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# PREFACE

The present publication is the 3rd issue of the APN Science Bulletin series to be published in the APN's Third 5-year Strategic Phase, which runs until March 2015. Issue 3 (2013) is a peer-reviewed publication that has become a main source, next to the APN website, for up-to-the-minute information on activities undertaken by the APN. As a landmark publication written by the global environmental community, supported by the APN, and focussing on issues of underpinning science that is policy-relevant, the 2013 Science Bulletin aims to satisfy readers in both the science and non-science communities with a keen interest in Global Environmental Change in the Asia-Pacific region.

The 2013 APN Science Bulletin highlights those APN projects either funded and/or completed in the year of publication (the present year runs from April 2012 – March 2013). The Science Bulletin has three main sections: 1) Featured Articles; 2) Regional Research Projects funded under the Annual Regional Call for Research Proposals (ARCP) Programme; and 3) Scientific Capacity Development Projects funded under the CAPaBLE Programme. A supplement to the Bulletin will be published in early summer 2013 and will include a number of important activities supported by the APN outside its core programmes, for example, the development of Future Earth in Asia and the Pacific, Focussed activities under Ecosystems, Biodiversity and Land-Use, a series of Hyogo-funded workshops on the New Commons, among others.

Under featured articles, nine scientific papers have been written and cover a number of major themes in the APN's science agenda. These include issues from the tracking of endangered tree species in the forests of Borneo to observing the impacts of extreme weather events and adaptation plans in major coastal cities. Other issues focus on the impacts of climate on the hydrological cycle, and on smallholder farms.

The core regional research programme is supporting twenty-four regional-based research activities this year, two of which are seed grants for further proposal development, and includes a wide array of biodiversity, ecosystems and land-use themes from looking at Seagrass-Mangrove ecosystems, terrace farming practices, marine ecosystems in Northwest Pacific, among others. The APN continues its underpinning and policy-relevant research by looking at impact assessment tools for urban policy makers.

The APN's capacity development programme, CAPaBLE, is the 2nd core programme of the network and reports fourteen capacity development activities and their impacts for the region. Activities extend from supporting young and early-career scientists to attend major global change programme events such as the PAGES and Earth System Governance Conferences, to providing regional climate modelling training programmes and looking at the impacts of global environmental change on human health.

On behalf of the Scientific Planning Group (SPG), who advises the scientific programme of the APN to the APN's governing body, the Inter-Governmental Meeting; and of the SPG Co-Chairs, the executive editors of the present publication; we hope that you find the information contained in the third issue of the APN Science Bulletin both interesting and useful in your work.

Linda Stevenson (Managing Editor)

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# FEATURED ARTICLES

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ARCP2010-01CMY-STHIANNOPKAO

# Trace Metal Contamination in Southeast Asian Rivers

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**ABSTRACT:** River water was collected from the Tonle Sap-Bassac Rivers (Cambodia), the Citarum River (Indonesia), the lower Chao Phraya River (Thailand) and the Saigon River (Viet Nam) in both dry and wet seasons. Nineteen trace metals were analysed (Be, Al, Ti, V, Cr, Mn, Fe, Co, Ni, Cu, Zn, As, Se, Mo, Ag, Cd, Ba, Tl and Pb). Dissolved metal concentrations of most target elements exceeded the background metal concentrations by multiples of 1.1 to 87.8. Cluster and stable lead isotope analyses confirmed metal contamination in Southeast Asian rivers is anthropogenically linked. For example, discharges of wastewater, road runoff and street dust. Quantitative risk assessments of metals in the rivers showed potential toxicity of additives and negative effects of metal mixtures at all sampling sites in all areas studied. The contribution of particular metals to the cumulative criterion units (CCU) score depended on their concentrations. Al in all study areas contributed the highest percentage (72% to 85%) to total CCU scores. Cd, Cr, Cu, Pb, Ni, Zn, As and Se had lower contributions (<1% to 19%).

***KEYWORDS:*** *metals, rivers, risk assessment, urbanization, source tracking, Southeast Asia*

## Introduction

Over the past four decades Southeast Asia (SEA) has witnessed rapid urbanization and population growth, accompanied by economic and industrial expansion. These have led to a fast-paced deterioration in the environment. Recent water quality monitoring programmes in several SEA countries have furnished data showing a severe deterioration in river water caused by a variety of pollutants, including suspended solids, nutrients, organic pollutants and pathogenic microorganisms (Marcotullio, 2007; Visvanathan & Padmasri, 2010; Evans et al., 2012). For trace metal contamination of river water, however, such data is not readily available, due to economic limitations and the lack of tools and techniques to accurately measure metal concentrations.

The objectives of this study on metal pollution were to i) determine the concentrations of trace metals in selected rivers of SEA, ii) identify the potential sources contributing trace metals into the rivers using a multivariate statistical approach and stable isotope analysis, and iii) assess the potential environmental risks of metal contamination to aquatic organisms using cumulative criterion units (CCU).

## Methodology

Water samples were collected from five selected rivers flowing through four main urban centres of SEA: the Tonle Sap-Bassac Rivers of Phnom Penh (Cambodia), the Citarum River of Bandung (Indonesia), the lower Chao Phraya River of Bangkok (Thailand) and the Saigon River of Ho Chi Minh City (Viet Nam). Two river water sampling campaigns were conducted to collect representative samples in both dry and wet seasons. All sampling points located along the river course, from both upstream and downstream, were selected to represent the whole urban area (Figure 1).

The concentrations of 19 trace metals were determined by inductively coupled plasma mass spectroscopy (ICP-MS; Agilent 7500ce) and inductively coupled plasma optical emission spectroscopy (ICP-OES; Perkin Elmer Optical 5300DV). In addition, four lead isotopes, $^{204}$Pb, $^{206}$Pb, $^{207}$Pb and $^{208}$Pb, in the water samples were also measured using the ICP-MS (Agilent 7500ce).

The SPSS software package was used to perform all statistical analyses on the database. A cluster analysis (CA) was applied to group the sampling sites into categories or clusters on the basis of similarities within a cluster and dissimilarities between different clusters, with respect to distance between objects. In addition, to identify sources of lead contamination using a graphical method, the results of the four lead isotopes in the water samples were compared to various composition sources and natural background levels obtained from the literature.

## Results and Discussion

Since surveys of dissolved metal concentrations in natural waters in SEA have received relatively little attention (Gaillardet et al., 2003), the world average dissolved metal concentrations of uncontaminated

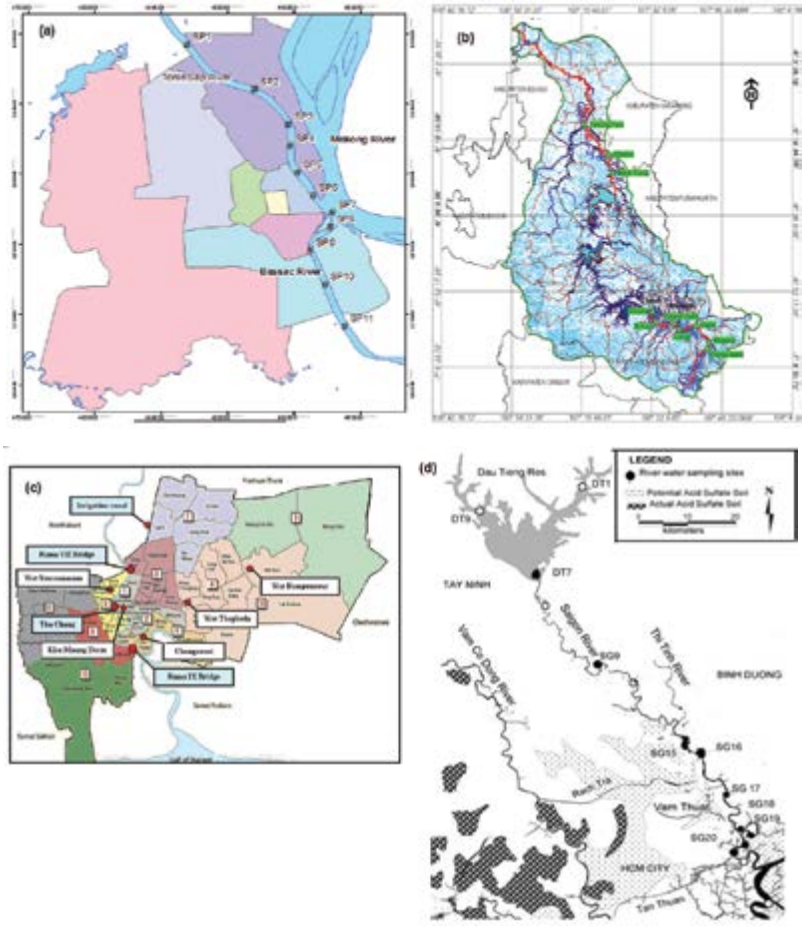


**Figure 1.** Maps show sampling site locations along the (a) Tonle Sap-Bassac Rivers (Cambodia), (b) Citarum River (Indonesia), (c) lower Chao Phraya River (Thailand) and (d) Saigon River (Viet Nam)

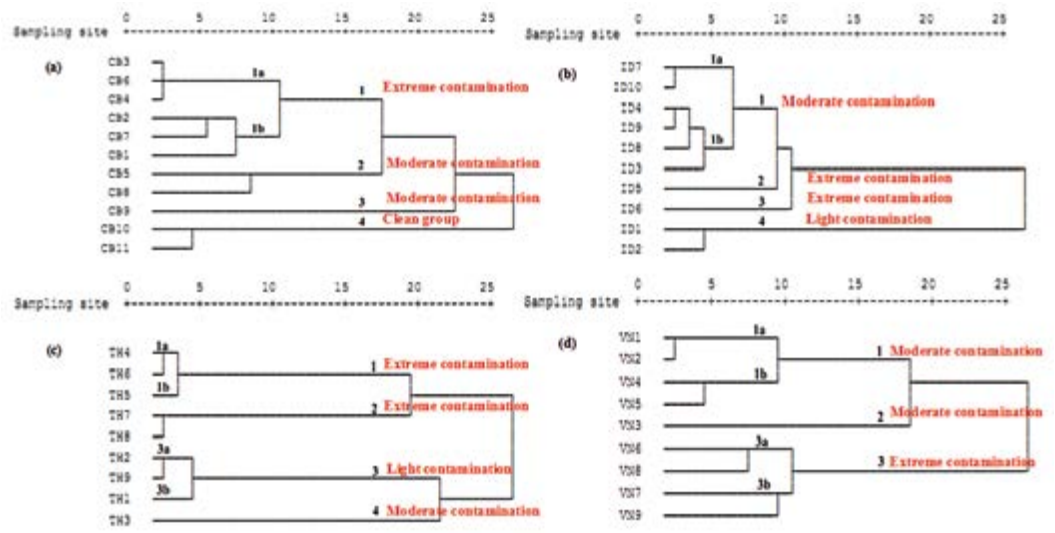


**Figure 2.** Dendrograms showing spatial similarities of monitoring sites in the (a) Tonle Sap-Bassac Rivers, (b) Citarum River, (c) lower Chao Phraya River and (d) Saigon River

rivers were used in this study to assess the degree of metal contamination; the natural background dissolved concentrations are not especially different among river systems (Luoma & Rainbow, 2008). Utilizing such an approach, Sindren et al. (2007) had concluded that anthropogenic enrichment of metals in a river system could be revealed by metal concentrations that exceeded the range of background concentrations.

The results of dissolved metal concentrations among the areas studied (Table 1) revealed that the Tonle Sap-Bassac Rivers were contaminated only with V and As. The Citarum River, the lower Chao Phraya River, and the Saigon River were contaminated with most metals of interest. Dissolved metals and the multiples of their background concentrations in this study were Al (1.9 to 3.0), Ti (2.5 to 5.6), V (1.2 to 5.4), Cr (1.3), Mn (1.1 to 5.7), Fe (1.6 to 3.9), Co (3.1 to 3.6), Ni (1.8 to 8.2), Cu (1.5 to 2.8), Zn (16.7 to 87.8), As (1.1 to 5.7), Mo (1.2 to 4.1), Cd (2.5 to 10.9), Ba (1.4 to 8.4) and Pb (5.5 to 7.1).

To help identify the likely sources of metal contamination in river water, cluster analysis (Figure 2) was used to categorize all monitoring sites in each area studied into several clusters, according to the sites' similarities in metal concentrations. This produced clusters labeled "clean", "light contamination", "moderate contamination" and "extreme (heavy) contamination."

The results of a scatter plot of stable lead isotope data ($^{206}Pb/^{207}Pb$ and $^{206}Pb/^{208}Pb$) (Figure 3) clearly revealed that anthropogenic sources are the major cause of Pb contamination in these Southeast Asia

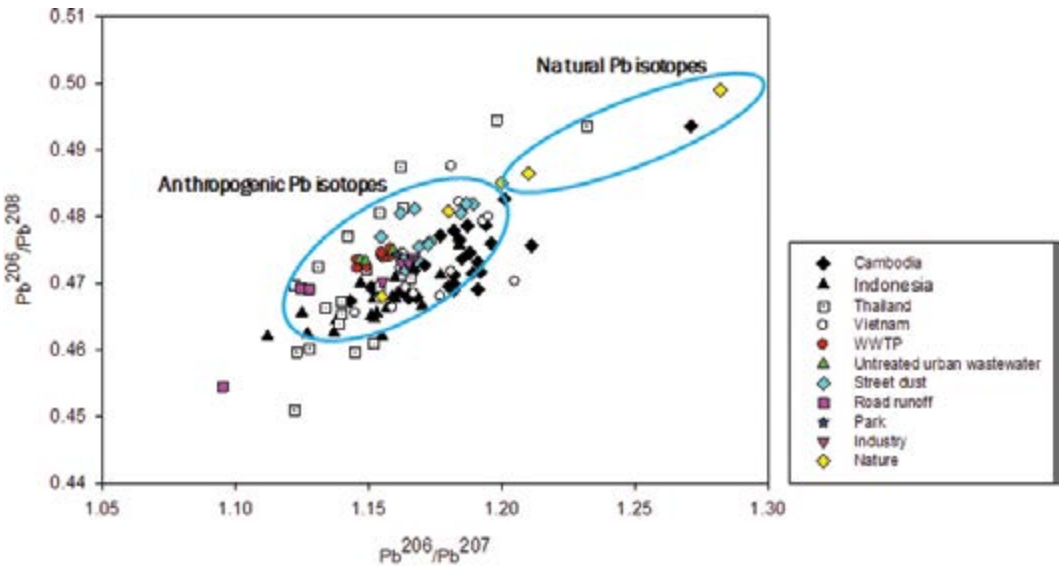


**Figure 3.** $^{206}Pb/^{207}Pb$ ratio as a function of $^{206}Pb/^{208}Pb$ in river waters of Southeast Asia countries (Cambodia, Indonesia, Thailand, and Viet Nam) compared with several sources of Pb pollution reported in previous studies

| Study area | | Be | Al | Ti | V | Cr | Mn | Fe | Co | Ni |
|---|---|---|---|---|---|---|---|---|---|---|
| **Cambodia** (Tonle Sap-Bassac Rivers) | Min. | ND | ND | ND | 0.67 | 0.10 | ND | ND | 0.01 | ND |
| | Max. | ND | 34.61 | 0.72 | 1.29 | 0.46 | 4.15 | 22.76 | 0.16 | 0.56 |
| | Median | - | 7.98 | 0.33 | **0.83** | 0.30 | 0.43 | 10.96 | 0.03 | 0.33 |
| **Indonesia** (Citarum River) | Min. | ND | 18.28 | 0.51 | 1.67 | ND | 6.89 | 17.65 | 0.19 | 0.17 |
| | Max. | 0.06 | 291.20 | 13.36 | 8.38 | 2.80 | 638.00 | 557.40 | 1.25 | 9.66 |
| | Median | 0.01 | **96.59** | **2.75** | **3.84** | 0.79 | **195.10** | **193.35** | **0.47** | **1.45** |
| **Thailand** (Lower Chao Phraya River) | Min. | ND | 32.25 | ND | 1.22 | 0.43 | ND | ND | 0.08 | 3.94 |
| | Max. | 0.50 | 267.83 | 1.32 | 2.64 | 6.49 | 1189.0 | 409.60 | 2.89 | 23.54 |
| | Median | 0.16 | **61.82** | 0.48 | **2.46** | **1.16** | **38.89** | **105.60** | **0.54** | **6.57** |
| **Viet Nam** (Saigon River) | Min. | ND | 5.99 | 0.09 | 0.24 | 0.01 | 9.03 | 7.59 | 0.08 | ND |
| | Max. | 0.08 | 2507.0 | 5.77 | 3.04 | 8.98 | 179.80 | 2590.0 | 1.30 | 3.90 |
| | Median | 0.00 | **70.04** | **1.24** | **1.55** | **1.13** | **72.49** | **258.08** | **0.50** | **2.26** |
| **World average** (as background concentrations) | | NA | 32.00 | 0.49 | 0.71 | 0.85 | 34.00 | 66.00 | 0.15 | 0.80 |

**Table 1.** Concentrations of dissolved metals (μg $L^{-1}$) in Southeast Asia rivers

rivers. It was found that both point sources (wastewater treatment plants, power stations) (Figure 4(a)) and non-point sources (atmospheric wet deposition, street runoff, street dust, automobile exhaust) (Figure 4(b)) were significant contributors of Pb into river waters. Natural Pb concentrations from sediment and seawater were found at some sampling sites in Thailand and Viet Nam. Stable Pb isotopic ratios found in this study were not close to those of the natural Pb components.

