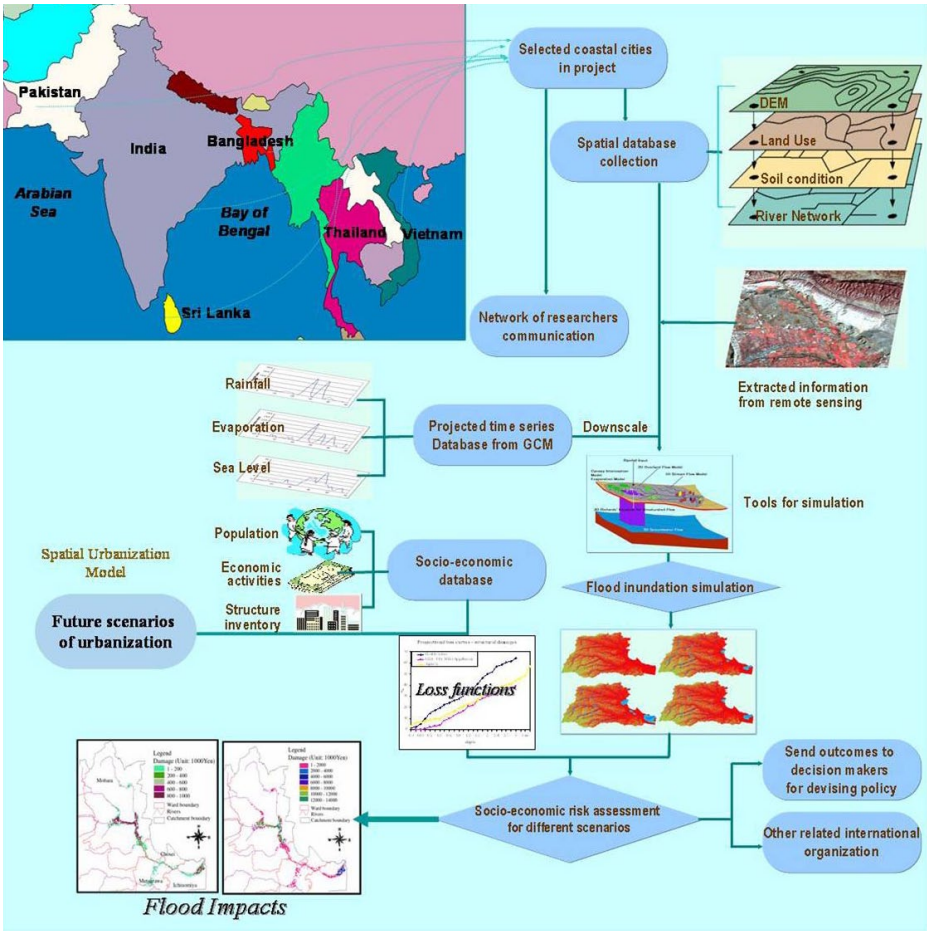


Figure 25: Framework for APN project on risk assessment of flooding in coastal cities [Source: Dutta]

3.7.3. Outcomes

Urban planners participating in the APN activities recognized the need for climate change to be factored into risk assessment and planning for the future development of coastal cities in Asia.

The APN project on risk assessment for a number of specific cities across Asia led to the development of a website to provide a forum for discussion among scientists and for data sharing. A GIS system that utilizes existing databases was developed and applied to the vulnerability studies. Scenario analyses were undertaken to estimate the socio-economic impacts of floods in the selected areas at 2025, 2050, 2075 and 2100 under sea level rise associated with climate change conditions. The vulnerability to flooding was found to vary substantially with the topography of each city. For example, more than 80% of the population in the Meghna Delta was found to be vulnerable to flooding, compared with less than 20% of the population of Matara City. In addition to variations in vulnerability, it was also found that different cities had quite different approaches to preparedness for flooding. In particular, Bangladesh was seen to be carefully addressing climate change as part of the overall policy development for flood mitigation, while other countries were less advanced in relevant policy development.

The participants in the risk assessment project agreed that there would be regional benefits from the establishment of a single body to deal with flood mitigation across the region. That body would need to account for climate change in its planning. The participants also saw the need to delineate flood mitigation issues from activities associated with disaster management. On future activities, the participants decided that the analysis methodology could be readily expanded to include other cities, assessment of risks to the natural environment, and sectoral analyses of optimal strategies for adaptation and mitigation.

The complexity of cities requires the enhancement of effective interactions between scientists, engineers, urban planners and policy-makers in order to plan for and mange the impacts of climate change.

Figure 26: APN brings its policy-makers and scientists together for the "Cities at Risk" workshop [Source: Pulhin]

The "Cities at Risk" workshop reached a number of conclusions that included the need for climate change to be recognized as a relevant aspect of urban planning; the need to promote better understanding between scientists and urban planners on differences in space and timescales used by each group in their analyses; the need to identify local champions to implement policy changes; the need to build capacity at both individual and institutional levels; and the need to extend governance arrangements across traditional sectors.

Owing to the involvement of urban planners and policy-makers in the workshop, the recommendations and summaries of the meeting were widely shared with a number of national institutions for planning and management. The results of the workshop fed into other training and adaptation exercises, and the workshop results were disseminated at UNFCCC COP15 in Copenhagen, Denmark in 2009. Workshops continue to be held in the region and a long-term plan for sustaining these is being considered by the APN, START and the East-West Center.

3.7.4. Conclusions and recommendations

As the population continues to increase in the Asia-Pacific region at the same time as urbanization continues to grow rapidly, the challenges of designing and managing urban environments will continue to grow and new strategies will need to be developed. In particular, urban areas are the main consumers of food, water and energy in most Asian countries; hence, they are the main sources of GHG emissions. The rapid development of mega-cities in Asia (especially along coastal areas) exacerbates the issues to be managed. Coastal cities are particularly vulnerable to the impacts of sea level rise. In order to manage the range of issues associated with urbanization, there is a need to promote links between scientists, engineers and technologists, urban planners and policy-makers to enhance the integration of knowledge across sectors.

Specific recommendations for coastal cities include:

- Encourage the urban planning community to take a comprehensive view of climate risks, including variability.
- Recognize and promote the importance of identifying champions in urban governments to help make climate change a priority.
- Acknowledge gaps in knowledge and invest in learning strategies.
- Move from the traditional top-down impact modelling approach to a critical threshold approach.
- Communicate science and vulnerability more effectively.
- Build capacity for individual and institutional participation in responding to climate change in Asia's coastal megacities.
- Effective overall governance is essential at the systemic level in mainstreaming adaptation strategies.

3.8. Climate Change Policy and Outreach

3.8.1. Issues and significance

Research in climate and climate change science has taken great strides in recent years and APN has been contributing significantly in promoting and facilitating such research. Making good use of climate change science is important for the benefit of humanity and, for this; climate change science has to be appropriately mainstreamed into the development process. This is a major issue and a great challenge. To address this challenge, policy-makers and decision-makers must be provided with appropriate scientific knowledge on climate change including the uncertainty associated with future climate prediction. Therefore, the climate science community has to work toward effectively communicating climate change science to those at the policy- and decision-making levels. Such activities will help narrow the gap between science and policy-making communities.

APN facilitated the mainstreaming of climate change science into the development process and bridging the gap between the scientific community and policy-makers.

APN addresses this issue through its core strategies, one of which "*promotes and encourages policy-relevant regional global change research*" and with one of its main goals of "*strengthening appropriate interactions among scientists and policy-makers, and providing scientific input to policy- and decision-making processes, and scientific knowledge to the public*".

APN facilitated disseminating results of climate change science to policy- and decision-makers as well as to people and communities; and explored means to undertake this task for different groups of people.

APN has been addressing the issue of policy outreach and effective science and policy interactions through its core research (ARCP) and capacity building (CAPaBLE) programmes, and has been systematically evaluating its performance in this area. While steps to enhance this area are taking place, more momentum is needed to reach a "striding" level that will make a difference. Steps taken have included invitations to researchers to submit proposals in the areas of science-policy communications and interactions in GC, as well as invitations, particularly under CAPaBLE, to the Asia-Pacific community including end-users and decision-makers, to submit proposals on relevant science for smooth decision-making in areas of adaptation and mitigation. APN will embark on a series of "Science-Policy Fora" with its GC partners in the near future.