For the quantitative assessment of trace metal contamination in Southeast Asia rivers, a quantitative risk evaluation (Figure 5) showed that CCU scores greater than 1 were found at all sites on the Tonle Sap-Bassac Rivers, the Citarum, the lower Chao Phraya, and the Saigon River. Figure 5 indicates the chronic, additive and unsustainable negative effects of metal mixtures in those river systems on aquatic organisms. The CCU scores for the Tonle Sap-Bassac, the Citarum, the lower Chao Phraya, and the Saigon rivers in the dry season varied from 8.1 to 29.5, 134.1 to 433.5, 1.2 to 3.4 and 22.3 to 180.5, respectively. The CCU scores at the same sites on the Tonle Sap-Bassac Rivers and the lower Chao Phraya in the wet season were higher than in the dry season by an average multiple of 13.9 and 2.4 (Figures 5(a) and 5(c)), respectively. In contrast, the CCU scores for the Citarum River were generally about 3.1 times higher in the dry season than in the wet (Figure 5(b)). The CCU scores for the Saigon River in the wet season were highly varied, from 13.2 to 140.0, and were not usually higher than the CCU scores at the same sampling sites in the wet season (Figure 5(d)). Interestingly, it was found that the contribution of each metal to the CCU score can change depending on its concentration. Aluminium (Al), a non-priority pollutant, in all areas studied contributed about 72% to 94.1% to total CCU scores. The other elements, including Cd, Cr, Cu, Pb, Ni, Zn, As and Se, generally had relatively lower contributions to total CCU scores (<1% to 19%). Therefore, among all metals, Al may exhibit greatest toxicity to aquatic organisms.

### HIGHLIGHTS

- Rivers in four Southeast Asia countries were contaminated with various trace metals.
- Non-point sources of metals in the rivers were from road runoff and street dust.
- Point sources of metals were from wastewater discharge.
- Metal contamination poses chronic and additive effects on aquatic microorganisms.
- Aluminium may present highest toxicity for aquatic organisms.

## Conclusions

Rivers in four SEA countries were found to be contaminated with various heavy metals. Anthropogenic sources, including non-point (road runoff and street dust) and point sources (discharge of industrial and household wastewater) were the major contributors of

| Study area | | Cu | Zn | As | Se | Mo | Ag | Cd | Ba | Tl | Pb |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Cambodia** (Tonle Sap-Bassac Rivers) | Min. | 0.25 | ND | 0.69 | ND | 0.02 | ND | ND | 2.34 | ND | ND |
| | Max. | 1.62 | ND | 3.46 | 0.12 | 1.21 | ND | ND | 15.13 | 0.01 | 0.17 |
| | Median | 1.06 | - | **1.57** | 0.00 | 0.21 | - | - | 5.03 | 0.00 | 0.02 |
| **Indonesia** (Citarum River) | Min. | 0.51 | 3.28 | 0.52 | 0.04 | 0.20 | ND | ND | 7.07 | ND | 0.10 |
| | Max. | 6.94 | 44.26 | 5.55 | 0.63 | 0.95 | 0.26 | 0.06 | 68.14 | 0.09 | 1.30 |
| | Median | **2.23** | **10.02** | **2.25** | 0.17 | **0.69** | 0.04 | 0.02 | **32.37** | 0.04 | **0.44** |
| **Thailand** (Lower Chao Phraya River) | Min. | 1.12 | 28.06 | 2.24 | ND | 0.72 | ND | ND | 104.40 | ND | 0.32 |
| | Max. | 14.22 | 160.60 | 5.23 | 0.68 | 3.25 | 2.50 | 0.32 | 255.50 | 0.30 | 1.88 |
| | Median | **4.23** | **52.69** | **3.53** | 0.21 | **1.71** | 0.20 | **0.20** | **203.30** | 0.15 | **0.54** |
| **Viet Nam** (Saigon River) | Min. | 0.55 | 5.38 | 0.24 | ND | 0.08 | ND | 0.20 | 9.28 | ND | ND |
| | Max. | 16.51 | 311.10 | 1.26 | 0.61 | 1.43 | 2.24 | 245.00 | 33.08 | 0.03 | 6.55 |
| | Median | **3.23** | **49.53** | **0.69** | 0.00 | **0.52** | 0.09 | **0.87** | 19.71 | 0.00 | **0.57** |
| **World average** (as background concentrations) | | 1.50 | 0.60 | 0.62 | NA | 0.42 | NA | 0.08 | 23.00 | NA | 0.08 |

**Table 1.** Concentrations of dissolved metals (μg $L^{-1}$) in Southeast Asian rivers (cont.)

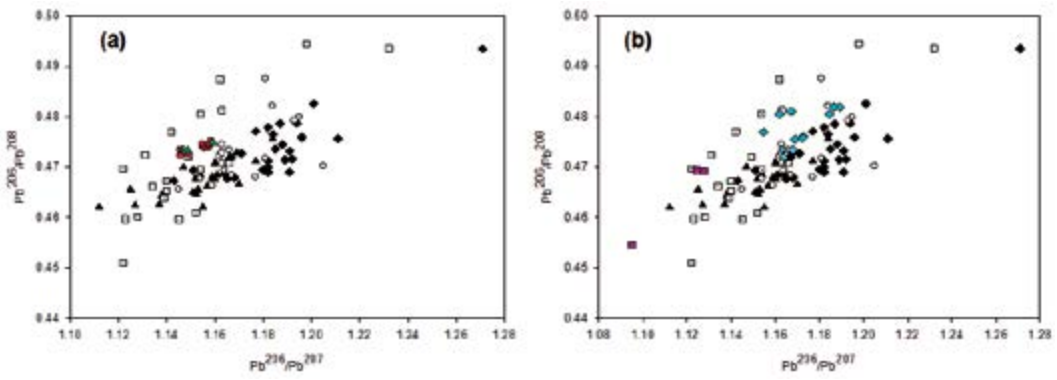


**Figure 4.** $^{206}Pb/^{207}Pb$ ratio as a function of $^{206}Pb/^{208}Pb$ in river waters of Southeast Asian countries (Cambodia, Indonesia, Thailand, and Viet Nam) compared with Pb pollution reported in (a) urban wastewater and (b) street dust and runoff obtained from previous studies

metal pollution in the rivers. Risk evaluation of metal toxicity using CCU scores clearly indicated the likelihood of additive and negative effects of metal pollution upon aquatic organisms in the study areas.

## Acknowledgements

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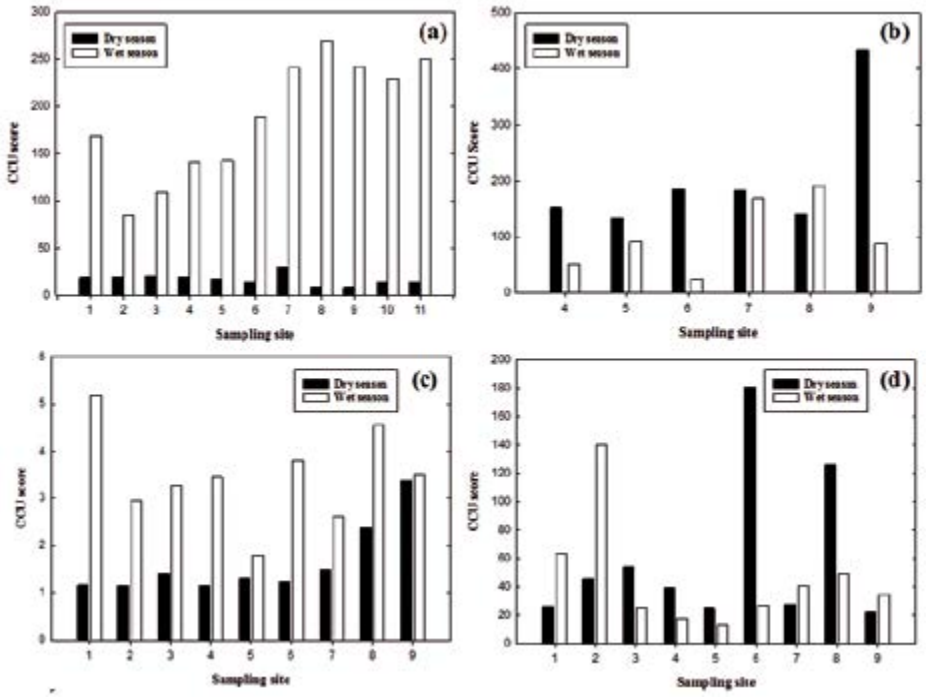


**Figure 5.** Quantitative risk evaluation of potential toxicity of metal mixtures in (a) Tonle Sap-Bassac Rivers, (b) Citarum River, (c) lower Chao Phraya River and (d) Saigon River

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## ARCP2010-01CMY-STHIANNOPKAO

### PROJECT TITLE

**Collaborative Research on Sustainable Urban Water Quality Management in Southeast Asian Countries: Analysis of Current Status (Comparative Study) and Strategic Planning for Sustainable Development**

### COUNTRIES INVOLVED

China, Cambodia, Indonesia, Republic of Korea, Thailand , Viet Nam

### PROJECT DURATION

2 years

### APN FUNDING

US$ 80,000

### PROJECT LEADER

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# Conservation Gap Analysis of Endemic Dipterocarp in Sarawak Using GIS and Remote Sensing Techniques

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**ABSTRACT:** Dipterocarps or Dipterocarpaceae are a commercially important timber-producing and dominant keystone tree family in the rain forests of Borneo. Borneo's landscape has been changing at an unprecedented rate in recent years, which affects this important biodiversity. The present paper applies Inverse Distance Weighting (IDW) method for modelling the occurrence of the endemic dipterocarp species in Sarawak, which is important for forest biodiversity conservation and management. The results indicate that only 3% and 4% of endemic dipterocarp of Borneo and Sarawak, respectively, are protected in existing totally protected areas (TPAs). The present study also shows that the central part of Sarawak is a hotspot area for both these endemic endemic species (i.e. Borneo and Sarawak). These hotspot areas should be prioritized.

**KEYWORDS:** *Dipterocarp, conservation gap, GIS, remote sensing, Sarawak*

## Introduction

Borneo is a global mega-diverse hotspot where biodiversity and endemism is high (Ashton, 1995). However, deforestation is an inevitable part of development in the tropics, including Borneo. The tropical forests of Sarawak are converted to other land uses as well as logged to provide capital for development. Average annual deforestation rate calculated from land cover classification maps of 1990 and 2009 was 0.64% (Tsuyuki et al., 2011), which is lower than that of Borneo. Bearing in mind that the deforestation rate for Sarawak was averaged over a long period of time and large-scale oil palm plantation development was very recent, this rate is a conservative estimate. Given current trends in deforestation and the lack of proactive intervention measures, it is estimated that forest cover in Sarawak will decline further, thereby affecting biodiversity.

The quality of protected areas, such as biodiversity, is as important as the size conserved. Dipterocarp is the dominant tree family of the tropical rain forests of Southeast Asia and a commercially important timber as well. It has its centre of diversity in Borneo where at least 267 species are found. The northern part of Borneo harbours a higher wealth of biodiversity than the rest of Borneo. For example, about 92% of dipterocarp species

in Borneo are found in Sarawak (Ashton, 2004). Such a keystone and dominant tree family ought to be conserved, and there is an urgent need to know where in the landscape they are located.

Species distribution modelling is significantly important for biodiversity conservation because it can determine areas that have high potential of occupancy by certain species. By conserving these areas that could be part of an endangered species habitat, conservation strategies would be more effective. The use of GIS with inventory data has been instrumental in plant species distribution modelling (e.g. Rael et al., 2009; Jantakat et al., 2010). Rael et al. (2009) combined abundant data of angiosperm families (including dipterocarp) in species distribution modelling using multiple linear regression. In a compilation of Peninsular Malaysian dipterocarp for plant red lists, distribution map of dipterocarp for Sabah and Sarawak species that occur in Peninsular Malaysia were also included (Chua et al., 2010). The distribution map shows species occurrence polygons that are created by following herbarium points, similar to the minimum convex polygon method. GIS-based modeling of dipterocarps distribution has been limited to only the dry dipterocarp forests of Thailand (Jantakat et al., 2010). The distribution of ten tree species including five dipterocarp species was predicted using environmental variables in the dry dipterocarp forest in northern Thailand. The lack of such modelling studies on dipterocarp could be due to the unavailability of field data, which is very costly to collect. Teo and Phua (2012) compared global and local modelling methods based on herbarium database coupling with GIS data for modelling species of selected genera of dipterocarp in Sarawak. Using the best modelling method, we discuss the conservation gaps of endemic dipterocarp in Sarawak.

## Methods

In Teo and Phua (2012), local modelling method of Inverse Distance Weighting (IDW) was compared with the commonly-used global method (Binary Logistic Regression) to build the best natural distribution models for three genera (*Anisoptera*, *Dipterocarpus* and *Upuna*) of dipterocarp. The three genera were selected as members found in different habitats and included both endemic and non-endemic species. *Upuna* is a monotypic genus endemic to Borneo. The results show that IDW produced the best and consistent prediction with an average accuracy of about 85%.