3.8.2. Scope of the activities

APN, as an intergovernmental network, has been working to produce sound scientific results in climate variability and change through its ARCP Programme. APN has made significant progress in achieving good results and many of these are published in peer reviewed scientific journals. However, mainstreaming the results of development processes of participating countries is an area that requires strengthening. At the same time, the APN attempts to provide underpinning science that is policy-relevant rather than policy-prescriptive. The main question is how to best feed scientific results into policy-making processes in the Asia-Pacific region?

Seven (7) projects were funded by APN to address science-policy interaction and outreach. Based on their objectives, the projects can be categorized into two groups: i) Climate change policy; and ii) Outreach. These two categories are dealt with separately in terms of their scope and outcomes.

3.8.3. Climate change policy

The main activities undertaken by APN projects dealing with climate change policy are highlighted here:

- Collaboration among countries in the Asia-Pacific region helped create greater awareness of climate change policy issues of individual participating nations. In this regard, attempts were made to analyze possibilities and constraints in developing collaboration among countries in Temperate East Asia including China, Japan, Republic of Korea and Russia. Possible activities were explored that had substantial financial benefit for the participating countries, such as CDM projects. At the same time, the activity identified barriers in efficiency, coordination, capacity and information fields in governmental mechanisms of the countries involved.
- There were efforts shown by projects to create a suitable atmosphere to allow for appropriate interactions between policy-makers to discuss and communicate climate-related issues.
- One APN-funded global-level activity, which was held in the Philippines, facilitated capacity building towards the preparation of national communications to the UNFCCC and especially targeted non-Annex I countries. The activity involved 50 countries and 11 organizations including governmental and non-governmental organizations.
- In order to convey climate change concerns to policy-makers, it is necessary to have appropriate techniques and skills in "negotiations" language in the international policy arena. For this purpose, APN workshops were conducted to strengthen the capacity of PICs to participate in not only UNFCCC/COP processes, but other international policy-level fora as well.
- Forestry is considered a significant contributor to GHG concentrations in the atmosphere through unsustainable forestry practices. Conferences and training workshops have been conducted on concepts and methods to transform research activities in the field of forestry and forest governance into usable information for problem solving and policy-making.

Outcomes

- Participants were trained in preparing national communications for UNFCCC processes.
- Participants developed the skills required to negotiate in UNFCCC processes and to effectively discuss climate change issues with policy-makers from their respective countries.
- Participants exchanged scientific knowledge on climate change research and its impacts in sectors such as forestry and forestry management. Participants also learned about best practices to work at the interface of forest science and forest policy.

3.8.4. Outreach

In addition to the activities mentioned above, it is equally important to disseminate available climate knowledge and information to all communities, including those at the grassroots level. This provides a better understanding of the science behind climate change and enhances capabilities to interact with leaders from various backgrounds and professions, such as agriculture, livestock, water resource management, health and other sectors influenced by weather and climate. Some of the salient features of the APN's outreach projects are outlined here.

- Projects conducted significant numbers of seminars and meetings to disseminate climate change knowledge, including the adaptation and mitigation aspect. One project based in Sri Lanka conducted 25 public seminars, with participants from a broad range of backgrounds.
- Depending on geographical location, projects were able to innovate unique ways to disseminate climate change messages. In Cambodia, for example, an APN project developed a Mobile Environmental Education Programme (MEEP) to raise awareness about climate change among communities around a lake area.
- Likewise, one case of a project conducted in the Pacific Islands is especially unique. In Fiji, Tuvalu and the Solomon Islands, workshops were conducted incorporating drama and theatre performances to raise awareness of the climate risks posed to Pacific Island communities.

Figure 27: Youth in the Pacific discuss likely impacts of climate change in 50 years [Source: Aalbersberg]

Figure 28: Diagram depicting a process that involves Pacific Island communities in climate change awareness-raising activities [Source: Aalbersberg]

The community-level audiences were then exposed to tailored exercises that improved their understanding of climate change and allowed participants to discuss risk assessment strategies (***Figures 27 and 28***).

Outcomes

- In Sri Lanka, 3448 participants including decision- and policy-makers were involved in an awareness raising campaign on climate change issues.
- Projects were successful in drawing the attention of decision- and policy-makers in dealing with climate change-related issues.
- Manuals and video tapes were prepared especially for PICs to facilitate climate change drama and risk assessment workshops. This specific project provided "training trainers" manuals to ensure sustainability at the community level.

3.8.5. Conclusions and recommendations

As part of the main aim of the APN, projects were able to promote awareness and provide communication materials including manuals, videos, and peer reviewed papers, targeting stakeholders from the science, policy, end-user and civil society communities.

According to geographic and socio-economic parameters, different options were adopted to convey the science of climate change to all stakeholders, as demonstrated in the PICs and Cambodia in particular. Small islands and mountainous countries, such as the Himalayas, with varied cultural and economic backgrounds have to be approached tactfully to ensure their communities, including policy- and decision- makers, are made aware of climate change and the risks and consequences posed. Some of these were taken up by APN projects in effective and unique ways.

Communities were given details on APN activities, which were considered essential to successfully undertake climate change policy and outreach activities in the smaller and least-developed Asia-Pacific countries. The number of individuals involved in seminars and workshops was significantly noteworthy.

One of the main aims of the APN is to sustain project activities in the participating countries beyond the period of APN funding. In this case, mechanisms and indicators to measure the sustainability factor should be developed and implemented by the APN.

4 Emerging Issues and Priorities

While substantial progress has been made by APN-supported projects on climate science, capacity building and policy outreach, much remains to be done in the Asia-Pacific region. Among the key trends impacting the region are rising population, increasing urbanization, globalization, rapid economic development, rising energy demand, massive land-use change, and an increase in extreme weather events related to global warming.

This chapter outlines the pressing issues and priorities that APN might wish to address in its future strategic planning, particularly through its funding process. These issues and priorities are those supportive of its main goals.

4.1. Science and Research (APN Goal 1)

Many countries in the Asia-Pacific region are very vulnerable to climate variability, extreme weather events and climate change. Agriculture and food security depend on timely availability of weather and climate information. More accurate seasonal climate forecasts are lacking in many countries in the region. Multi-year climate models/predictions are needed for agriculture and other sectors. Modelling the effects of climate on agriculture and fishery production needs to be refined. Critical to climate adaptation research, practice, and policy are downscaled climate data. There is a need for RCMs which can help localize GCM results. Especially problematic are Small Islands States and areas with rough and steep terrain like those of the Himalayas.

In an effort to build strategies to enhance resilience, there is a need to further investigate climate variability and trends at the regional level. Climate drivers at the regional level are still poorly understood. Apart from reliable climate data, consistent socio-economic data collection is also needed for development of IAMs. The increasing frequency and severity of floods, droughts and extreme temperatures require use of appropriate indices so as to improve monitoring and prediction of these extreme events.

Vulnerability assessments have been conducted in previous APN projects. However, vulnerability assessment of cities is still not well understood. This is critical as more and more people choose to live in cities and urbanized areas. Coastal cities in the region are particularly vulnerable to rising sea levels, storm surges and more intense typhoons.

Adaptation strategies for decadal climate change in various sectors (e.g. food, water, urban sectors) are insufficient and more adaptation options are needed. The link between climate adaptation and disaster risk reduction (DRR) has to be encouraged as they share many common determinants and goals. Planning at the local and national levels for climate-related hazards such as floods and drought needs to be strengthened. Attention must be given to community-based climate adaptation since this is where the most vulnerable are in developing countries. Technology transfer to developing countries should be increasingly encouraged.

The effects of climate on water resources have been studied in previous APN projects but many issues remain woefully unclear. There is a need for models to predict the effects of seasonal to inter-annual climate on water supply. Projected water supply and demand in cities and in rural areas must be considered. Watershed and water management models need to be coupled with crop simulation models to optimize water use efficiency for food production. Special attention should be given to the Hindukush-Karakoram-Himalaya region, which feeds Southeast Asia's major rivers. Further research using advanced Remote Sensing (RS) and GIS techniques is required to monitor snow cover and temporal changes in the major glaciers in the region. In tropical regions of Asia, water-conserving agricultural practices must be identified.