Species Occurrence Models (SOMs) were generated for all endemic dipterocarp in Sarawak using IDW in ArcGIS 9.0 software. Species occurrence density maps for endemic Borneo and Sarawak dipterocarp were generated by overlaying SOMs of the species. The resulting species density maps for all of Sarawak were then re-classified into 4 groups: 0–25%, 26–50%, 51–75% and

### HIGHLIGHTS

- Herbarium and GIS data provide a species occurrence model of dipterocarp, the most important commercial timber species in Sarawak.
- Hotspot areas of endemic Borneo and Sarawak dipterocarp were found in central Sarawak.
- Boreno and Sarawak dipterocarp inside existing totally protected areas are only 3% and 4%, respectively, of the entire Sarawak area.

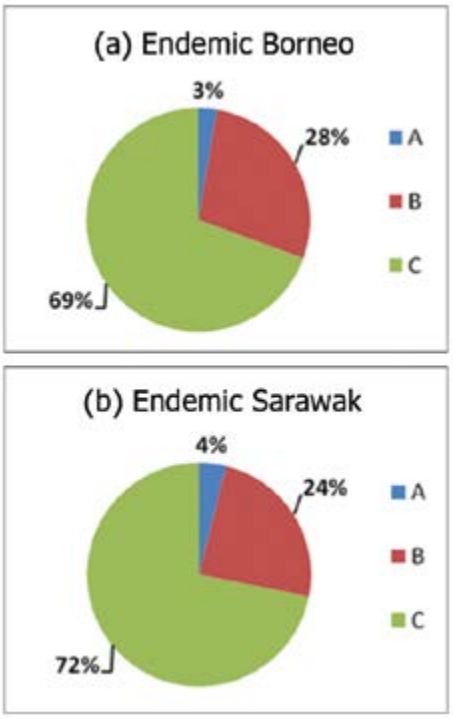



**Figure 1.** Hotspot areas (>75% species density) of Sarawak's total area for (a) Endemic Borneo and (b) Endemic Sarawak

Note:
(A) Inside protected areas;
(B) outside protected areas with intact forest cover;
(C) outside protected areas without intact forest cover.

76–100%, expressed in percentage of total species in that category. For example, if the species occurrence density of a particular genus is 5 and the total number of species in that genus is 28, the percentage will be 5/28 x 100% = 17.8% and fall under the 0–25% classification. Hotspot areas were represented by the 76–100% class in the re-classified density map. The total area of hotspots that are covered by intact forest and situated inside or outside TPAs were determined by overlaying TPA and land cover maps that were generated from supervised classification of Landsat TM or ETM+ images (Kamlun et al., 2012).

## Results

For Borneo's endemic dipterocarp species, hotspot areas (with species density >75% of the total endemic species) inside protected areas were only about 3% of the total area of Sarawak. The hotspot areas for Sarawak's endemic dipterocarp species were slightly higher at 4%. For areas outside the protected areas, about 69% and 72% were still covered with intact forest for high species density areas (>75%) for endemic Borneo and Sarawak, respectively. This indicates that dipterocarp species, irrespective of Borneo or Sarawak endemism, are inadequately conserved in existing protected areas.

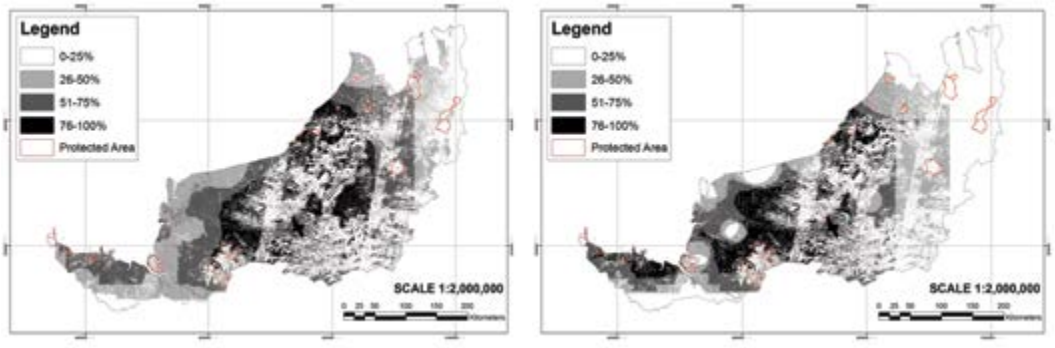
In terms of distribution, the major hotspot of dipterocarp endemism was located in central Sarawak, which is least protected. Overlaying between the species density and protected area maps revealed that most protected areas are in southwestern Sarawak (for example, Bako, Kubah and Gunung Gading National Parks) and in northern Sarawak (for example, Niah and Lambir National Parks).

## Discussion

Current conservation policy is inadequate for biodiversity conservation and specifically for dipterocarp conservation because forest policy does not specifically address dipterocarp conservation despite the fact that this timber contributes enormously to revenue in Sarawak. Also, forest policy lacks spatial information for prioritizing conservation.

Conservation hotspots have been identified globally but not locally, especially for dipterocarp in Sarawak. Most hotspots for endemic species at the local scale have been identified along the Atlantic coast of Brazil (Zaforlin et al., 2007). The study showed for the first time that the central region of Sarawak appears to be a hotspot for endemism of dipterocarp in Sarawak. Currently, almost all totally protected areas (TPAs) are concentrated in northern and southern parts of Sarawak. A systematic approach as demonstrated in this study can be used to identify TPAs to ensure conservation of endemic species.

There is a priority now for Sarawak to set aside 10% (about 1.2 million ha) of its land as TPAs. Currently, over 500,000 ha have already been gazetted as TPAs. Remaining TPAs to be gazetted ought to take into account the geographical distribution of the TPAs, especially by considering central




(a) Endemic Dipterocarp (Borneo) (b) Endemic Dipterocarp (Sarawak)

**Figure 2.** Hotspot Areas of (a) Endemic Dipterocarp (Borneo) and (b) Endemic Dipterocarp (Sarawak) in the Intact Forest of Sarawak

Sarawak as an important hotspot area for endemic dipterocarp.

This study provide strong and scientific justifications for gazetting the proposed TPAs in central Sarawak such as the Proposed Hose Mountains-Batu Laga National Park, the Proposed Bukit Sarang National Park, the Proposed Bukit Mersing National Park as well as the Proposed Bukit Kana National Park as well as other forested areas in the central region. These hotspot areas must therefore be considered as priority areas for conservation.

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# Impacts of Extreme Weather Events and Implications for Adaptation Planning for Coastal Cities

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**ABSTRACT:** This paper describes a study undertaken in three coastal cities of Asia — Mumbai, Bangkok and Manila — to assess the impacts of extreme weather events and measure the physical, economic and social impacts of the resultant massive floods in these cities. The focus of this paper is on estimating the uninsured losses resulting from extreme precipitation events, which normally do not get accounted for in the absence of data. The study has analysed primary data collected from households, farms and small commercial and industrial establishments located in flood-affected areas in the three cities. The information collected through the surveys has been supplemented with secondary data to identify and measure impacts such as damage to property and infrastructure, damage to stocks like physical capital, inventory and indirect impacts on flows like income, investment, employment and disruption of essential services. The findings have significant policy implications for integrating adaptation strategies with long-term development plans for the coastal cities.

***KEYWORDS:*** *coastal cities, extreme weather events, uninsured losses, adaptation planning*

## Introduction

Extreme weather events affect vulnerable urban areas (cities) adversely, with substantial damage and disruption of normal economic and social activities. The loss of physical, economic and financial resource base is also augmented by the loss of economic and social services. This combination of stock and flow effects can potentially alter the medium- to long-term development trajectory of the city. Since it is now widely accepted that impacts of future climate change will often be observed through changes in the magnitude and frequency of existing hazards such as extreme weather events, disaster management is an important context for integrating adaptation into decision-making for the cities at risk.

This paper describes the study undertaken in three coastal cities of Asia — Mumbai, Bangkok and Manila — to measure the physical, economic and social

impacts, in particular the uninsured losses resulting from extreme precipitation events and massive floods. The study analysed primary data collected from households and commercial establishments and supplemented the findings with secondary data to identify and measure impacts such as loss of life, injuries, damage to property and infrastructure, damage to stocks like physical capital, inventory and indirect impacts on flows like income, investment, employment and disruption of essential services. The findings have significant policy implications for integrating disaster management and adaptation strategies with long-term development plans for the coastal cities.

## Study Areas

The study selected extreme precipitation events in three cities, namely, Mumbai (India), Bangkok (Thailand) and Manila (Philippines). The selected cities fall under the densely populated low-lying coastal areas described by the IPCC Fourth Assessment report as "key societal hotspots of coastal vulnerability." With millions of residents, the risk to life and property increases manifold with vulnerability to extreme weather events leading to floods.

### *Mumbai*

Mumbai, the financial capital of India, is one of the largest megacities with a population of more than 12 million. The city is acutely vulnerable to climate risks due to its location on the sea coast, flood prone topography and landmass composed largely of reclaimed areas. The extreme precipitation event of July 2005 was selected in this study to examine the impacts and policy implications for long-term adaptation capacity. On 26 July 2005, Mumbai was struck with a heavy storm and recorded 944 mm rainfall (45% of the annual average rainfall in Mumbai) over a 24-hour period. This unprecedented rainfall, coinciding with high tide, brought the city to a standstill. The impacts of this event are discussed in this paper.

**HIGHLIGHTS**

- The study focuses on extreme precipitation events and resultant floods in three coastal cities in Asia — Mumbai, Bangkok and Manila.
- Primary surveys were carried out among households and commercial establishments to identify and measure the physical and socioeconomic impacts and their costs.
- The cost estimates suggest substantial losses due to heavy floods resulting from the extreme weather events studied.
- These costs are borne by the residents themselves in the absence of insurance coverage and social security mechanisms.
- These costs can be avoided in future with effective adaptation planning.

### *Bangkok*

Bangkok, the capital of Thailand, is a sprawling urban agglomeration with a population of 5.7 million. Much of Thailand's industrial and commercial capacity is concentrated within metropolitan Bangkok, as well as the bulk of its communications and transport infrastructure. When a major flood event affects Bangkok, it not only threatens the political and administrative functioning of the capital, but also puts much of the country's factories and industrial parks at risk, and by extension, the homes and livelihoods of hundreds of thousands of the city's residents. This study examines the impact of the 2006 floods, with a focus on four districts in the eastern region of Bangkok: Minburi, Nong Jork, Lat Krabang and Klong Samwa.

### *Manila*

Metro Manila or the National Capital Region (NCR), with a population of more than 12 million, is the centre of political, economic, and sociocultural activities of the Philippines. Being near a river and a good harbour has made possible the development and expansion of the city of Manila to its suburbs in the last 30 years. This study was carried out in Metro Manila in the Pasig-Marikina flood basin. Both Marikina and Pasig suffered extreme flooding brought about by the tropical storm Ondoy in late September 2009 and Pepeng in early

October 2009. In this study, the impacts and responses to Ondoy in these cities were compared to another flooding event in 2011.

## Methodology

The study carried out in Mumbai, Bangkok and Manila is based on the analysis of primary and secondary data on physical, economic and social impacts pertaining to extreme weather events and resultant flooding. The study also identified the immediate to medium-term post-disaster responses of the civic administration and citizens to cope with future floods. We describe the methodology used for the study here:

- Primary data were collected through random sampling from households, families engaged in agriculture (in Bangkok) and commercial and small industrial establishments in Mumbai, Bangkok and Manila by administering detailed questionnaires in flood-prone areas.
- The questionnaire focused on the stock and flow impacts of flooding due to extreme precipitation, costs of damage and repairs/replacements and response measures undertaken by the civic administration and citizens themselves.
- Primary surveys were supplemented with semi-structured interviews and discussions were carried out with residents, local government officials, civil society leaders and the private sector.
- In addition to the above, secondary data were collected from local government departments, published reports and previous studies on damage assessments.
- The primary and secondary data obtained through the above sources

| | Mumbai | Bangkok | Manila |
|---|---|---|---|
| **Population (in millions)** | 11.9 (Census 2001) | 5.67 (official estimates for 2009) | 12.10 |
| **Total area (km²)** | 437.71 | 1569 | 636 |
| **Population density (per km²)** | 27,209 | 3,617 | 15,617 |
| **Extreme weather event** | 26 July 2005 | Oct 2006 | Sept–Oct 2009 |
| **Affected regions** | Eastern and Western suburbs | Bangkok Metropolitan Region | Metro Manila |
| **Total estimated damages (official estimates of public infrastructure and insured losses)** | US$ 68 million | US$ 117 million | US$ 590 million |
| **Study areas for primary survey** | Six wards of Mumbai worst affected by floods | Minburi, Nong Jork, Lat Krabang and Klong Samwa | Cities of Marikina and Pasig |
| **Sample size** | 1,168 households; 792 commercial | 300 households; 50 farms and 30 commercial | 200 households; 87 commercial |
| **Monthly average incomes of households** | US$ 330 | US$ 660 | US$ 380 |
| **Estimated uninsured losses per entity** | n/a | US$ 1,500 for households; US$ 1,000 for businesses; US$ 1,900 for farms | US$ 700 |
| **Total extrapolated losses** | US$ 267 million for households; US$ 90 million for commercial establishments | n/a | n/a |

**Table 1.** Summary of findings in study areas

Note: The exchange rates used in this table are:
US$1 = Indian Rupees 45; US$1 = Thai Baht 30; US$1 = Pesos 42

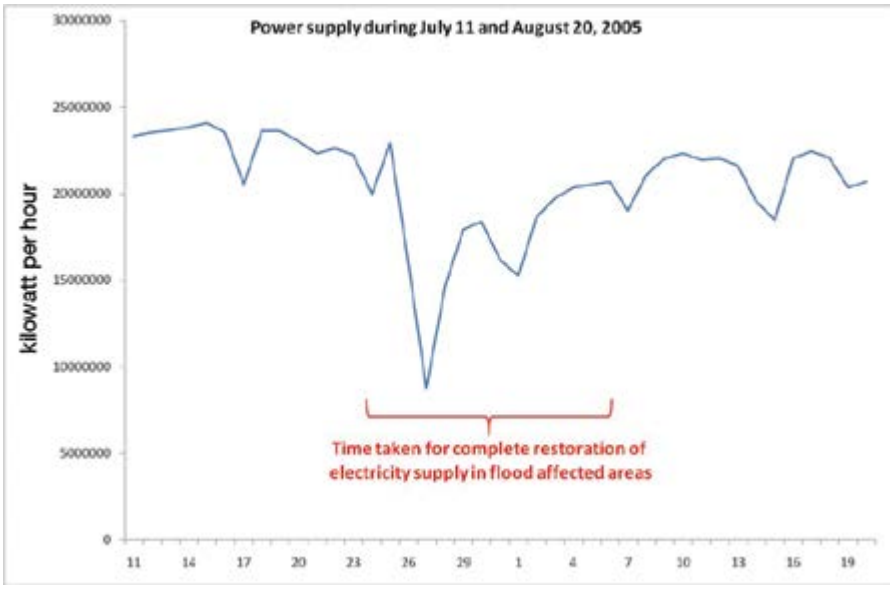


**Figure 1.** Daily power supply between 11 July and 20 August 2005 in Mumbai suburbs
Source: Reliance Energy Daily Drawal Data

were analysed using the appropriate statistical techniques.

## Results and Discussion

The study examined the physical, economic and social impacts of extreme precipitation events and resultant flooding. Table 1 summarizes the study areas and the main findings of the primary survey. Based on the data gathered through questionnaires, we estimated the damages and costs of repairs/replacements on account of floods. The estimated costs are essentially uninsured losses suffered by households belonging to poor and middle-income strata and the private sector engaged in mostly informal activities (small commercial establishments).