Urbanization, which is a ubiquitous phenomenon in the Asia-Pacific region, needs to be better understood. Its effect on food, water and energy supply could be very significant. For example, many peri-urban areas, which used to be highly productive farms, have now been converted to housing villages and industrial zones. Migration of young people to cities could leave rural areas without a young skilled labour force threatening food production. In addition, the continued growth of Asian cities has led to severe pollution problems and overcrowding.

Coastal cities are also highly vulnerable to sea level rise and storm surges. Further research is needed to identify appropriate adaptation measures, strategies, and policies in response to further sea level rise. Similarly, small islands are especially vulnerable to sea level rise and research is required into relocation or engineering options.

Most countries recognize the need to reduce their emissions and move towards a low carbon society and mitigation options, such as solar, wind, tidal, wave, biomass, and hydro; fusion or fission power for base load power generation appear to be well understood. However, wide variations exist in GHG emissions between countries, from fossil fuel emissions in China to deforestation in Indonesia and reduction in agricultural emissions from rice fields and livestock. Research is needed to help identify cost-effective and socially acceptable mitigation options that take into account country-specific conditions and economic development. Appropriately designed models that take into account these factors can help validate mitigation options. Among the issues that need to be addressed include large base load energy consumption especially in cities, appropriate farming management practices including the role of trees and forests, and sustainable agricultural practices. Urban design options (e.g. green areas) need to be identified to minimize the heat-island effect. There is also a need to improve national capacity to conduct GHG inventories including the generation of and access to activity data and emission factors. On a regional and national scale, transitions towards a low carbon economy should be explored.

The emerging global market for GHG offers an opportunity for developing countries to participate in climate change mitigation while helping meet their sustainable development goals. However, there is little benefit to the poor both in urban and rural areas. For example, there is much discussion on REDD but it is not clear how small farmers and local communities will benefit. Research is needed to elaborate mechanisms to ensure that the poor benefit from the GHG market including supporting sustainable development.

There is a need to support international efforts to promote open access to all climate data including socio-economic data, as agreed under the UNFCCC.

4.2. Policy and Outreach (APN Goal 2)

In spite of a number of activities to encourage science and policy links, there is still a large gap between the science community and policy-makers. One reason for this is the asymmetry between the time horizon of scientists (up to decades) and policy-makers (often less than two years). More innovative approaches need to be devised to help bridge this gap. One way to do this is by supporting local champions. The flow of communication between experts and decision-makers needs to be studied and facilitated through the identification and study of issues that connect science and policy in a more coherent way. This could be followed by communicating case studies that highlight successful unification of science and policy (referred to as *operationalization of the research*). Disaster management may be a connecting issue to facilitate links between science and policy.

Close collaboration between experts and media organizations needs to be supported to assist in the mainstreaming of climate information in various sectors. The role of farmer groups and associations to spread collective knowledge that farming communities have on climate and crop management need to be explored.

On a wider front, climate policies and programmes need to be mainstreamed or integrated into national and local development planning. This is to affirm that addressing climate issues share common goals and determinants with sustainable development.

4.3. Capacity Building (APN Goal 3)

Capacity building of human resources continues to be important for many countries in the Asia-Pacific region. This activity should focus on the following areas:

(1) Seasonal to inter-annual forecasts critical to agricultural risk management
(2) Integrated regional assessment models
(3) Sustainability issues in capacity development projects
(4) Vulnerability assessments
(5) Climate change mitigation
(6) Improving institutional capacity to undertake quality GHG inventories

APN has supported many scientific capacity development projects. Long-term impact assessments of these projects may now be conducted to glean lessons for future projects. Innovative impact assessments including both quantitative and qualitative indicators should be implemented with in-depth case studies to better reflect APN's influence in developing countries. The sustainability of APN projects should also be evaluated bearing in mind that continuation of capacity building outcomes can be manifested in different forms such as in the widening influence of APN grantees.

4.4. Cooperating and Networking (Goal 4)

Countries in the Asia-Pacific region need to enhance cooperation and networking. Links between regional and global climate modelling communities must be supported especially in the use of RCMs in various sectors.

Targeted climate synthesis and integration into applied risk management are required at the farm level. This requires new institutional arrangements and multidisciplinary partnerships especially between meteorological offices, ministries of agriculture and local farming communities.

There is also a need to promote links between science and technology communities.

Some level of donor coordination of support to developing countries is critical. APN should explore the formation of links with large multi- and bi-lateral donors for greater effectiveness and leveraging of resources.

5 Conclusions and Recommendations

Human activities and the natural environment of Asia and the Pacific are influenced profoundly by the climate of the region. Food and water security depend vitally on local climate, and they are susceptible to the natural variability of climate and to the trends associated with anthropogenic climate change. ***Investments by APN in projects aimed at improving our understanding of the climate of the region, at assessing the risks to society and nature from climate variability and change, and at raising awareness of these issues to decision-makers and the public are well justified in terms of need and benefits.***

For more than a decade, the APN has supported a range of activities related to the climate of the Asia-Pacific region. The scope of activities has extended from leading-edge research on the climate of the region, to forums for dialogue between scientists and decision-makers, and to public meetings to raise awareness of climate change issues. ***Formal assessments and literature citations have demonstrated that these activities have been effective and of high quality.***

In Chapter 2 we have outlined the scope of APN activities in climate research and highlighted some of the outstanding projects. Chapter 3 provides an overall synthesis of the work supported by the APN. Each project has focused on regionally important issues, and has led to significant outcomes as indicated by approximately 100 publications in the scientific literature (***Appendix 3***), citations by the IPCC, and impacts on decision-makers and the public.

While the activities of APN have been comprehensive, there are a number of emerging issues that will need to be taken into consideration as the APN plans its future directions, these issues are discussed in Chapter 4. In summarizing the results of this synthesis, a number of overarching conclusions have become apparent.

It is clear that many projects are extremely successful in their own right, but they should provide a basis for further activity that can be sustained over a longer term. The APN however is not able to continue to fund activities indefinitely and the resources of many institutions in developing countries are insufficient to sustain such activities. ***Given the high quality of APN projects and the potential of many to yield longer-term benefits through the provision of marginal resources, there should be an investigation of innovative means to sustain such projects beyond the term of initial APN support.*** A particular focus should be placed on attempts to employ the strategy of "training trainers," where it must be recognized that trainers need continuous training and support, for example through engagement with local tertiary education institutions.

A key factor in assessing the longer-term impact of research and related activities is the development of indicators of impact that can be used to monitor the benefits of APN and other investments. This issue is internationally recognized as important, yet difficult. ***Strategic planning of APN would benefit***

by ensuring that it maintains close contact with the relevant international developments of indicators on the impact of research and capacity building activities.

Science has benefited over the last century by focusing on the analysis of a problem within its specific discipline. However, the impact of climate across disciplines and societal sectors means that climate activities are essentially multi-disciplinary. It is apparent that modelling provides a mechanism to bring together the complex crosscutting aspects of multi-disciplinary problems. In recent decades, a hierarchy of models has been developed with varying balances of complexity and depth in any one aspect. ***The APN should continue to recognize the benefits of applying appropriate models to assist the integration and synthesis of information in complex systems.***

There is increasing attention to issues associated with adaptation to climate change. Currently, the focus is on assessing vulnerabilities and identifying adaptation options. ***The complexity of adaptation due to the multidisciplinary nature of the solutions required and the lack of long-term data poses a great challenge.*** Approaches that involve communities and local governments to incorporate climate change adaptation practices into development planning will be needed, and IAMs will need to be customized for local to regional and sectoral levels.

Climate change and variability affect almost all sectors of society as well as the natural environment. Food and water security as well as energy efficiency are closely linked to climate on a range of scales. These links mean that ***the effective application of climate knowledge to practical problems of societies across the Asia-Pacific region requires effective dialogue across the traditional boundaries of science, technology and policy.*** The APN has been active in promoting the required dialogues but as climate change continues to impact across our societies these interactions will become more critical.

The importance of cross-sectoral interactions is especially clear when the relationship between climate and sustainable development is considered. There must be advancement in the economic status and well-being of developing societies across the Asia-Pacific, while simultaneously recognizing the need to mitigate and adapt to the impacts of climate change and variability. ***The APN has a role to play in promoting research in the region that clarifies the strategies that lead to true sustainable development.***

The Asia-Pacific region has a rich variety of cultures and the APN has been effective in promoting connections and alliances across all of these cultures. This effectiveness comes from recognition of cultural differences and not imposing a monolithic approach. These sensitivities to culture will be especially important as the APN continues to promote exchanges of knowledge on climate-related issues across disciplines and sectors.

The exchange of knowledge is ultimately dependent upon access to and exchange of observed data. The open exchange of climate related data, which extends from traditional records of temperature and rainfall to socio-economic data that quantify the impacts of climate variability and change on societies, benefits all nations by allowing the regional and global scale features of climate to be documented and understood. These larger scale features provide a vital context for interpreting national scale features and trends. The increasing connections between economies and societies provide greater incentives to enhance understanding of larger scale features. ***It is in the interest of all countries of the APN to promote the open exchange of climate-related data.***

Clearly, the most important aspect of interactions across a region is the human factor. The APN has been effective in promoting innumerable networks of participants in its projects related to climate. These networks have involved scientists from a range of disciplines, urban planners, policy-makers, natural resource managers, farmers and the general public. In addition to establishing such networks, the APN should strive to maintain them beyond the term of specific projects. ***One potential element in the development of sustained networks is through the engagement of young people who can carry their scientific and social networks into the future.***

Appendix 1: Tables and Figures

Table 1: List of 56 Climate Projects

CS Project (CSP#)	Project Reference	Project Leader	Title	Collaborating Countries	Regional Focus	Major Outcomes	APN Website
CSP1	1998-01 1999-05 2000-05 2001-05 2002-02	Congbin FU	Continuation of Regional Climate Modelling (RCM) Development	Australia, India, Italy, Japan, P.R. China, Republic of Korea, and USA	Asia	Extensive data archive, two workshops, inter-comparison methodologies and results, and development of a web-based platform for regional climate modelling.	http://www.apn-gcr.org/newAPN/resources/projectBulletinOutputs/finalProjectReports/1998/1998-01fr.pdf
CSP2	1998-02	C. M. FINLAYSON	Vulnerability Assessment of Major Wetlands in the Asia-Pacific Region	Australia, Philippines and China	Asia-Pacific	Increased awareness on concepts of climate change and sea level rise, and coastal vulnerability assessment; Vulnerability assessment reports.	http://www.apn-gcr.org/newAPN/resources/projectBulletinOutputs/finalProjectReports/1998/1998-02fr.pdf
CSP3	1998-03 1999-13 2001-01 2002-01 2003-01	Michael MANTON/ Neville NICHOLLS	Asia-Pacific Workshop on Indicators and Indices for Monitoring Trends in Climate Extremes	Australia, Cambodia, Fiji, French Polynesia, Japan, Indonesia, Malaysia, Myanmar, New Caledonia, New Zealand, Pakistan, Papua New Guinea, P. R. China, Philippines, Republic of Korea, Solomon Islands, Thailand and Viet Nam.	Southeast Asia and the Pacific	Developed new knowledge on local / regional climate extremes and trends in APN countries - by building on data and capabilities from within these countries, through providing training and tools. Results were used in IPCC assessments.	http://www.apn-gcr.org/newAPN/resources/projectBulletinOutputs/finalProjectReports/1998/1998-03fr.pdf
CSP4	1998-06	Xiulian HU / Jiang KEJUN/P.R. SHUKLA	International Workshop for Integrated Assessment Model (IAM)	Key IAM teams from USA, the Netherlands, Japan, Austria, and researchers from Asian countries including India, Korea, Viet Nam, Mongolia, Philippines and China presented their research activities.	East Asia	Brought together people from developed and developing countries to exchange information and experience, and to strengthen the capacity for East Asian countries to apply IAMs.	http://www.apn-gcr.org/newAPN/resources/projectBulletinOutputs/finalProjectReports/1998/1998-06fr.pdf

CS Project (CSP#)	Project Reference	Project Leader	Title	Collaborating Countries	Regional Focus	Major Outcomes	APN Website
CSP5	1999-07	Richard WARRICK	The Use and Extension of PACCLIM Integrated Model for Climate Change Vulnerability and Adaptation Assessment in Pacific Island Countries	Australia, New Caledonia, New Zealand, United States of America, Cook Islands, Federated States of Micronesia, Fiji, Kiribati, Marshall Islands, Nauru, Samoa, Solomon Islands, Tuvalu, Vanuatu, Niue, Papua New Guinea, Tonga	Pacific	Capacity building on the use of PACCLIM prototype model; 35 people attended the training.	http://www.apn-gcr.org/newAPN/resources/projectBulletinOutputs/finalProjectReports/1999/1999-07fr.pdf
CSP6	1999-11	John L. MCGREGOR	Analysis of Climate Change Simulations of Southeast Asia	Australia, Cambodia, Fiji, India, Indonesia, Malaysia, Papua New Guinea, Philippines, Samoa, Singapore, Thailand, Viet Nam	Southeast Asia	15 participants sponsored by APN were trained in the analysis of large data sets produced by regional climate simulations.	http://www.apn-gcr.org/newAPN/resources/projectBulletinOutputs/finalProjectReports/1999/1999-11fr.pdf
CSP7	1999-12 2000-12 2001-12	Yihui DING	Monitoring and Prediction of ENSO Event and SSTA over the Warm Pool in the Western Pacific Ocean	Australia, China (including Hong Kong and Macao), Indonesia, Japan, Malaysia, Philippines, Republic of Korea, United States and Viet Nam	Western Pacific	Collection of data and information relative to ENSO and the warm pool; Establishment of website; International workshop on seasonal to inter-annual monitoring and prediction of ENSO events	http://www.apn-gcr.org/newAPN/resources/projectBulletinOutputs/finalProjectReports/2001/2001-12fr.pdf
CSP8	1999-15	Hassan VIRJI	CLIMAG-Asia Scoping Workshop	Australia, Fiji, Indonesia, Japan, Philippines, Thailand and USA	Pan Asia	The major product of the meeting was a draft proposal for each of the candidate projects.	http://www.apn-gcr.org/newAPN/resources/projectBulletinOutputs/finalProjectReports/1999/1999-15fr.pdf
CSP9	2000-03	Eileen L. SHEA	Training Institute on Climate and Society in the Asia-Pacific Region	Australia, Bangladesh, China, Cook Islands, Fiji, India, Indonesia, Pakistan, Philippines, Papua New Guinea, Sri Lanka, Thailand and Viet Nam. In addition, resources from the NOAA Office of Global Programs were used to support a highly qualified participant from Ethiopia.	Asia-Pacific	Creation of a regional network of individuals actively engaged in the development and use of climate information to support economic development, community planning, resource management and practical decision-making in key sectors throughout the region.	http://www.apn-gcr.org/newAPN/resources/projectBulletinOutputs/finalProjectReports/2000/2000-03fr.pdf