### *Mumbai*

For Mumbai, in the aftermath of the 26 July 2005 floods, the total cost of damage was estimated US$ 68 million by the government agencies. The Indian Merchants Chamber estimated these losses at US$ 1,100 million. However, most damages and costs for households and small commercial establishments were not accounted for in the absence of insurance coverage and unavailability of data. This study estimated these uninsured losses through the primary survey. The extrapolated costs or repair/replacement for the flood affected households and commercial establishments are shown in Tables 2 and 3. What is important here is that in the absence of insurance coverage, the extrapolated costs calculated here (US$ 267 million for households and US$ 90 million for commercial establishments) were the out-of-pocket expenses borne by city residents on account of unprecedented floods. In addition to these, there were a number of indirect impacts like the non-availability of essential supplies, price rise due to shortages, unavailability of transportation and disruption of essential services such as electricity and drinking water supply. The disruption of electricity supply is shown in Figure 1.

### *Bangkok*

The extent of damage due to the 2006 floods was estimated by the government agencies for the four districts of the eastern region of Bangkok at US$ 117 million, which included damage to highways, rural roads, railways, waterways and dykes. These four districts have a mixed character of former agrarian regions now undergoing rapid suburbanization, with the damage extending to not only national infrastructure but

| Item | Average cost of repairs/ replacement per household (in INR) | % of households reporting these costs in survey (N=1,168) | Estimated number of households affected by floods for Mumbai* | Estimated costs of damage in INR million for Mumbai* |
|---|---|---|---|---|
| Income loss | 5,000 | 84 | 352,800 | 1,764 |
| Reconstruction of house | 15,000 | 86 | 361,200 | 5,418 |
| Stove | 1,500 | 57 | 239,400 | 359.1 |
| Electric fans | 1,000 | 35 | 147,000 | 147 |
| TV | 7,000 | 42 | 176,400 | 1,234.8 |
| VCR/VCD | 2,700 | 7 | 29,400 | 79.38 |
| Music system | 3,000 | 1 | 4,200 | 12.6 |
| Motorcycle | 8,000 | 13 | 54,600 | 436.8 |
| Refrigerator | 7,000 | 30 | 126,000 | 882 |
| Washing machine | 6,000 | 8 | 33,600 | 201.6 |
| Furniture | 5,000 | 31 | 130,200 | 651 |
| Wardrobes | 4,000 | 32 | 134,400 | 537.6 |
| Utensils | 3,000 | 38 | 159,600 | 478.8 |
| | | | Total Estimated costs | 12,202.68 (US$ 267 million) |

**Table 2.** Cost of repairs/replacements in households in Mumbai for July 2005 floods

* 2001 census data show the total population of around 8.5 million in eastern and western suburbs of Mumbai. Assuming the average of 4 members per family, this translates to about 2.1 million households. We made a rough estimation that 20% of these households (about 420,000) were directly affected due to floods in July 2005 given the extent of flooding in suburbs and calculate the costs accordingly. It must be noted here that we are considering households that are located at the ground level and first storey of residential buildings. Hence 20% seems a reasonable estimate for directly affected households. This exercise provides at best only indicative estimates of the overall costs that households have had to bear in the absence of insurance coverage.

| Item | Average cost of repairs/ replacement per establishment (in INR) | % of establishments reporting these costs in survey (N=792) | Estimated number of establishments affected** | Estimated costs in INR million** |
|---|---|---|---|---|
| Grounds and fences | 40,000 | 48 | 46,080 | 1,843.2 |
| Walls | 11,000 | 26 | 24,960 | 274.56 |
| Windows | 5,000 | 4 | 3,840 | 19.2 |
| Doors and mouldings | 6,000 | 18 | 17,280 | 103.68 |
| Electrical wiring and switches | 10,000 | 28 | 26,880 | 268.8 |
| Heating | 10,000 | 1 | 960 | 9.6 |
| Air conditioning | 14,000 | 1 | 960 | 13.44 |
| Machine tools | 15,000 | 25 | 24,000 | 360 |
| Finished products | 24,000 | 28 | 26,880 | 645.12 |
| Raw materials | 20,000 | 13 | 12,480 | 249.6 |
| Inventory | 24,000 | 13 | 12,480 | 299.52 |
| | | | Total Estimated costs | 4,086.72 (US$ 90 million) |

**Table 3.** Cost of repairs/replacements in small commercial and industrial establishments in Mumbai for July 2005 floods

**MCGM records show around 400,000 registered retail shops and other commercial establishments in the city out of which 60% or 240,000 are located in the suburbs. We make a rough estimation that 40% of these establishments were affected due to floods in July 2005 given the extent of flooding in suburbs and calculate the costs accordingly. This exercise provides at best only indicative estimates of the overall costs that such establishments have had to bear in the absence of insurance coverage.

| | Proxy variables | Sub-proxies | | | | Total |
|---|---|---|---|---|---|---|
| **Household sector** | ***Loss incurred*** | Food and utilities | Transportation | Repairs | Flood prevention | |
| | | 15,000 | 600 | 25,000 | 5,000 | 44,400 |
| | ***Work absence*** | Daily income | Day(s) absent | | | |
| | | 300 | 3 | | | 900 |
| | ***Health*** | Medication | | | | |
| | | 300 | | | | 300 |
| | | | | | | **45,600** |
| **Business sector** | ***Loss incurred*** | Lost customers | Stock damage | Repairs | Flood prevention | |
| | | 15,000 | 5,000 | 5,000 | 5,000 | 30,000 |
| | ***Work absence*** | Daily income | Day(s) absent | | | |
| | | 300 | 3 | | | 900 |
| | | | | | | **30,900** |
| **Agricultural sector** | ***Loss incurred*** | | Field damage | | Flood prevention | |
| | | | 30,000 | | 12,000 | 42,000 |
| | ***Work absence*** | Daily income | Day(s) absent | | | |
| | | 500 | 30 | | | 15,000 |
| | | | | | | **57,000** |

**Table 4.** Flood related costs calculated based on primary survey in Bangkok

| PROXY PARAMETERS | Household Sector (300HH) | | | | | | | | Agricultural Sector(50) | | | Business Sector(30) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Community | | | | Home | | | | | | | | |
| | <10,000 | 10,000-30,000 | 30,000-50,000 | >50,000 | <10,000 | 10,000-30,000 | 30,000-50,000 | >50,000 | Farm | Livestock | Fishery | Consumer Goods | Services |
| Flood Level | 57.14% | 54.07% | 52.22% | 63.16% | 32.14% | 41.48% | 47.78% | 42.11% | 45.45% | 66.67% | 60.00% | 68.75% | 57.14% |
| No. of Days Flooded | 62.50% | 47.41% | 52.00% | 52.63% | 57.14% | 38.52% | 44.44% | 42.11% | 78.79% | 75.00% | 80.00% | 56.25% | 57.14% |
| Loss Incurred | 44.64% | 43.70% | 45.56% | 31.58% | 30.36% | 28.15% | 28.89% | 36.84% | 42.42% | 50.00% | 40.00% | 43.75% | 50.00% |
| Work Absence | * | * | * | * | 39.29% | 29.63% | 43.33% | 47.37% | 90.91% | 91.67% | 80.00% | 56.25% | 42.86% |
| Health | * | * | * | * | 66.07% | 59.26% | 74.44% | 68.42% | * | * | * | * | * |
| Production Price | * | * | * | * | * | * | * | * | 75.76% | 58.33% | 100.00% | * | * |
| Stock | * | * | * | * | * | * | * | * | * | * | * | 31.25% | * |
| Customer | * | * | * | * | * | * | * | * | * | * | * | 43.75% | 64.29% |

| | Flood Level | No.of flood days | Loss Incurred | Work Absence | Health |
|---|---|---|---|---|---|
| High | 30 cm | > month | >10,000 | > week | Admission |
| Medium | 15 cm | 1-4 week | 5,000-10,000 | 3-5 days | District Officer |
| Low | 5 cm | < week | <5,000 | 1-2 days | Store Purchases |
| No Impact | No impact | No impact | No impact | No impact | No impact |

**Table 5.** Intensity of flood impact by sector and income level in Bangkok

community buildings, fisheries and farms. Thus, this study estimated the average loss for each individual household, farm and business through the primary survey, the results of which are given in Table 4. The losses include repair costs for housing, vehicles and other equipment and also indirect costs resulting from illness and work absence. As is evident from the table, these costs are substantial for individual households, farms and businesses, where average monthly incomes of households are Thai Baht 20,000 (US$ 660). These findings are further reinforced in Table 5 when we examine the intensity of flood impact by sector as reported by the respondents.

### *Manila*

In 2009, the typhoons Ondoy and

| | Pre-Ondoy | | Ondoy Period | | Post-Ondoy | |
|---|---|---|---|---|---|---|
| | Men HH | Women HH | Men HH | Women HH | Men HH | Women HH |
| Absences from school | 6 | 8 | 14 | 17 | 6 | 7 |
| Number of workdays lost from sickness due to flood | 5 | 7 | 9 | 10 | 5 | 8 |
| Number of work days lost due to flood | 6 | 8 | 20 | 22 | 6 | 9 |
| Average income loss due to floods | P1,715 | P3,250 | P7,250 | P6,450 | P2,750 | P3,400 |
| Average amount of spent on medicine | P300 | P400 | P3,200 | P3,000 | P500 | P450 |
| Average losses (appliances, etc.) | | | P25,000 | P20,000 | | |
| Average income | P6,250 | P5,000 | - | - | P6,500 | P4,200 |

**Table 6.** Costs due to floods in Marikina and Pasig city during 2009 floods

| | | Pre-Ondoy | | Ondoy Period | | Post-Ondoy | |
|---|---|---|---|---|---|---|---|
| | | Men HH | Women HH | Men HH | Women HH | Men HH | Women HH |
| Food | | P6,000 | P5,800 | P2,500 + relief goods | P2,000 + relief goods | P6,500 | P6,000 |
| Water | Drinking | P50 | P45 | P240 | P240 | P60 | P50 |
| | Cooking/washing utensils | P80 (well)<br>P500 (piped) | P80 (well)<br>P550 (piped) | P80 (well, long lines)<br>P1,500 (piped) | P80 (well, long lines)<br>P1,500 (piped) | P80 (well)<br>P740 (piped) | P80 (well)<br>P700 (piped) |
| Energy/electricity | | P2,000 | P1,800 | P5,000 | P4,500 | P2,000 (wet)<br>P3,000 (dry) | P1,800 (wet)<br>P2,500 (dry) |
| Sanitation/laundry (mud, waist deep; cleaning, two weeks – one month) | | P300 | P310 | P2,000 | P2,000 | P360 | P320 |
| House repair | | | | P1,500 – P15,000 | P1,000 – P8,000 | | |

**Table 7.** Costs of basic needs in Marikina and Pasig city during 2009 floods

Pepeng caused total damage in Pesos (P) of 28.6 billion, including reconstruction costs of P 200 billion or almost 3% of the national GDP as per the government estimates. The primary survey carried out in the two cities in Metro Manila focused on how residents with no insurance coverage had to bear the brunt of the typhoons. With the average income level of P16,000 per month, the residents of these cities had to spend large amounts on repairing and reconstructing their homes with Marikina residents spending P141,000 and Pasig city residents spending P12,000 for the same. This difference in spending is due to the fact that the extreme flood levels (average height of 20 ft) affected even the upper and middle-income households in Marikina city, whereas, mostly low-income households were affected in Pasig city. Other losses were in terms of lost workdays, absenteeism from school, income loss and damage to appliances. The comparative summary of these losses is indicated in Table 6. Similarly, in Table 7, summary of costs of basic requirements is indicated, which shows how the expenditure on basic necessities increased substantially for the residents during floods.

The physical and socioeconomic impacts

of extreme weather events and their costs calculated for the three cities as a part of this study, thus, highlight the importance of a localized analysis to assess the impacts of flooding, as the nature and intensity of the impact would vary from area to area and also for the households belonging to different income groups. An important finding is that these huge monetary costs are the uninsured losses borne by residents belonging to poor strata or engaged in informal commercial sectors. There are no insurance or social security mechanisms currently in place that would help them to deal with the adverse impacts of floods.

## Conclusions

The study carried out for the three coastal cities in Asia — Mumbai, Bangkok and Manila — identifies and measures the physical and socioeconomic impacts of extreme precipitation events resulting in unprecedented floods. These impacts and the costs of damage and repairs/reconstruction have important policy implications for long-term adaptation planning for these cities. As the results of the empirical study show, the costs of damage are very high for the city residents. Most importantly, these costs are out-of-pocket expenses to be borne by them in the absence of insurance coverage and social security.

The study in a way highlights the cost of inaction if very little is done in future to enhance the coping capacity of the cities for future weather events and climate risks in general. The study puts forth a convincing argument that adaptation strategies need to become a part of mainstream planning while devising strategies of developing infrastructure, housing, transport network and other facilities and services in the city. Although adaptation is costly, the costs of inaction can prove to be costlier. Hence, there is a need for integrated and coordinated efforts from all agencies including local government, planners, public utilities and community at large to work towards greater adaptation to future climate risks for the city.

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## ARCP2010-09NSY-PATANKAR

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### PROJECT DURATION

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# Climate Change Assessment in Asian Water Cycle Initiative (AWCI) River Basins

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**ABSTRACT:** The AWCI countries represent a wide variety of geographical, climatic and hydrological conditions and thus various tools and methods are required for climate change impact assessment. This article introduces some of the tools developed as a part of the AWCI activities. A hydrological model for cold regions was developed by incorporating a multi-layer energy-balance based snowmelt scheme into the Water and Energy Budget Distributed Hydrological Model (WEB-DHM). A method was developed for estimating snow depth spatial distribution in mountain areas using a radiative transfer model and microwave radiometer observations (AMSR-E satellite data) and validated in the Puna Tsang basin in Bhutan. Moreover, an improved statistical method for GCM precipitation output bias correction was developed that covers extreme rainfall, normal rainfall and frequency of dry days, and was validated in the Pampanga basin in the Philippines. In addition, the bias correction method and WEB-DHM model were employed in a climate change impact assessment study in the Philippines, focusing on flood peaks and droughts. Results showed future flooding trends are virtually certain to increase while drought trends are likely not to increase in the uplands but very likely to increase in the flood plains.

***KEYWORDS:*** *climate change impacts on water cycle, AWCI river basins, GCM bias correction, WEB-DHM, snow processes*

## Introduction

The consequences of climate change that are unavoidable over the next several decades will have enormous impacts on a range of natural and socioeconomic systems. Therefore, it is very urgent to develop roadmaps for laying down proper adaptation strategies together with mitigation approaches. The Global Earth Observation System of Systems (GEOSS) Asian Water Cycle Initiative (AWCI) has been striving to develop and promote appropriate strategies for addressing issues associated with climate change impacts on water resources and their management in AWCI participating countries that include Bangladesh, Bhutan, Cambodia, India, Indonesia, Japan, Republic of Korea, Lao PDR, Malaysia, Mongolia, Myanmar, Nepal, Pakistan, Philippines, Sri Lanka, Thailand, Uzbekistan and Viet Nam. The APN-funded project "River Management System Development in Asia Based on Data Integration and Analysis System (DIAS) under the GEOSS" aims to develop an advanced river management system in member countries by exploiting and integrating data from earth observation satellites and *in situ* networks with other types of data, including numerical weather prediction model outputs, climate model outputs, geographical information, and socioeconomic data. The AWCI countries represent a wide variety of geographical, climatic and hydrological conditions and thus various tools and methods may be required, although the overall approach is common among the countries.

This article introduces some of the research outcomes of the AWCI activities related to the mentioned project including (i) snow processes, (ii) GCM bias correction and downscaling for climate change assessment, and (iii) impacts of changing climate on floods and droughts.

### HIGHLIGHTS

- Development of a distributed hydrological model in AWCI basins by integrated *in situ* and satellite data and model outputs.
- Development and validation of WEB-DHM-S, a hydrological model for cold regions including an advanced, multilayer energy-balance based snowmelt scheme.
- Development and validation of a method for snow depth distribution estimation using satellite data.
- Development and validation of a GCM precipitation output bias correction method for use in climate change assessment studies.
- Application of developed methods in climate change impact analysis in AWCI basins.
- Dam operation optimization using forecast precipitation data and employing WEB-DHM in AWCI basins — ongoing.

## Snow Modelling

Snow and glaciers are natural reserves of freshwater in a number of AWCI countries and thus tools and methodologies considering these phenomena are needed. From a hydrological point of view, the temporal and spatial variability of the snow distribution on a basin scale plays a key role in determining the timing and magnitude of snowmelt runoff. Considering the effect of snow on land and atmospheric processes, it is essential that hydrological models accurately describe seasonal snow evolution. For applications in the AWCI basins, such a model was developed by incorporating a multi-layer energy-balance based snow scheme into a distributed hydrological model (Shrestha et al., 2010, 2012). In addition, a method for estimating snow amount spatial distribution was developed using a microwave radiative transfer model (RTM) in mountain regions (Duran-Ballen et al., 2012).

### *WEB-DHM-S Model Description*

The Water and Energy Budget Distributed Hydrological Model with improved snow physics (WEB-DHM-S; Shrestha et al., 2010, 2012) was developed by coupling the three-layer energy balance snow physics of the Simplified Simple Biosphere, version 3 (SSiB3) and the prognostic albedo scheme of the BATS into the Water and Energy Budget Distributed Hydrological Model (WEB-DHM; Wang et al., 2009a,b). The WEB-DHM realistically simulates the land surface and hydrological processes, providing a consistent description of water, energy, and $CO_2$ fluxes at a basin scale. WEB-DHM-S

adds more features to the WEB-DHM for simulating the spatial distribution of snow variables such as the snow depth, snow water equivalent, snow density, liquid water and ice contents in each snow layer, snow albedo, snow surface temperature, and snowmelt runoff. Following the basic model structure (Wang et al., 2009a), the basin and sub-basins are delineated employing the Pfafstetter scheme, and sub-basins are divided into a number of flow intervals based on the time of concentration. All external parameters (for example, land use, soil type, hillslope properties and vegetation parameters) and a meteorological forcing data set including precipitation are attributed to each model grid, in which water, energy, and $CO_2$ fluxes are calculated. A hillslope-driven runoff scheme employing a kinematic wave flow routing method is adopted in calculating runoff. For snow-covered model grids, a three-layer energy-balance-based snow accumulation and melting algorithm is used when the simulated snow depth is greater than 5 cm; otherwise, a one-bulk-layer snow algorithm is used. Each model grid maintains its own prognostic snow properties (temperature, density and ice/water content) and/or land surface temperature and soil moisture content. The model was validated in the Dudhkoshi region of the Koshi basin, located in the northeast Nepal Himalayas (Shrestha et al., 2012).

## *Snow Depth Spatial Distribution Using Microwave Remote Sensing at the Puna Tsang River Basin in Bhutan*

*Methodology*

A new approach was developed to estimate snow amounts using a microwave radiative transfer model (RTM) in mountain regions, which takes into account local terrain slope and incidence angle of a radiometer scanner (Duran-Ballen et al., 2012). AMSR-E satellite observations of brightness temperature (Tb) at 18.7 GHz and 36.5 GHz frequencies were compared to calculated values of Tb in Lookup Tables generated by the RTM model. The snow algorithm used to derive the snow depth and temperature

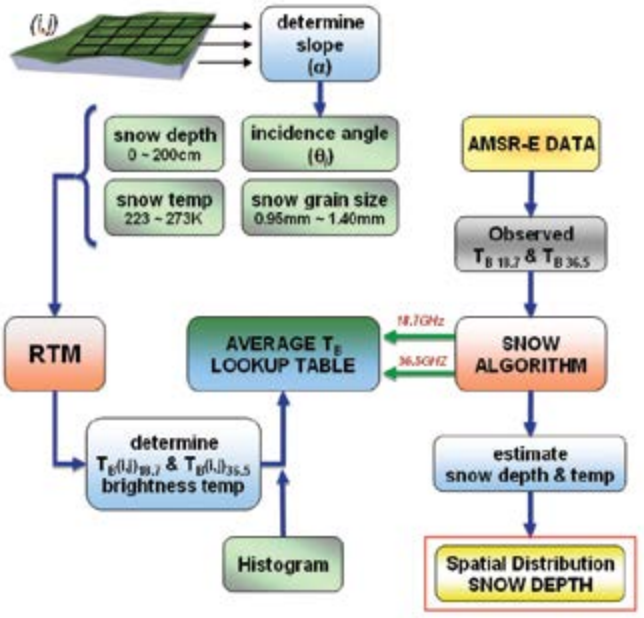



**Figure 1.** Framework of the snow depth spatial distribution estimation method

spatial distribution was validated in a flat region using *in situ* recorded snow depth data (Tsutsui & Koike, 2009a,b). However, remote sensing instruments are sensitive to the effects of the terrain slope, where the local incidence angle is different than the 55-degree incidence angle in case of a flat surface.

The terrain DEM is used to calculate the slope and aspect of each grid and the local incidence angle is computed with the geolocation of the satellite as it passes over. To overcome the difference of spatial resolution between the AMSR-E data (25x25 km) and the DEM (resolution 1x1 km to express appropriately the terrain), Tb for the both frequencies is estimated with the local incidence angle for each terrain grid and then averaged for the larger satellite footprint grid using a weighted average based on the occurrence of the same local incidence angle. A uniform snow depth and temperature is assumed within each satellite footprint.

The lookup tables are generated by inputting the snow depth and temperature into the RTM model for a range of local incidence angles (25°–80°), snow depths (1–200 cm), and snow temperatures (223–273 K). One 18.7 GHz Tb and one 36.5 GHz Tb are calculated for each combination of snow depth and temperature and for each terrain grid. Then, the observed Tb is compared

to the calculated average Tb in the lookup tables and corresponding snow depth and temperature of each footprint grid is estimated (Figure 1).

*Results and Conclusions*

The algorithm was applied to the Puna Tsang river basin in Bhutan (Figure 2). Due to the lack of *in situ* snow observation, it was validated against the outputs of snow depth of the WEB-DHM-S (this model is described in sub-section 1 above by Shrestha et al. (2012)). WEB-DHM-S outputs of stream discharge and snow cover area were validated with measured flow discharge at 4 gauge stations and MODIS snow cover area, respectively. As indicated by comparison in Figure 3, the RTM successfully estimates the snow depth trend and seasonal behaviour of the snow cover areas. The best spatial correlation of 0.3 was for 26 February 2006.

The developed method is a useful tool for snow depth estimation from satellite observations in the snow-melt dependent basins. Together with the WEB-DHM-S model, these tools are essential for further research on climate change impacts on water cycle in AWCI countries with cold regions.

## Bias Correction Method for Climate Change Impact Assessment

Realistic representation of precipitation fields in future projections from climate models is crucial for impact and vulnerability assessments. However, General Circulation Models (GCMs) often fail to simulate regional climate features required by basin-scale impact studies due to inadequate parameterization of several processes associated with cloud formation and land surface interactions with the atmosphere. To overcome this issue, a comprehensive statistical bias correction method for climate change assessment on the catchment scale was developed for applications in the AWCI basins (Nyunt et al., 2013). The method was applied and validated in the Pampanga,

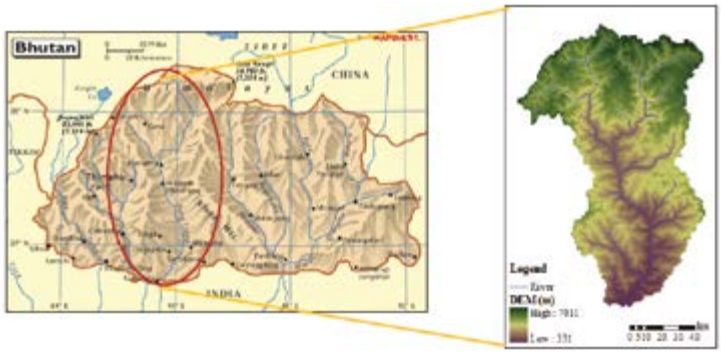



**Figure 2.** Puna Tsang river basin in Bhutan

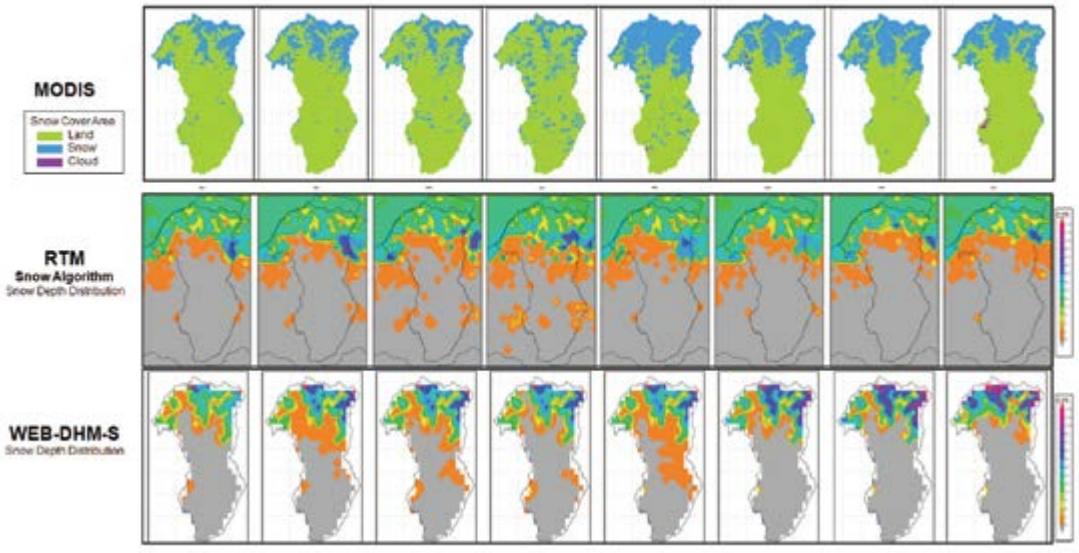



**Figure 3.** Snow depth spatial distribution over the target region from October 2005 to May 2006

Angat, and Kaliwa basins in the Philippines (Figure 4).

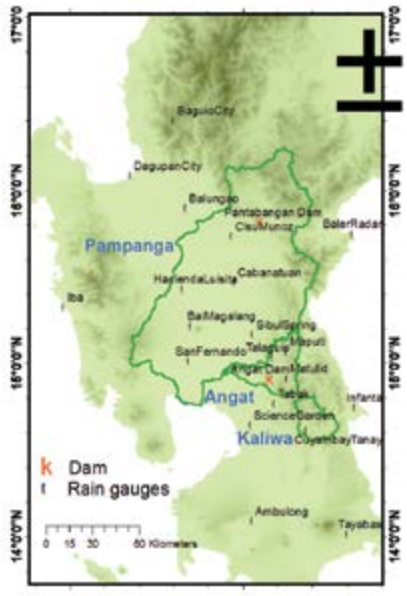



**Figure 4.** Location of Pampanga, Angat and Kaliwa Basins

## *Method Description*

The method uses an ensemble of available GCM outputs (daily values) and begins with selection of suitable GCMs for a given region. Then the daily precipitation output is corrected in three steps including extreme rainfall correction, correction of frequency of wet days (no-rain-day threshold), and correction of frequencies between the no-rain-day threshold and extreme events. The GCM rainfall is corrected using historical *in situ* rainfall observation. The method is in details described in Nyunt et al., 2013).

*GCM selection*

GCM selection is based on historical simulation of daily rainfall and other atmospheric parameters of 24 GCMs from the Coupled Model Intercomparison Project 3 (CMIP3) project over a targeted area. The scores are determined from spatial correlation coefficient (Scorr) and root mean square error (RMSE), which are derived from comparison of model outputs with reference data sets. Reference data sets include Global Precipitation Climatology Project (GPCP) products for precipitation and Japanese 25-year Reanalysis Project (JRA-25) for other atmospheric parameters. The area of interest for GCM selection in this study covered the Bay of Bengal, Indian Ocean, Philippine Sea, Java Sea and part of Southeast Asia (80°E–160°E and 0°N–20°N), while a smaller window is used for precipitation (115°E–130°E and 10°N–20°N).

*Rainfall Bias Correction*

The analysis of extremes has traditionally been tested using annual maximum series (AMS), and adjusted to suitable distributions (Gupta & Duckstein, 1975). However, this causes a loss of further high rainfall events within one year that may be considered extremes and that may exceed the maximum rainfall of other years. Therefore a new approach is employed to correct both intensity and frequency of extreme events. It is based on partial duration series (PDS), which are constructed using values above a threshold regardless of their year of occurrence, and permit inclusion of more than one event per year (Hershfield, 1973). The generalized Pareto distribution (GPD), which is the limit distribution of excess over a threshold series, is used to model PDS (Bobee & Rasmussen, 1995). A major issue of using PDS is the selection of threshold rainfall value to fit GPD. In this study, the lowest AMS from observed rainfall is defined as the first trial threshold of the GPD series. The same number of extreme events is defined for GCM gridded series by ranking. Then, GCM series are fit to the GPD and bias-corrected GCM precipitation is calculated:

$$x'_{GCM} = F^{-1}_{OBS}\left(F_{GCM}\left(x_{GCM}\right)\right) \quad (1)$$

where $x'_{GCM}$ is bias-corrected extreme rainfall, $F^{-1}_{OBS}$ is the inverse function of GPD probability of observed rainfall, $F_{GCM}$ is the GPD probability of GCM rainfall, and $x_{GCM}$ is the raw GCM output. Moreover, the corrected extreme rainfalls are calibrated by tuning the different thresholds to minimize RMSE between the corrected GCM and the observed extreme. The future projection rainfall is corrected by applying the same

transfer function between GCM and observations during the historical period:

$$x'_{GCM\_fut} = F^{-1}_{OBS}\left(F_{GCM\_past}\left(x_{GCM\_fut}\right)\right) \quad (2)$$

where $x'_{GCM\_fut}$ is the future bias-corrected rainfall $F_{GCM\_past}$ is the GPD probability of GCM rainfall for historical period, and $x_{GCM\_fut}$ is the raw GCM future projection.

The next step is to correct the frequency of wet days because most GCMs generate unrealistic low-intensity rainfall during a large number of wet days. This issue is resolved by using the ranking order statistics of the entire time series. The total frequency of wet days in the observed data set is attained and applied to the GCM output to find the threshold rank and rainfall value, below which the GCM output is then considered zero, i.e. no-rain-day. For future projection, the same threshold for no-rain-day correction is used.