CS Project (CSP#)	Project Reference	Project Leader	Title	Collaborating Countries	Regional Focus	Major Outcomes	APN Website
CSP10	2000-04 2001-10 2003-11	Jim SALINGER	APN Workshop on Climate Variability & Trends in Oceania	Australia, Cook Islands , Fiji, French Polynesia, New Caledonia, New Zealand, Niue, Papua New Guinea, Samoa, Solomon Islands, Tonga, Tuvalu and Vanuatu.	Oceania	Development of closer collaboration between climate researchers in the region; capacity building for assessment of historical climate in the Pacific; Development of Metadata to support global change and variability research.	http://www.apn-gcr.org/newAPN/resources/projectBulletinOutputs/finalProjectReports/2003/2003-11.pdf
CSP11	2000-17	Holger MEINKE	Management Responses to Seasonal Climate Forecasts in Mixed Cropping Systems of South Asia's Semi-Arid Tropics (CLIMAG)	Australia, India, Pakistan and USA	South Asia	Site visits for collection of data and analysis of seasonal weather patterns and effects on agriculture in India and Pakistan; Workshop consisting of an analysis of site visits; Showcased results at Training Institute on Climate Variability and Society in the Asia-Pacific Region.	http://www.apn-gcr.org/newAPN/resources/projectBulletinOutputs/finalProjectReports/2000/2000-17fr.pdf
CSP12	2001-07	Hideaki NAKATA	Workshop on the Causes and Consequences of Climate-Induced Changes in Pelagic Fish Productivity in East Asia	China, Japan, Malaysia, Republic of Korea and USA	East Asia	The identification of target species and the identification of subjects for future research in the region.	http://www.apn-gcr.org/newAPN/resources/projectBulletinOutputs/finalProjectReports/2001/2001-07fr.pdf
CSP13	2002-07	Jim SALINGER	International Workshop on Reducing Vulnerability of Agriculture and Forestry to Climate Variability and Climate Change	Australia, Bangladesh, Cook Islands, Fiji, India, Indonesia, Malaysia, Maldives, Mongolia, Nepal, New Zealand, Pakistan, P. R. China, Philippines, Russia, Sri Lanka and Viet Nam	Asia-Pacific	Enabled APN scientists to interact with experts and scientists from other regions; Workshop papers were featured in an issue of Climate Change; Summary Report translated into 6 languages and distributed to all co-sponsors.	http://www.apn-gcr.org/newAPN/resources/projectBulletinOutputs/finalProjectReports/2002/2002-07fr.pdf
CSP14	2000-15 2001-15	Tae Yong JUNG	Policy Design of Climate Change Collaboration in Northern Asia: Possible Options and Constraints for Cooperative Efforts between Russia, Japan, China and Korea	China, Japan, Republic of Korea, Russia	Temperate Asia	Analysis of co-operative efforts in establishing UNFCCC regulations between the 4 countries; Assessment of Russia's role in and affect on Climate Change; Identification of future research and collaborative opportunities.	http://www.apn-gcr.org/newAPN/resources/projectBulletinOutputs/finalProjectReports/2001/2001-15fr.pdf

CS Project (CSP#)	Project Reference	Project Leader	Title	Collaborating Countries	Regional Focus	Major Outcomes	APN Website
CSP15	2001-18	Nguyen Huu NINH	Training Workshop on Forecasting El Niño and La Niña in Indochina	Australia, Cambodia, Laos, Myanmar, Thailand, United Kingdom, USA and Viet Nam	Southeast Asia	The meeting provided further understanding of El Niño and La Niña with specific relation to work area of participants and opportunity for discussion with participants from the region and international advisors on mutual problems and future collaborations.	http://www.apn-gcr.org/newAPN/resources/projectBulletinOutputs/finalProjectReports/2001/2001-08fr.pdf
CSP16	2002-10	R. K. GUPTA	Climate Variability and Rice-Wheat Productivity in the Indo-Gangetic Plains	Australia, Bangladesh, Germany, India, Japan, Nepal, New Zealand, Philippines, and USA.	South Asia	Identification of key areas in field research and modelling, as well as, key issues in the rice-wheat systems that need immediate attention.	http://www.apn-gcr.org/newAPN/resources/projectBulletinOutputs/finalProjectReports/2002/2002-10fr.pdf
CSP17	2002-09-NMY 2003-02-CMY 2004-01-CMY	Holger MEINKE	Applying Climate Information to Enhance the Resilience of Farming Systems Exposed to Climatic Risk in South and Southeast Asia	Australia, USA, India and Indonesia	South and Southeast Asia	An international, multi-disciplinary network of systems scientists who are committed to the creation of "actionable climate knowledge" by building partnerships with stakeholders; Better understanding of climate variability impacts and climate-related vulnerabilities; A consortium of partners to build and extend the existing nodes and pilot studies.	http://www.apn-gcr.org/newAPN/resources/projectBulletinOutputs/finalProjectReports/2004/2004_01_CMY-Meinke.pdf
CSP18	2004-17-NSY	Sulochana GADGIL	Climate Prediction and Agriculture: An Assessment and Perspective	Indonesia, Viet Nam, India and China	Southeast Asia	Review and assessment of the application of forecasts of seasonal and intra-seasonal climate variability to agriculture production published in Climatic Research; Identification of gaps in knowledge, tools and methodologies, capacity building priorities and institutional needs.	http://www.apn-gcr.org/newAPN/resources/projectBulletinOutputs/finalProjectReports/2004/2004_17_NSY-Gadgil.pdf

CS Project (CSP#)	Project Reference	Project Leader	Title	Collaborating Countries	Regional Focus	Major Outcomes	APN Website
CSP19	2005-06-NSY	Julie BRIGHAM-GRETTE	PAGES Second Open Science Meeting	Australia, China, India, Japan, Mongolia, Nepal, New Zealand, Russia, USA	Global activity	Brought together paleoscientists from various disciplines and background (as well as environmental historians and modelers); Facilitated successful dialog and networking between participants from 45 countries; Boosted visibility of paleoresearch in China.	http://www.apn-gcr.org/newAPN/resources/projectBulletinOutputs/finalProjectReports/2005/APN2005-06-NSY-Brigham-Grette.pdf
CSP20	2005-10-NSY	Muhammad Munir SHEIKH	Development and Application of Climate Extreme Indices and Indicators for monitoring Trends in Climate Extremes and their Socio-Economic Impacts in South Asian Countries	Bangladesh, India, Nepal, Pakistan, Sri Lanka, Australia and USA	South Asia	Data collected yielded trend changes in 19 core climate indices; Enhanced capacity building and strengthened collaboration between participating countries.	http://www.apn-gcr.org/newAPN/resources/projectBulletinOutputs/finalProjectReports/2005/APN2005-10-NSY-Sheikh.pdf
CSP21	CBA2005-14-NSY	John CAMPBELL	Community relocation as an option for adaptation to the effects of climate change and climate variability in Pacific Island Countries (PICs)	Kiribati, New Zealand, Papua New Guinea, Solomon Islands, United States of America, Vanuatu	Pacific	Identified various issues concerning costs, land tenure, and political borders; Developed steps that might be considered in relocation decision-making.	http://www.apn-gcr.org/newAPN/resources/projectBulletinOutputs/finalProjectReports/2005/APN2005-14-NSY-Campbell_FinalReport%20formated-no%20appx.pdf
CSP22	2005-15-NSG	Nirmalie PALLEWATA	Climate change impacts on the ecology of the rice pest complex and the resulting threat to food security and farming economy in South Asia	Bangladesh, India, Pakistan, Sri Lanka	South Asia	The workshops refined and provided a final proposal that was submitted to the APN Call for Proposals 2005.	http://www.apn-gcr.org/newAPN/resources/projectBulletinOutputs/finalProjectReports/2005/APN2005-15-NSG-Pallewatta.pdf
CSP23	ARCP2006-10-NMY ARCP2007-05-CMY	Rodel LASCO	Linking Climate Change Adaptation to Sustainable Development in Southeast Asia	Indonesia, Lao PDR, Philippines, Viet Nam	Southeast Asia	Activities helped identify most appropriate climate change adaptation strategies for natural resources, agricultural sector, and rural areas; Synthesized recent climate change adaptation and related research in the region; Results used for capacity building of national decision-makers.	http://www.apn-gcr.org/newAPN/resources/projectBulletinOutputs/finalProjectReports/2007/ARCP2007-05CMY%20Lasco_Final%20Report.pdf

CS Project (CSP#)	Project Reference	Project Leader	Title	Collaborating Countries	Regional Focus	Major Outcomes	APN Website
CSP24	ARCP2006-12-NMY ARCP2007-06-CMY	Samsul HUDA	Climate Crop Disease Risk Management: An International Initiative in the Asia-Pacific Region	Australia, India, Bangladesh, Cambodia, the Netherlands and USA	Asia-Pacific	Created a collaborative network between scientists and policy-makers; Identified, adapted, and tested 2 climate and crop disease models; Provided a regional focus for research in climate and disease risk management. Developed ideas and planned new network activities and research projects.	http://www.apn-gcr.org/newAPN/resources/projectBulletinOutputs/finalProjectReports/2007/ARCP2007-06CMY-Huda%20Project%20Final%20%20Report.pdf
CSP25	ARCP2007-20-NSG	Won-Tae KWON	Development of Indices and Indicators for Monitoring Trends in Climate Extremes and its Application to Climate Change Projection	Australia, Bangladesh, Cambodia, China, Fiji, India, Indonesia, Japan, Lao PDR, Malaysia, Mongolia, Nepal, New Zealand, Pakistan, Philippines, Republic of Korea, Russian Federation, Sri Lanka, Thailand, USA, Viet Nam	Asia-Pacific	Enhanced close collaboration between APN member countries and allowed recognition of the importance of monitoring and understanding global change in Asia-Pacific region.	http://www.apn-gcr.org/newAPN/resources/projectBulletinOutputs/finalProjectReports/2007/ARCP2007-20NSG-Kwon%20Final%20Report.pdf
CSP26	2003-CB02-NMY 2004-CB03-CMY 2005-CB04-CMY	Kanayathu KOSHY	Training Institute on Climate and Extreme Events in the Pacific	Fiji, USA, New Zealand and PICs (Kiribati and Samoa)	Pacific	Training Institute provided understanding of consequences of climate variability and change, extreme events, etc. on society, economy, and resources.	http://www.apn-gcr.org/newAPN/resources/projectBulletinOutputs/finalProjectReports/2005/APN2005-CB04CMY-Koshy_FinalReport.pdf
CSP27	2003-CB04-NSY	Holger MEINKE	Creating Climate Change Knowledge Networks through Strategic Global Linkages	Australia, Brazil	Asia-Pacific	Identified priority areas of research and methodology in South American based on the Asian experience as case study; Brought focused scientists in Asia together in a knowledge-based network.	http://www.apn-gcr.org/newAPN/activities/CAPaBLE/2011/CSP27-Meinke-FinalReport.pdf

CS Project (CSP#)	Project Reference	Project Leader	Title	Collaborating Countries	Regional Focus	Major Outcomes	APN Website
CSP28	2003-CB05-NMY 2004-CB04-CMY	Maasaki NAITO	Capacity Building in Climate Change Mitigation with Locally Owned Technology and Systems	Japan, India, and China	Asia-Pacific	Information gathered on locally owned technology and systems focusing on China and India; Concepts of ecologically sound technology were summarized and intermediate technologies in energy, water, and sanitation were illustrated.	http://www.apn-gcr.org/newAPN/resources/projectBulletinOutputs/finalProjectReports/2004/2004-CB04CMY-Naito_Final%20Report.pdf
CSP29	2003-CB06-NSY	Martha PERDOMO	UNFCCC Training Workshop for National Climate Change Focal Points on Guidelines for National Communications from Non-Annex I Parties	APN Countries that are parties to the UNFCCC	Asia-Pacific	Attended by 99 experts from Non-Annex I Parties; Participants trained in National Communications; Provided with tools and methodologies to conduct GHG inventories, vulnerability and adaptation assessments, mitigation, etc.	http://www.apn-gcr.org/newAPN/activities/CAPaBLE/2011/2003-CB06-NSY-Perdomo.pdf
CSP30	2003-CB08-NSY-WCRP	Valery DETEMMERMAN	WCRP-01: Conference/ Climate Modelling Workshops on RCMS Travel WCRP-02: Fellowships for Young Scientists to attend the 1st CLIVAR	Young scientists from selected APN member countries	Global activity	Funded 2 scientists from APN region to attend Climate Modelling Workshops on RCMS; Provided travel support for 3 scientists to attend 1st CLIVAR Conference	http://www.apn-gcr.org/newAPN/activities/CAPaBLE/2011/2003-CB08-NSY-WCRP1.pdf http://www.apn-gcr.org/newAPN/activities/CAPaBLE/2011/2003-CB08-NSY-WCRP2.pdf
CSP31	2004-CB01-NSY	Dushmanta DUTTA	An Assessment of the Socio-Economic Impacts of Floods under Climate Change Conditions in Large Coastal Cities in South and Southeast Asia	Bangladesh, India, Pakistan, Sri Lanka and Viet Nam	South and Southeast Asia	Scenario analyses provided comprehensive information for vulnerability assessments; Highlighted the lack of existing policies and strategies dealing with climate change issues in the region.	http://www.apn-gcr.org/newAPN/resources/projectBulletinOutputs/finalProjectReports/2004/2004-CB01-NSY-Dutta_Final%20Report.pdf

CS Project (CSP#)	Project Reference	Project Leader	Title	Collaborating Countries	Regional Focus	Major Outcomes	APN Website
CSP32	2004-CB07-NSY	Michael GLANTZ	Prototype Training Workshop for Educators on the Effects of Climate Change on Seasonality and Environmental Hazards	India, Malaysia, Philippines, P.R. China, Sri Lanka, Thailand, USA and Viet Nam	Southeast Asia	Website set up with links to relevant sites and publications, Created a network of educators.	http://www.apn-gcr.org/newAPN/resources/projectBulletinOutputs/finalProjectReports/2004/2004-CB07-NSY-Glantz-Final%20Report.pdf
CSP33	2004-CB09-NSY	G.H.P. DHARMARATNA	National Climate Change Public Awareness and Outreach in Sri Lanka	Sri Lanka	South Asia	Created awareness of climate change amongst stakeholders.	http://www.apn-gcr.org/newAPN/resources/projectBulletinOutputs/finalProjectReports/2004/2004-CB09-NSY-Dharmarathna_FinalReport.pdf
CSP34	2005-CB01-NSY-GEOSS	Organized by the APN Secretariat in Kobe, Japan; Reports written by Professor LAL	APN Scoping Workshops on Global Earth Observations System of Systems (GEOSS) & the Capacity Building Needs of the Region: Focus Climate	Australia, Bangladesh, China, Cambodia, Indonesia, India, Japan, Korea, Malaysia, Mongolia, New Zealand, Pakistan, Samoa, Sri Lanka, Thailand, and Viet Nam.	Asia-Pacific	Workshops are mentioned in GEOIV documents for presentation at the GEOIV summit in Cape Town in November 2007; Results were disseminated at the 14th UN Commission on Sustainable Development / CAPaBLE Side event	http://www.apn-gcr.org/newAPN/resources/proceedingsAndMeetingReports/workshopsAndMeetings/2nd%20Scoping%20Workshop%20Report.pdf
CSP35	2005-CB07-NSY	Sovannora IENG	Development of a Mobile Environmental Education Programme to Raise Awareness about Climate Change	Cambodia	Southeast Asia	Completed feasibility study and prepared detailed design for MEEP.	http://www.apn-gcr.org/newAPN/resources/projectBulletinOutputs/finalProjectReports/2005/MEEP~Final%20Report~25Jun07-Eng-Pic.pdf
CSP36	2003-CRP01-NMY 2004-CRP01-CMY 2005-CRP01-CMY	Dr. Arshad Muhammad KHAN	Enhancement of National Capacities in the Application of Simulation Models for the Assessment of Climate Change and its Impacts on Water Resources and Food & Agricultural Production	Pakistan, Bangladesh and Nepal	South Asia	Simulation Models (RCMs, WSMs, and CSMs) put to use; 99 personnel trained in Simulation Modelling; 62 personnel trained in Harmonization of Climate Change Research Results	http://www.apn-gcr.org/newAPN/resources/projectBulletinOutputs/finalProjectReports/2005/2005-CRP01-CMY-Khan_CAPaBLE_FinalReport.pdf