Finally, rainfall intensities between the extreme and no-rain-day thresholds are classified as normal rainfall in both observed data and GCMs. A two-parameter gamma distribution is used to correct bias of normal rainfall. It is assumed that the cumulative distribution function (CDF) of normal daily rainfall at a certain grid point follows the gamma distribution function. The daily GCM and observed rainfall data are fitted to a two-parameter gamma distribution for 12 months. Then, the CDF of daily GCM rainfall is mapped to the CDF of observed data for each month. The corrected normal rainfalls are calculated by the fitted gamma CDF using Eq. 1. This procedure adjusts only the rainfall intensity at monthly scale; it does not correct any errors in monthly frequency. The same transfer function for future projection is used (Eq. 2).

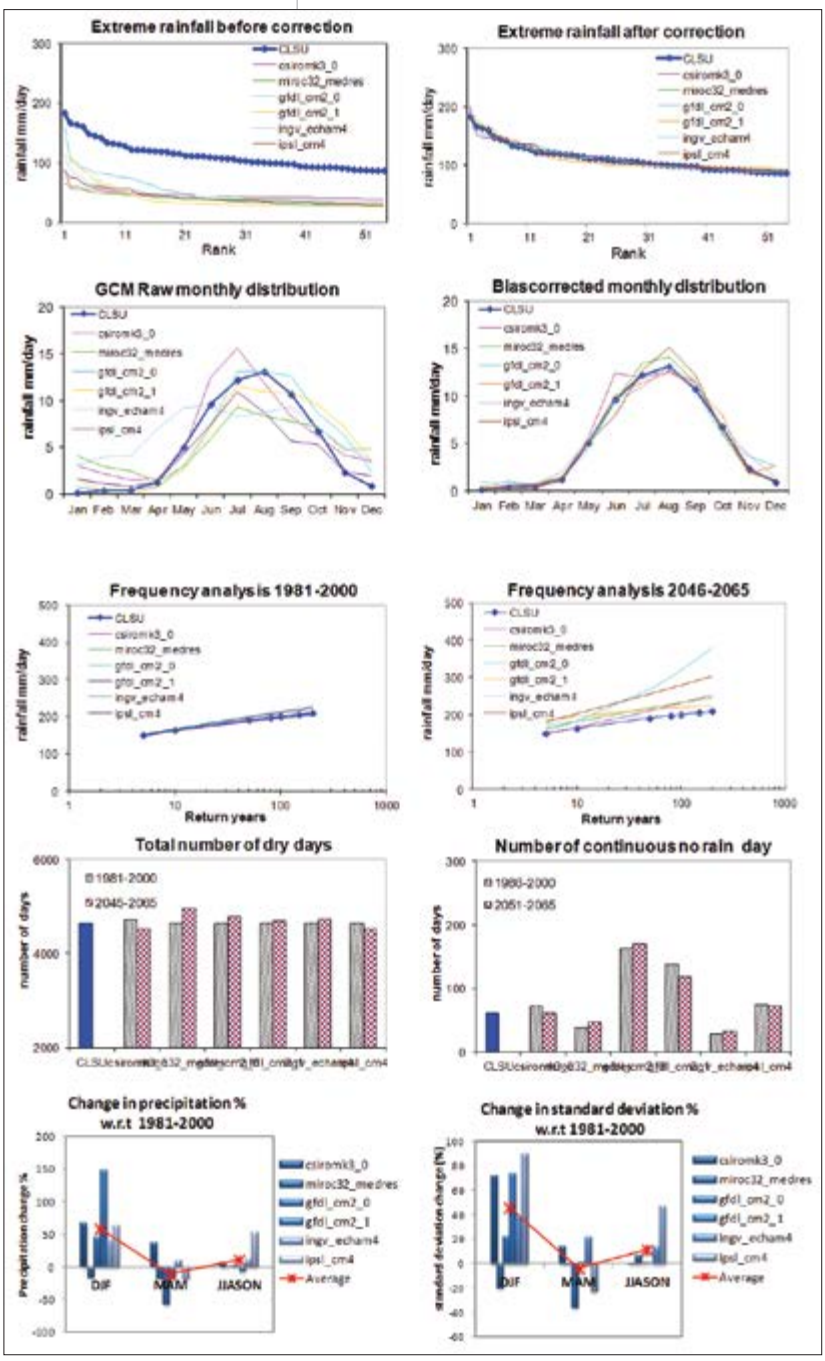



**Figure 5.** Results of the bias correction of six selected GCM rainfall outputs using *in situ* observations at the CSLU station in the Pampanga basin

## *Application at the Pampanga Basin*

The method was applied and validated at the Central Luzon State University (CLSU) station in the Pampanga basin. The Philippine Atmospheric, Geophysical and Astronomical Services Administration (PAGASA) and MWSS provided the *in situ* data. CMIP3 GCM gridded daily precipitation was acquired from the DIAS server, developed at the University of Tokyo. The control historical period was 1981–2000 and the projected period was 2046–2065, under the Special Report on Emissions Scenarios (SRES) A1B.

### *Results and Conclusion*

Six GCMs were selected according to their simulated performances over Luzon Island in the Philippines, to reduce the uncertainty of single GCM use. The results

of bias correction are shown in Figure 5. The biases of extreme rainfall are successfully controlled by GPD fitting of their sorted ranks, not only in frequency but also in intensity of extremes. The method was validated through frequency analysis of extremes during the control period and then the trends in extreme intensities were identified (Figure 5, third row). It is important for deciaion-making and infrastructure design in future strategies. All GCMs show general increases in intensity in future, except the INGV_ECHAM4 which is the same as CLSU in high return years.

Frequencies of no-rain-days were corrected as described in the previous section. The analysis of future projections showed that four out of six GCMs predicted larger numbers of total dry days in the future, by nearly 70 to 80 days (Figure 5, fourth row). After correcting all the components including normal intensity rainfall, the seasonal variability was validated against observation, which was well captured (Figure 5, second row). Remaining small discrepancies originate from errors in the monthly frequency distribution. The future change in seasonal rainfall (%) and standard deviation change (%) for three seasons with respect to 1981–2000 was investigated (Figure 5, bottom row). DJF is December-January-February, MAM is March-April-May and JJASON is wet season from June to November. By averaging all GCM outputs, maximum increase in precipitation is indicated for winter, while there is a decrease during the monsoon season and a small increase during the rainy season.

The developed statistical bias correction method was validated for both intensity at a point and for long-term average seasonal rainfall climatology. It can be applied in further hydrological impact studies analysing river discharge and other hydrological parameters at the basin scale.

## Impacts of Climate Change Assessment and Runoff Simulation in Philippine Basins

The study (Jaranilla-Sanchez et al., 2013) is an example of an analysis of possible impacts of climate change on water resources in an AWCI country using some of the tools introduced in previous sections. The objective is to assess these impacts in three river basins in the Philippines, including Angat, Kaliwa and Pampanga in terms of flooding trends and drought trends. To accomplish this, hydrometeorological parameters (rainfall, temperature, short wave and long wave radiation) from CMIP3 GCMs archived in DIAS were used as forcing data for a hydrological model to determine past and future climate change projections at the three river basins.

### *Method and Data*

Selected GCM ensembles were incorporated into the Water and Energy Budget-Based Distributed Hydrological Model (WEB-DHM; Wang et al., 2009a,b) and 1981–2000 (past) versus 2046–2065 (future) impacts on floods and droughts were analysed by focusing on climate change effects on surface flow. However, large biases in GCM output (especially in precipitation) need to be reduced as well as the mismatch of grid resolution between GCM outputs and basin-scale hydrological model inputs. The three-step bias correction described in the previous section was used prior to GCM output utilization. Spatial downscaling by bias correcting on 21 gauges with observed data were employed while temporal downscaling by using specimen hourly rainfall distribution for different intensities were used. Analysis of flooding trends were based on the analysis of the 10th percentile of peak flow trends while for drought, low flow was analysed based on the second lowest of the 20-year past drought discharge (355th value descending order). Long-term drought intensity trends were analysed using the Standard Anomaly Index (SA; Jaranilla-Sanchez et al., 2011) applied to discharge flows in each basin to quantify (monthly scale) drought trends for the past versus the future. This index can be utilized to determine drought frequency and intensity using at least 20 years of monthly data sets from different hydrological parameters

by fitting an appropriate distribution pattern to the monthly data and standardizing and categorizing the deviations from the mean with increasing dryness (if below -1).

The study included three river basins: Angat (1,085 km$^2$), Kaliwa (280 km$^2$) and Pampanga (10,981 km$^2$) (Figure 4). There are two dams (Angat and Pantabangan) and several water conveyance constructions in these basins including Umiray-Angat tunnel, Casecnan trans-basin tunnel, Aurora trans-basin channel and Masiway spillway outflow that are considered in the simulations. Digital elevation model was derived from 90 m SRTM data and re-sampled to 500x500 m grid size. The soil and land-use data were prepared from local maps and re-classified according to the FAO and SiB2 categories.

*In situ* meteorological forcing data used for calibration and historical simulations were taken from 12 local gauges and include: surface air temperature (K), relative humidity (%), total cloud cover (%), downward long wave and short wave radiation flux at surface (W/m$^2$). Rainfall was from daily data in 12 meteorological stations and 35 synoptic stations. These were spatially distributed and downscaled by inverse distance weighing interpolation (IDW). The Nash Coefficients (Nash; Nash & Sutcliffe, 1970) and relative errors (RE) were used in the WEB-DHM calibrations of the 3 basins.

GCM forcing data for future simulations include output of 6 models: gfdl_cm2_0, gfdl_cm2_1, ipsl_cm4, ingv_echam4 and miroc3_2_medres. The selection procedure (described in the previous section) considered seven parameters: precipitation, longwave radiation, sea surface temperature, sea level pressure, air temperature, meridional and zonal wind. The three-step bias correction method (described in the previous section) was used to correct rainfall while no bias correction was done for the other meteorological parameters (temperature, short wave and long wave radiation). Spatial downscaling was done by correcting the biases on each of 21 selected rain gauge data, temporally downscaling them using average hourly rainfall factors from several rain gauges and re-gridding the hourly rainfall data. Hence this method assumes that future rainfall will have similar climatology and distribution as that of past rainfall. Soil moisture verification in the basin for the WEB-DHM calibration used the Land Data Assimilation System developed by the University of Tokyo (LDAS-UT; Yang et al., 2007).

## Results and Conclusions

Calibration of Angat dam inflow was done by comparing dam inflows for the year 2003 (Nash=0.72, RE=23%). Currently there are no installed streamflow gauges in the Kaliwa river basin. Hence calibration of this basin was done by assuming similar soil properties for the same soil types in Angat and Kaliwa. Calibration in the Pampanga river basin was done for 2002 upstream in Pantabangan dam (Nash=0.5, RE=3.8%), Cabanatuan (Nash=0.05, RE=83%), Zaragoza (Nash=0.35, RE=34%), San Isidro (Nash=0.22, RE=50%) and 2001 for Arayat streamflow gauge (Nash=0.31, RE=24%). Results showed that the temporal behaviour of soil moisture from basin scale hydrological modelling and larger scale estimation using LDAS-UT can be used to estimate large scale soil moisture of the area. RE was found to be 2.23%. The simulated soil moistures assimilated by LDAS-UT and simulated by WEB-DHM were not used to project future climate change effects on basin scale droughts since the focus of the study was mainly on the behaviour of discharge during extreme events.

Peak flow trends can be good indicators of future floods. Results after ranking (in descending order) the past and future 20 years daily discharge show that similar patterns can be expected in the near future. However, the 10th percentile peak daily discharges for Angat, Kaliwa and Pampanga river basins showed that all 6 models of each basin had higher peak discharges in the future (Figure 6). In all 3 basins, highest peak discharge can go from 1.5x to 6x increase from past values while the remaining 19 peak flows show only a slightly higher (1x) to double (2x) the past peak values. These simulations were under the assumption

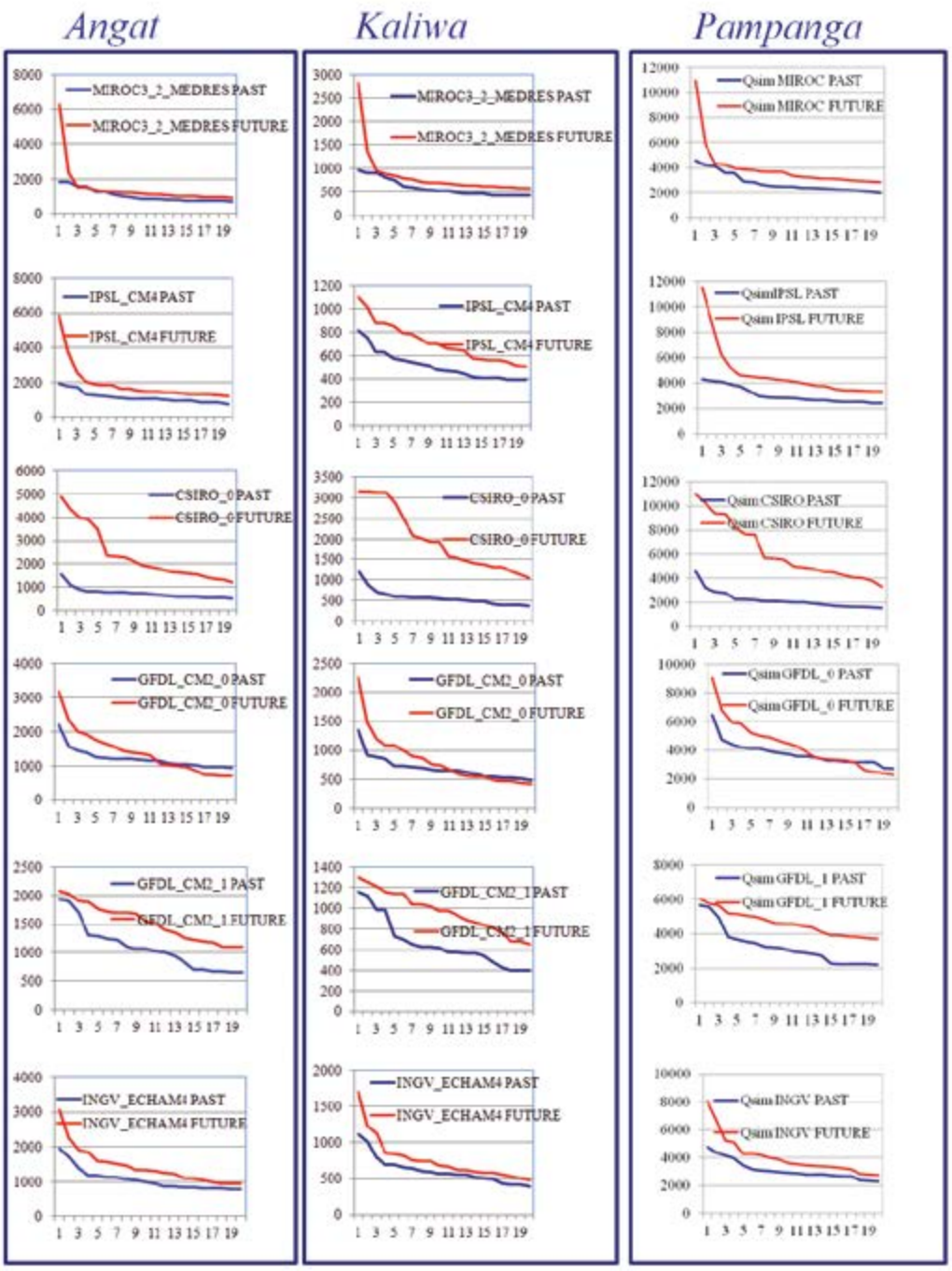



**Figure 6.** The 10th percentile peak flows for past (blue) and future (red) simulations in the Angat, Kaliwa and Pampanga basins

that climatology will be similar in the past and in the future. However, even after bias correction and temporal downscaling, only the intensities and frequency of the extreme events can be simulated. Further studies are still needed to improve the timing as to when the extreme events occur.