CS Project (CSP#)	Project Reference	Project Leader	Title	Collaborating Countries	Regional Focus	Major Outcomes	APN Website
CSP37	2003-CRP02-NMY 2004-CRP02-CMY 2005-CRP02-CMY	Professor P.R. SHUKLA	Integrated Assessment Model for Developing Countries and Analysis of Mitigation Options and Sustainable Development Opportunities	India, Thailand and China	South and Southeast Asia	Contributed to numerous research publications; Website developed for sharing information, capacity building, and research networking.	http://www.apn-gcr.org/newAPN/resources/projectBulletinOutputs/finalProjectReports/2005/2005-CRP02-CMY-Shukla_CAPaBLE_FinalReport.pdf
CSP38	CBA2006-04NMY CBA2007-01CMY	Channa BAMBARADENIYA	Removing Barriers to Capacity Building in Least Developed Countries: Transferring Tools and Methodologies for Managing Vulnerability and Adaptation to Climate Change	Bangladesh, Cambodia, Indonesia, Lao PDR, Malaysia, Mongolia, Nepal, Pakistan, Sri Lanka, Viet Nam	Southeast Asia	Four-day trans-regional consultative workshop that was organized for developing nations in the Asia and Africa regions; Capacity building of developing country experts and national teams.	http://www.apn-gcr.org/newAPN/resources/projectBulletinOutputs/finalProjectReports/2007/CBA2007-01CMY-Bambaradeniya_Final%20Report.pdf
CSP39	CBA2006-08NSY	M.J. SALINGER	International Workshop on Coping with Agrometeorological Risks and Uncertainties: Challenges and Opportunities	Global activity	Global activity	188 participants from 78 countries attended the Workshop; Policy options to cope with agrometeorological risk were presented and appropriate adaptation strategies were discussed.	http://www.apn-gcr.org/newAPN/resources/projectBulletinOutputs/finalProjectReports/2006/CBA2006-08NSY-Salinger_%20Final%20Report.pdf
CSP40	CBA2007-05NSY	Ulka KELKAR	New Risks of Climate Change - Building Capacity to Protect the Most Vulnerable	India	South Asia	Identification of tools and techniques to help policy making related to climate change, Creation of comprehensive web-based database and tools for policy-makers.	http://www.apn-gcr.org/newAPN/resources/projectBulletinOutputs/finalProjectReports/2007/CBA2007-05NSY-Kelkar_APN-Report-Final.pdf
CSP41	CBA2007-07NSY	Bin WANG	Advanced Institute: The Monsoon System - Prediction of Change and Variability	China, India, Malaysia, Pakistan and USA	Asia-Pacific	Brought together early career scientists from APN member countries to learn about advances in the monsoon system; Regional research network was developed.	http://www.apn-gcr.org/newAPN/resources/projectBulletinOutputs/finalProjectReports/2007/CBA2007-05NSY-Kelkar_APN-Report-Final.pdf

CS Project (CSP#)	Project Reference	Project Leader	Title	Collaborating Countries	Regional Focus	Major Outcomes	APN Website
CSP42	CBA2007-09NSY	Moekti SOEJACHMOEN	Capacity Building in Asian Countries on Climate Change Issues Related to Future Regime	Indonesia, Thailand, India, Bangladesh and China,	Asia-Pacific	Series of interactive discussions for researchers and stakeholders; In-country dialogues and brief papers contributed significantly to their country's position and submissions to the UNFCCC process.	http://www.apn-gcr.org/newAPN/resources/projectBulletinOutputs/finalProjectReports/2007/CBA2007-09NSY-Soejachmoen.pdf
CSP43	ARCP2007-11NMY ARCP2008-04CMY	Ji-Hyung PARK	Regional Collaborative Research on Climate Change Impacts on Surface Water Quality in Eastern Monsoon Asia: Towards Sound Management of Climate Risks	Cambodia, China, Indonesia, Malaysia, Republic of Korea, Thailand	Southeast Asia and Temperate East Asia	Identified the complex relationship between climate and surface water quality in East Asia.	http://www.apn-gcr.org/newAPN/resources/projectBulletinOutputs/finalProjectReports/2008/ARCP2008-04CMY-Park-Final%20Report.pdf
CSP44	CBA2006-05NMY CBA2007-02CMY	Bill AALBERSBERG	Climate Change and Variability Implications on Biodiversity – Youth Scenario Simulations and Adaptations	Pacific Island Countries	Pacific	138 youth gained skills in using drama for climate change awareness raising, 127 people gained skills in climate change risk assessment and adaptation planning; Conducted a total 51 climate change theater performances; 10 soft measure adaptation activities were undertaken.	http://www.apn-gcr.org/newAPN/resources/projectBulletinOutputs/finalProjectReports/2007/CBA2007-02CMY-Aalbersberg-FINALREPORT.pdf
CSP45	CBA2006-12NMY CBA2008-01CMY	Rizaldi BOER	Increasing Adaptive Capacity of Farmers to Extreme Climate Events and Climate Variability through Enhancement of Policy-Science-Community Networking	Indonesia	Southeast Asia	10 local scientists were trained in using tools and methods for Climate Risk Management; Improved analytical skills of local scientists to identify critical issues in their region, build technical capacity of local government staff, increase awareness of farmers on value of climate information.	http://www.apn-gcr.org/newAPN/resources/projectBulletinOutputs/finalProjectReports/2008/CBA2008-01CMY-Boer-Final%20Report_2009.pdf
CSP46	CBA2008-03NSY	Karumuri ASHOK	Training Course on Regional Downscaling for Asia-Pacific Region Using APEC Climate Centre Global Seasonal Climate Prediction	Republic of Korea, New Zealand, Russian Federation, Viet Nam, Philippines, Thailand	Asia-Pacific	Participants acquired latest downscaling and climate prediction techniques; Development of new and existing co-operative networks in the region.	http://www.apn-gcr.org/newAPN/resources/projectBulletinOutputs/finalProjectReports/2008/CBA2008-03NSY-Ashok-Final%20Report.pdf

CS Project (CSP#)	Project Reference	Project Leader	Title	Collaborating Countries	Regional Focus	Major Outcomes	APN Website
CSP47	CBA2008-04NSY	Tohru NAKASHIZUKA	Training in Science-Policy Interfacing to Promote the Application of Scientific Knowledge on Adaptation of Forests and Forest Management to Climate Change	Japan, USA, Bangladesh, Cambodia, China, Fiji, India, Indonesia, Lao PDR, Mongolia, Nepal, Pacific Island Countries, Pakistan, Philippines, Sri Lanka, Thailand,Viet Nam	Asia-Pacific	Improved understanding of how to work effectively at the interface of forest science and forest policy; Participants obtained cutting edge knowledge on climate change research and effects on forest management worldwide.	http://www.apn-gcr.org/newAPN/resources/projectBulletinOutputs/finalProjectReports/2008/CBA2008-04NSY-Nakashizuka-Final%20Report-MK030609.pdf
CSP48	CBA2008-06NSY	Roland FUCHS	Cities At Risk: Developing Adaptive Capacity for Climate Change in Asia's Coastal Mega Cities	USA, Bangladesh, Sri Lanka, China, Thailand, Japan, Australia, Indonesia, Singapore, Malaysia, India, Pakistan, Viet Nam, Republic of Korea, Philippines	Asia	Initiated a dialogue between scientists, urban planners, representatives of disaster management and development agencies concerning emerging risks and challenges faced by megacities due to climate change; Examined potential vulnerabilities and current coping mechanisms.	http://www.apn-gcr.org/newAPN/resources/projectBulletinOutputs/finalProjectReports/2008/CBA2008-06NSY-Fuchs-FinalReport.pdf
CSP49	CBA2008-09NSY	Linda PEÑALBA	Enhancing the Climate Change Adaptation Capacity of Local Government Units and Scientists in the Philippines	Philippines	Southeast Asia	Better understanding of participants of climate change and the need for climate risk preparedness; Established partnerships between public educational institutions, communities and local government units concerning science based adaptation planning.	http://www.apn-gcr.org/newAPN/resources/projectBulletinOutputs/finalProjectReports/2008/CBA2008-09NSY-PenalbaFinalReport.pdf
CSP50	2004-CB08-NSY	Michio KISHI	Toward Quantitative Understanding of the Natural Fluctuations of Marine Coastal Fisheries of Sardines and Anchovies and their Impact on Fishing-Dependant Human Communities	Bangladesh, India, Japan, China and USA	Asia	Planned to initiate a review paper on processes that affect sardine and anchovy populations; Development of growth models for sardine and anchovy feeding behaviour and inter-species energetic; Apply and expand the NEMURO.FISH model to include sardine and anchovy populations; Analyze existing field data to compare and quantify response of sardine and anchovy populations to environmental conditions.	http://www.apn-gcr.org/newAPN/resources/projectBulletinOutputs/finalProjectReports/2004/2004-CB08-NSY-Kishi_FinalReport.pdf

CS Project (CSP#)	Project Reference	Project Leader	Title	Collaborating Countries	Regional Focus	Major Outcomes	APN Website
CSP51	2003-CB03-NMY 2004-CB05-CMY 2005-CB05-CMY	Hideaki NAKANE	Capacity Development for Greenhouse Gas Inventory Development in Asia-Pacific Developing Countries	Japan, Cambodia and Thailand	Asia-Pacific	Improved availability of local information and data and standard forest measurement was learnt in Cambodia; Constructed, tested, and confirmed a semiconductor sensor and identified the potential of utilizing the laser gas detector for measurement of methane flux in Thailand; Progress and outcomes of above projects were discussed at a subsequent Workshop.	http://www.apn-gcr.org/newAPN/resources/projectBulletinOutputs/finalProjectReports/2005/2005-CB05CMY-Nakane_FinalReport(submission).pdf
CSP52	CBA2006-06NSY	Sirintornthep TOWPRAYOON	Greenhouse Gas (GHG) and Aerosol Emissions Under Different Vegetation Land Use in the Mekong River Basin Sub-region	Australia, Cambodia, Japan, Thailand, USA and Viet Nam	Southeast Asia	Concluded that biogenic and biomass burning constitutes a major source of air pollutants in the region; Transferred methodologies and experimental procedures were evaluated as appropriate for measuring and monitoring local parameters related to biogenic and biomass burning emissions.	http://www.apn-gcr.org/newAPN/resources/projectBulletinOutputs/finalProjectReports/2006/CBA2006-06NSY-Towprayoon_FinalReport.pdf
CSP53	ARCP2005-12-NSY	Faizal PARISH	Vulnerabilities of the carbon-climate system: Carbon pools in Wetlands/Peatlands as positive feedback to global warming	Australia, China, Indonesia, Japan, Malaysia, Papua New Guinea, Thailand, Philippines and the USA	Asia	Riau Declaration on Peatlands and Climate Change; Synthesis on the extent, depth, and carbon content of peatlands in SE Asia; Prepared a special issue in ECOSYSTEMS; Prepared an APN proposal on Mitigation and Adaptation in tropical peatlands.	http://www.apn-gcr.org/newAPN/resources/projectBulletinOutputs/finalProjectReports/2005/APN2005-12-NSY-Parish.pdf

CS Project (CSP#)	Project Reference	Project Leader	Title	Collaborating Countries	Regional Focus	Major Outcomes	APN Website
CPS54	ARCP2007-15-NSY	Faizal PARISH	Assessing the Mitigation and Adaptation Options for Tropical Peatlands to Reduce GHG Emissions and Increase Resilience to Climate Change	Australia, Bangladesh, Japan, Sri Lanka, Thailand and Viet Nam	Southeast Asia	Contributed to debate on impact of oil palm cultivation on peatlands on GHG emissions; Enhanced understanding and partnerships researchers, policy-makers, government agencies working on peatlands, biodiversity, climate change and oil palm industry in SE Asia; Contributed to policy decisions on palm oil.	http://www.apn-gcr.org/newAPN/resources/projectBulletinOutputs/finalProjectReports/2007/ARCP2007-15NSY-Parish_Final%20Report_formatted.pdf
CSP55	CBA2009-05NSY	Jim SALINGER	International Workshop on the Content, Communication and Use of Weather and Climate Products and Services for Sustainable Agriculture	Australia, Bangladesh, Japan, Sri Lanka, Thailand and Viet Nam	Global activity	Provided Capacity Building in area of strategies for more targeted weather and climate information and forecasting; Attempted to communicate issues on climate variations that impact crop production to farmers through media products.	http://www.apn-gcr.org/newAPN/resources/projectBulletinOutputs/finalProjectReports/2009/CBA2009-05NSY-Salinger-FinalReport.pdf
CSP56	2002-12-NMY 2003-04-CMY 2004-02-CMY	Amir MUHAMMED	Water Resources in South Asia: An Assessment of Climate Change—Associated Vulnerabilities and Coping Mechanisms	Bangladesh, India, Nepal, Pakistan and USA	South Asia	Regional maps of climate variability and change with areas at risk identified; Presentations from the final reports presented at stakeholders meetings; Various articles published.	http://www.apn-gcr.org/newAPN/resources/projectBulletinOutputs/finalProjectReports/2004/2004_02_CMY-Muhammed_.pdf

Figures:

Appendix 2: Abbreviations & Acronyms

APN	Asia-Pacific Network for Global Change Research
ARCP	Annual Regional Call for Research Proposals
AusAID	Australian Agency for International Development
AWCI	Asian Water Cycle Initiative
CAPaBLE	Scientific Capacity Building/Enhancement for Global Change and Sustainable Development in Developing Countries
CLIK	Climate Information Tool Kit
CLIMAG	Climate Prediction and Agriculture
CLIVAR	Climate Variability and Predictability
COP	Conference of the Parties
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DARLAM	Division of Atmospheric Research Limited Area Model
DIVERSITAS	International Programme of Biodiversity Science
ENSO	El Niño Southern Oscillation
ESC	Earth Simulator Centre
ESSP	Earth System Science Partnership
EU	European Union
GC	Global (Environmental) Change
GCISC	Global Change Climate Impact Centre
GCM	Global Climate Model
GCOS	Global Climate Observing System
GEF	Global Environment Facility
GEO	Global Earth Observations
GEO-4	Global Environment Outlook 4
GEOSS	Global Earth Observation System of Systems
GHG	Greenhouse Gas
GIS	Global Information System
IAM	Integrated Assessment Model
ICT	Information and Communication Technology
IGM	Inter-Governmental Meeting
IGBP	International Geosphere-Biosphere Programme
IGCI	International Global Change Institute
IHDP	International Human Dimensions Programme on Global Environmental Change
IPCC	Intergovernmental Panel on Climate Change
IPCCTAR	IPCC Third Assessment Report
IPCCAR4	IPCC Fourth Assessment Report
IPCCAR5	IPCC Fifth Assessment Report
LGU	Local Government Unit
MJO	Madden-Julian Oscillation
NAASP	New Asian African Strategic Partnership
NAPA	National Adaptation Programme of Action
NMHS	National Meteorological and Hydrological Service
NGO	Non-Governmental Organization
PACC	Pacific Adaptation to Climate Change
PACCLIM	PACific CLimate Impacts Model
PAGES	International "Past Global Changes" Programme
PICCAP	Pacific Island Climate Change Assistance Programme

PDO	Pacific Decadal Oscillation
RCM	Regional Climate Model
RIEMS	Regional Integrated Environmental Modelling System
RMIP-Asia	Regional climate Model Inter-comParison for Asia
RS	Remote Sensing
SimCLIM	Integrated modelling system for assessing climate change impacts and adaptation
SMS	Short Message Service
SPREP	Pacific Regional Environment Programme
SSTA	Sea Surface Temperature Anomalies
START	global change SysTem for Analysis, Research and Training
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
UNITAR	United Nations Institute for Training and Research
WCRP	World Climate Research Programme
WMO	World Meteorological Organisation

Appendix 3: Peer Reviewed Papers & Other Publications

CSP1: Continuation of Regional Climate Modelling (RCM) Development

1. Fu CB and Wen G. 1999. Variation of ecosystems over East Asia in association with seasonal, inter-annual and decadal monsoon climate variability. Climatic Change, 43: 477-494.
2. Fu CB, Diaz HF, Dong DF, and Fletcher JO. 1999. Changes in atmospheric circulation over northern hemisphere oceans associated with the rapid warming of the 1920s. International Journal of Climatology, 19:581-606.
3. Giorgi F, Huang Y, Nishizawa K and Fu C. 1999. A seasonal cycle simulation over eastern Asia and its sensitivity to radiative transfer and surface processes, J.G.R. vol. 104: 6403-6424.
4. Wei HL, Fu CB and Wang, WC 1998. The effect of lateral boundary treatment of regional climate model on the East Asian summer monsoon rainfall simulation. Chinese Journal of Atmospheric Sciences. Vol.22, No.3:231-243.
5. Fu CB and Xie L. 1998. Global oceanic climate anomalies in 1980's. Advances in Atmospheric Sciences. Vol.15, No.2:167-178.
6. Fu CB and Ye DZ. 1998. Towards predictive understanding of the environmental change in China on decadal to centennial scales. Global Environmental Research, Vol.1, No.1&2: 83-93.
7. Qian Y and Giorgi F. 1999. Interactive coupling of regional climate and sulfate aerosol models over eastern Asia. Journal of Geophysical Research, Vol.104, No.D6: 6477-6499.
8. Wei HL and Fu CB. 1998. Study of the sensitivity of a regional model in response to land cover change over northern China. Hydrological Processes, 12: 2249-2265.
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