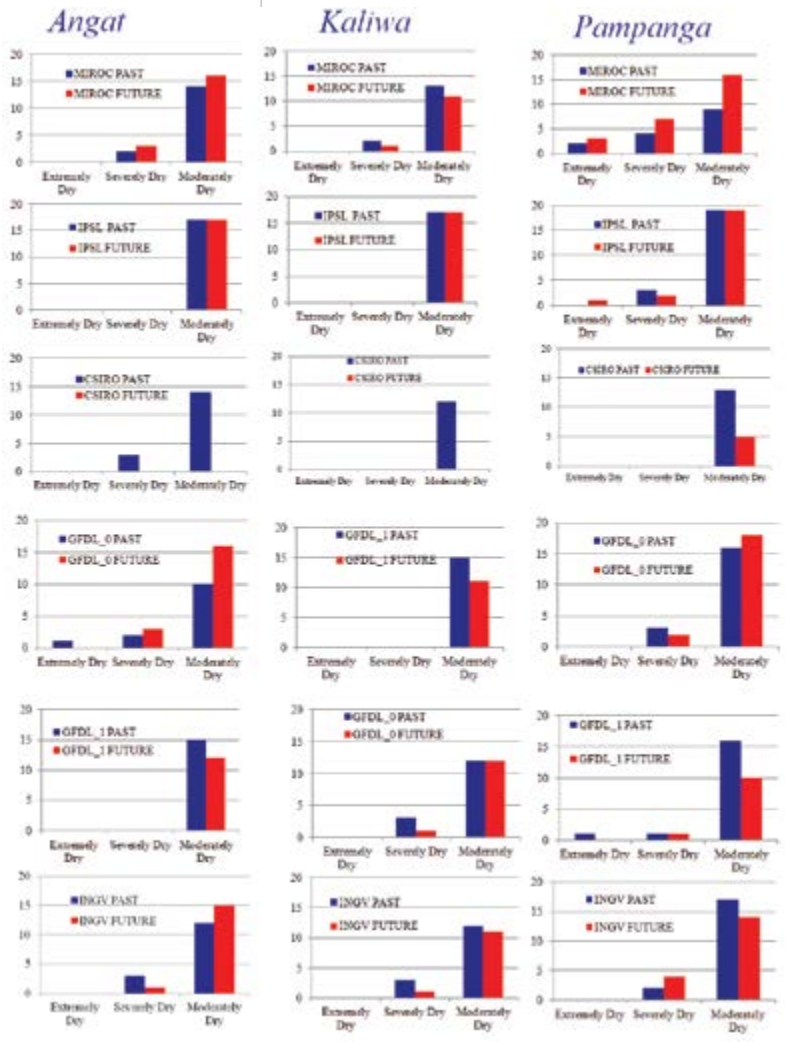
Base flow trends were used to determine drought trends in future. The 355th rank of the past climatologically averaged daily discharge simulation was used as the basis of drought discharge. The 10th percentile was additionally used to identify drought discharge for the 20 year simulation in past GCMs. The number of days that base flow was less than past drought discharge was identified as well as the longest number of days each year that is below average drought discharge. The Angat and Kaliwa river basin show a 50%–60% chance of drought in the future while a 90% chance of increasing drought conditions in the future is shown in the Pampanga river basin. This difference is due mainly to the local land-use and

climatologic conditions (forest and higher rainfall in the two smaller basins vs. croplands and low rainfall in Pampanga). The SA drought index was used to project longer duration (at least one month) drying trends in the future (Figure 7). For Angat, 3 models increase, 2 models remain the same and 1 model decreased while for Kaliwa, 4 models decreased and 2 models remained the same. For Pampanga, only miroc model increased in all SA categories while the rest showed different degrees of increase and decrease in the categories.

## Conclusion

This article introduced several outcomes of the research work carried out in the AWCI countries and contributing to the highlighted APN project. Advanced tools and methods were developed to enable climate change impact assessment on water cycle in basins in Asia, including WEB-DHM-S, a hydrological model addressing snow and glacier processes, a method for snow depth distribution estimation in mountain regions, and a GCM precipitation output bias correction technique. A comprehensive study on climate change impacts in three basins in the Philippines, employing some of the developed tools, was carried out and indicated a very likely increase in flood intensities and frequencies in all the basins. On the other hand, the results also suggested that severe droughts are very likely to occur in the Pampanga river basin but not as likely in Angat and Kaliwa basins, with local conditions playing a very important role in how floods and droughts affect them. Careful consideration of uncertainty should be considered for water resource management planning factoring in future climate changes in these basins.

**Figure 7.** Long-term drought intensity analysis using Standard Anomaly Index

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## ARCP2011-02CMY-KOIKE

### PROJECT TITLE

**River Management System Development in Asia Based on Data Integration and Analysis System (DIAS) under the GEOSS**

### COUNTRIES INVOLVED

Bangladesh, Bhutan, Cambodia, India, Indonesia, Japan, Korea, Lao PDR, Malaysia, Mongolia, Myanmar, Nepal, Pakistan, Philippines, Sri Lanka, Thailand, Uzbekistan, Viet Nam

### PROJECT DURATION

2 years

### APN FUNDING

US$ 90,000

### PROJECT LEADER

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ARCP2011-03CMY-ASANUMA

# Intercomparison of Land Surface Process Modelling in Asian Drylands

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**ABSTRACT:** For better prediction of the future climate at Asian drylands by using climate models, a community of Asian scientists, including young scientists, was formed to intercompare numerous land surface process models. These models are sub-modules of climate models to reproduce water, energy and vegetation processes at land surface, and are used independently, i.e. "offline," from climate models in the present study. The Asian Dryland Model Intercomparison Project (ADMIP) is an international project driven by this community. The data needed to drive the models at the target sites were collected and archived: one of the finest data sets for Asian drylands was constructed. Then, these data were used to drive a number of state-of-the-art numerical models of land surface processes. The outputs generated were also archived, and they were subject to mutual comparison. This way of comparison is called model intercomparison, which sheds light on differences in the reproducibility of land surface processes caused by different coding between the models. This gave an insight into the current status of modelling skills of land surface processes at Asian drylands.

***KEYWORDS:*** *land surface model, terrestrial ecosystem model, drought prediction, land degradation, Asian drylands*

## Introduction

### *Why Drylands?*

Drylands account for 40% of the earth's land surface, and also a similar fraction of Asian land surface (FAO, 2008; Figure 1). Characterized by dry climate, low vegetation cover and low nutrients, its ecosystem and the society that depends thereon, have inherently large vulnerability to the external perturbations, such as climate change and land-use change. IPCC AR4 predicts drier climate in the extratropical arid regions during the latter half of this century, and overgrazing and/or land-use change are triggering desertification and land degradation in Asian drylands, especially in the transitional zones (Fu, 2009). Because it concerns the poorest population groups, essentially living off threatened natural resources, desertification and land degradation

are challenges for achieving the Millennium Development Goals (UNCCD).

### *What is Land surface Process Modelling?*

In order to facilitate sustainable land management in Asian drylands, increasing our predictive capability of land surface processes is indispensable. This can be achieved through improvement of land surface process modelling, that refers, in this proposal, to land surface models (LSMs, Figure 2) and terrestrial ecosystem model (TEMs), each of which are briefly described below.

Land surface models (LSMs) were initially developed as a sub-module of general circulation models (GCMs) to incorporate energy and water exchange at the land surface into global atmospheric simulation (Manabe, 1969). Since the mid-1980s, LSMs have been developed separately from those of their parent GCMs. Now, most sophisticated LSMs in the world compute processes such as heat and water budget for different land cover/use, transpiration and carbon assimilation of plants, river discharge, groundwater, urban environment, and even usage and control of river water by human beings (Pitman, 2003; Oki & Kanae, 2006).

Terrestrial ecosystem models (TEMs) has also been developed in conjunction with GCM simulations, particularly to incorporate response of ecosystems to elevated $CO_2$ concentrations in future projections. TEMs specialize in carbon dynamics, such as plant growth, ecological succession and soil organic processes at longer time-scales larger than, for example, months, while

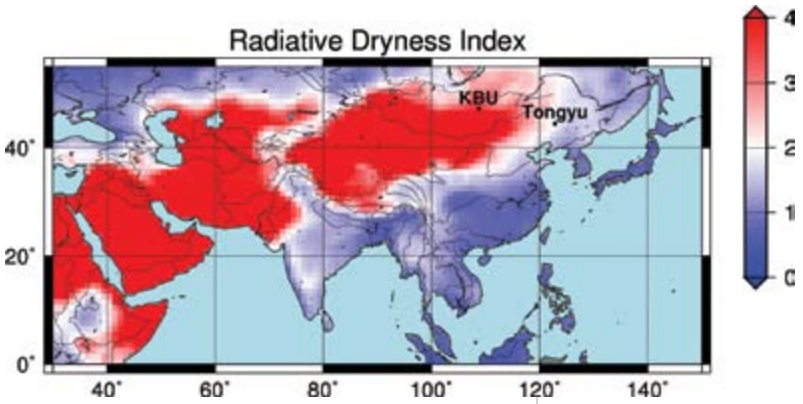



**Figure 1.** Dryland in Asia, indicated by the radiative dryness index (RDI), which is proportional to the ratio of the net radiation to the precipitation. RDI=1-2 is steppe, and RDI>3 is desert. The target stations of the project are marked.

LSMs, that major in water and energy at shorter time-scales such as hours and days, take vegetation as a static component. Though these models are initially developed for a sub-module of GCMs as stated, they can be used independently of GCMs (offline), and can serve as a modelling tool for land surface environments at the regional and point scales.

### *What is Model Intercomparison?*

The current most sophisticated LSMs and TEMs utilize the latest scientific knowledge on the hydrosphere, atmosphere and biosphere, and use state-of-the-art computer simulation techniques. Nevertheless, uncertainties in the model results are, in general, large, and the origins of these uncertainties are still a matter for research targets. In particular, it is already known that the ability of these models to reproduce land processes at Asian dryland surface processes are still limited (Figure 2), partly because they are not sufficiently tested at short grass vegetation in Asian drylands, where plant activities are strongly regulated by water availability. In other words, Asian drylands are one of the largest gap regions in land surface modelling work. Note that most LSMs and TEMs are initially developed for tropical and boreal forests as a major target. In addition, until recently, the observed data that is needed to drive and validate these models were not easily available for Asian drylands.

The model intercomparison (Henderson-Sellers et al., 1993, 1995; Figure 3) is a way toward

#### HIGHLIGHTS

- A community was formed for the intercomparison of land surface process models for Asian drylands with 18 participating models and their operating scientists.
- The procedure of model intercomparison was documented.
- One of the finest data sets for Asian drylands was constructed for modelling work.

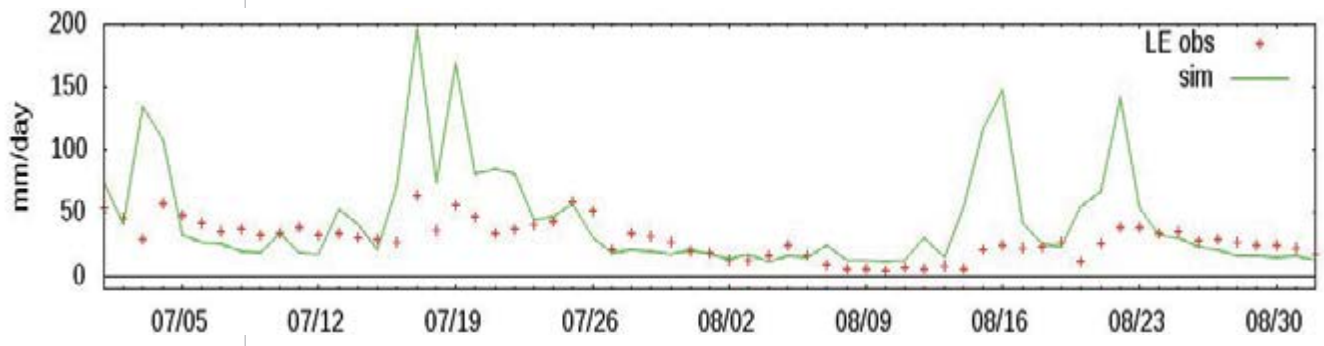



**Figure 2.** An example of LSMs simulation results of evaporation at Mongolian grassland (line) compared with the observations (cross)

improvement of LSMs and TEMs, where multiple models are run with a common driving meteorological data set, and the results are compared to identify relative model performance as well as ensemble characteristics common to all of the models tested. This facilitates intensive tests of LSMs at the targeted site as well as provide best-estimate of model uncertainties from the inter-model variations.

## *Target Phenomena and Scientific Questions*

### *Target Phenomena*

Target phenomena that will be tested through the intercomparison of LSMs and TEMs are energy, water and carbon exchange at the land surface under a water-limited environment, and/or under the control of vegetation growth, at the temporal scales of three-hourly, daily and monthly.

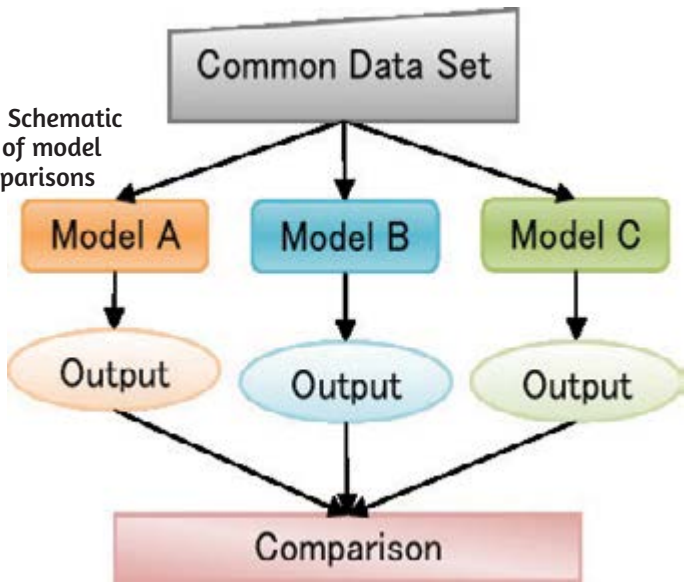



**Figure 3.** Schematic diagram of model intercomparisons

### *Scientific Questions*

Scientific questions that will be answered through the intercomparison of TEMs and LSMs are:

- What is the ability of models to reproduce energy, water, and carbon exchange at dryland surface (reproducibility)?
- Do current ecosystem models, developed mainly for forests, reproduce energy, water and carbon exchange in arid regions?
- Does the current complexity of models effectively simulate land surface processes (complexity issues, also related to benchmarking)?
- Does the multi-model ensemble of LSMs outperform single model output (ensemble)?

## *The Purpose of this Project*

In the project, several LSMs and TEMs were intercompared using common data obtained from Asian drylands. LSMs and TEMs were chosen from selected research and operational institutes. Two selected sites provided meteorological data to drive the models. These sites started their observations within this century, and have continued the observations to acquire high-quality and continuous data that are needed to drive LSMs and TEMs in the intercomparison.

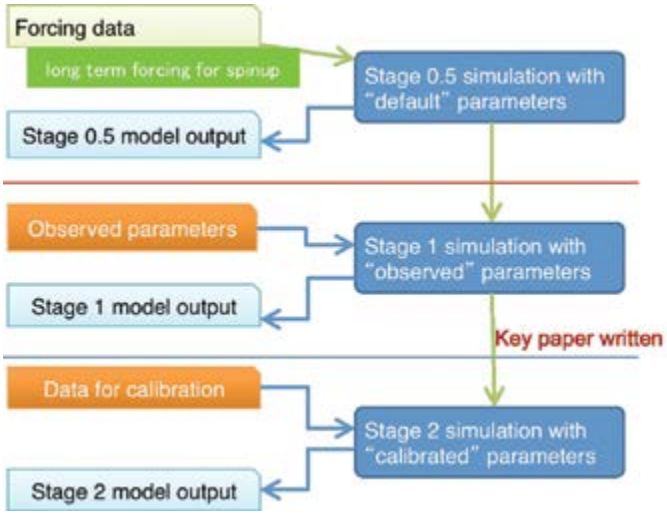



**Figure 4.** Schematic diagram for the blind policy in ADMIP

Through the intercomparison work, the project aimsed to increase modelling capacity of drylands in Asia and build a "land surface modelling community" in the region for future cooperation.

## Intercomparison Design

### *Target Sites*

Two target sites were chosen for the intercomparison. The observed data at these sites were archived and used in the intercomparison.

*a) Tongyu (China)*

- Contact: Dr. Ailikun (MAIRS-IPO, ailikun@gmail.com)
- Target period: 2003–2009
- Note: GEWEX-CEOP registered
- Website: http://www.eol.ucar.edu/projects/ceop/dm/insitu/sites/ceop_ap/Tongyu/Cropland

*b) Kherlen Bayan Ulaan (KBU, Mongolia)*

- Contact: Dr. Jun Asanuma (Tsukuba University, asanuma@suiri.tsukuba.ac.jp)
- Target periond: 2003–2007
- Note: GEWEX-CEOP and IGBP-AsiaFlux registered
- Websites:
  - » http://www.eol.ucar.edu/projects/ceop/dm/insitu/sites/ceop_ap/Northern_Mongolia/Kherlen
  - » http://asiaflux.yonsei.ac.kr/network/021KBU_1.html

### *Intercomparison Stages (Blind Policy)*

In general, a model will perform better when it is provided with more information about the target location. However, different models will perform differently depending on the extent of information provided about the target site.

In order to evaluate model differences in terms of how they rely on data provided, three stages with varying extents of information were defined as an experimental design of the intercomparison.

In stage 0.5, no information was given to the models, except the time series of meteorological variables and the location of the sites, for example longitude and latitude. This is called the "blind" stage. The performance of the model at this "blind" stage was tested. At stage 1, the models will be given information about the target site, such as soil and vegetation properties. This information is provided when the models are run within climate models. Stage 2 will provide the models with data for calibration.

*Stage 0: Analyses of Existing Data Set*

Basic investigation of the results from previous intercomparison or analyses. For example, GSWP 1 and 2, GLDAS and CEOP-MOLTS, were used to evaluate overall performance.

*2) Stage 0.5: With "Default" Parameter Set*

"Totally-blind" stage. No observed information was made available at this stage. Data provided was climatological values of LAI derived from MODIS for LSMs.

*3) Stage 1: With "Observed" Parameter Set*

This stage of the project is about to get underway and is the "half-blind" stage. Data to be provided will include LAI from MODIS, albedo, vegetation type and properties including root profiles, soil type and properties for LSM. For TEMs, soil type and properties were provided.

*4) Stage 2: With "Calibrated" Parameter Set*

"Calibration" stage. In addition to the data that is expected under Stage 1, other data provision will include energy, water and carbon fluxes for LSMs; and energy, water and carbon fluxes, above- and below-ground biomass; and LAI for TEMs.

### *Registered Models*

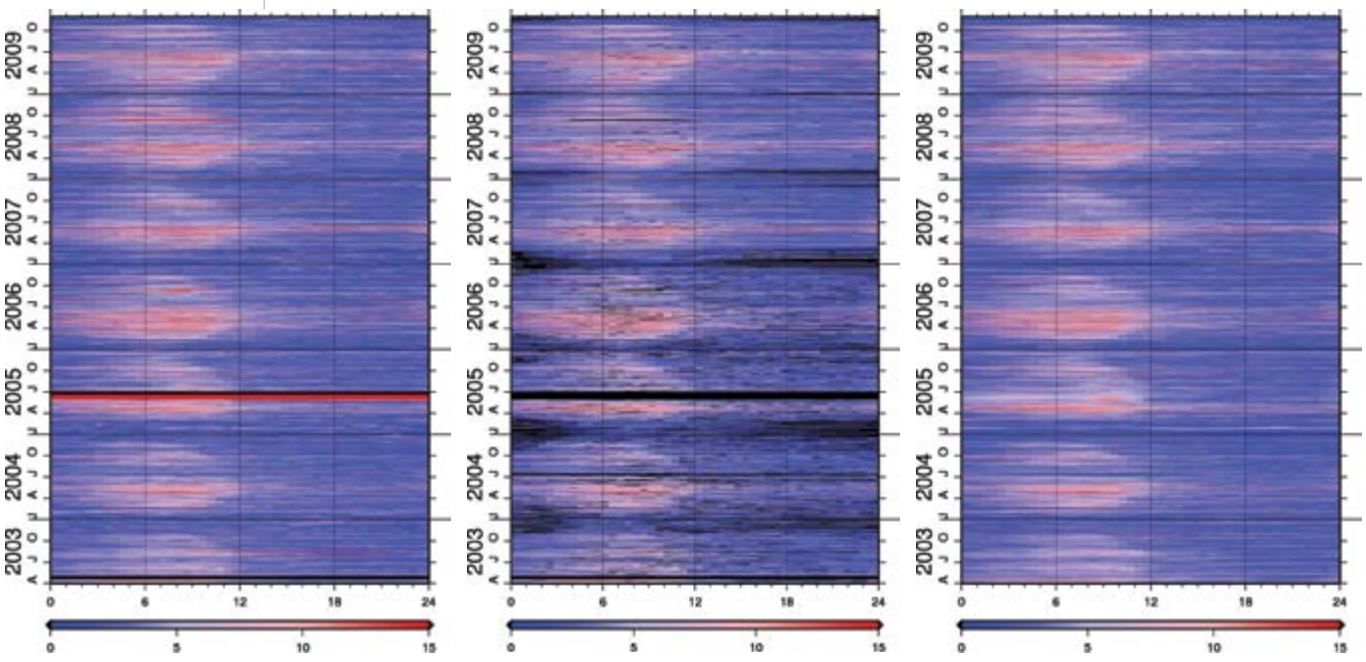
LSMs and TEMs registered for the project are listed in Table 1.

## Results and Discussion

### *Data Preparation*

A forcing data set that can drive LSMs and TEMs were derived from the observational data at Tongyu and KBU. This process includes quality-controlling (QC), which evaluates the quality of each observational value to remove less-qualified data points, and gap-filling (GF), which fill gaps generated during QC using statistical techniques (Lee, Massman, & Law, 2004). Figure 5 is an example of these processes for wind speed, where the number of error values increased after QC and these errors are replaced with statistically-computed values after GF. Through these processes, continuous (i.e., without gaps) and well-qualified data series with high 30-min temporal resolution were generated for KBU and Tongyu.

In addition, forcing data with longer time period was derived from a historical record of meteorological variables. This was needed to run models for a long period to reach a realistic initial state of model variables (spin-up), such as vegetation amount and soil moisture. The "spin-up" data set was derived from a historical forcing record constructed at NCAR (Qian et al., 2006) at KBU, and from




(a) measured values (b) after QC (c) after GF

**Figure 5.** An example of data preparation for wind speed (m/s) measured at KBU. The x-axes indicate the time of the day in UTC, while the y-axes are days. Black colour indicates error values. (Asanuma, 2011)

| Model Acronym | Model name and version | Principal investigator |
|---|---|---|
| BAIM | Biosphere-Atmosphere Interaction Model, ver 2 | Kazuo Mabuchi, Meteorological Research Institute, Japan |
| JULES | Joint UK Land Environment Simulator, ver 2 | Hong Jinkyu, Korea |
| SiBCrop | Simple Biosphere Model-Crop, ver 1 | Erandi Lokupitiya, USA |
| CABLE_UNSW | Community Atmosphere Biosphere Land Exchange, ver 1.0 | Jason P. Evans, Climate Change Research Centre, University of New South Wales, Australia |
| CLM | Community Land Model, ver 3.5 | Jun Asanuma, Tsukuba University, Japan |
| CoLM | Common Land Model, ver 3 | Guo Weidong, Institute of Atmospheric Physics, Chinese Academy of Sciences, China |
| MATSHIRO | Minimal Advanced Treatments of Surface Interaction and Runoff, ver 5.6 | Shin Miyazaki, Hokkaido University, Japan |
| Noah 2.7 | Noah land surface model, revised ver 2.7 | Chen Yingying, Chinese Academy of Sciences, China |
| SiB2 | Simple Biosphere Model, revised ver 2 | Chen Yingying, Chinese Academy of Sciences, China |
| SiBUC | Simple Biosphere including Urban Canopy, ver 1 | Kazuaki Yorozu, Kyoto University, Japan |
| SM/TEA | Soil model | Zhang Xia, Institute of Atmospheric Physics, Chinese Academy of Sciences, China |
| Biome-BGC | Biome-BGC | Kazuhito Ichii, Fukushima University, Japan |
| SEIB-DGVM | Spatially Explicit Individual-Based Dynamic Global Vegetation Model, ver 2.53 | Kaoru Tachiiri, Japan Agency for Marine-Earth Science and Technology, Japan |
| VISIT | Vegetation Integrative SImulator for Trace gases, ver 1 | Akihiko Ito, National Institute for Environmental Studies, Japan |
| SSiB | The Simplified Simple Biosphere model | Qian Li, Institute of Atmospheric Physics, Chinese Academy of Sciences, China |
| HAL | HAL | Masahiro Hosaka, Meteorological Research Institute, Japan |
| DayCent | DayCent | Dennis Ojima, Colorado State University, USA |
| NoahMP | Noah with multiple physics | Guo-Yue Niu, The University of Arizona, USA |

**Table 1.** Registered models

historical meteorological records compiled at the Institute of Tibetan Plateau, Chinese Academy of Sciences. The data was utilized after comparing with ground observations when available, and similar data sets (Figure 6). These include GLDAS (Global Land Data Assimilation System; Rodell et al., 2004) versions 1 and 2, and APHRODITE (Asian Precipitation — Highly Resolved Observational Data Integration Towards Evaluation of Water Resources; Yatagai et al., 2012). It was observed that out of these data sets, Qian et al. (2006) has the best consistency with the observed data, and therefore used in this project.

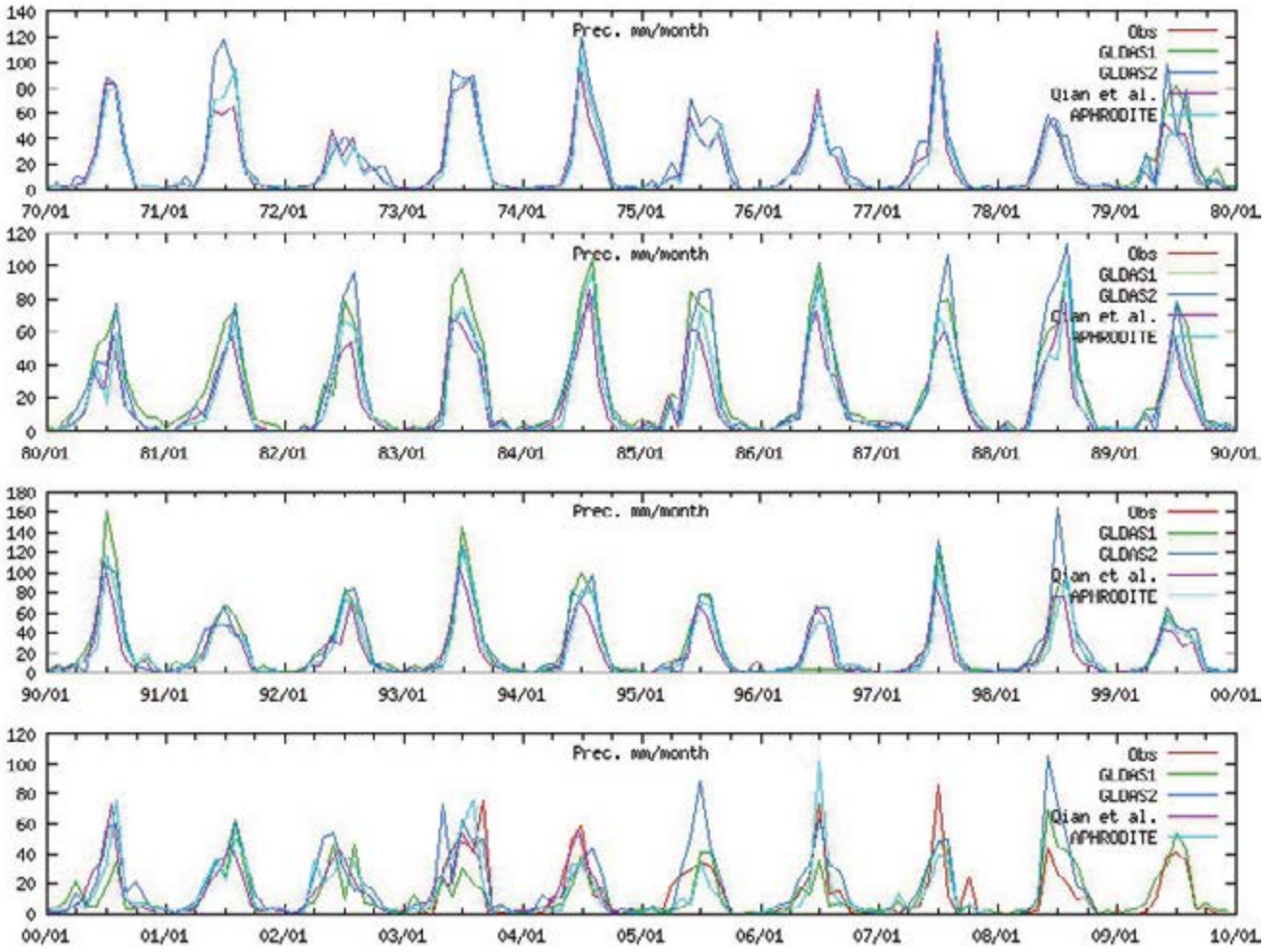



**Figure 6.** Comparison of monthly precipitation between the spin-up data set used in this project (purple line) and that from various sources, for 40 years. The latter includes the ground observation data (i.e. the forcing data, red line) marked as Obs, GLDAS version 1 and 2, and APHRODITE

### *Intercomparison of the Model Results*

Figures 7 and 8 show the comparison between monthly model outputs of latent heat flux (Qle), and sensible heat flux (Qh), from the participating models. It was found that differences between models are larger with Qh than with Qle. This is in contrast to general knowledge about the physical process in land surface modelling. While sensible heat flux from the surface to the atmosphere, that is the heating of air by the land, is mainly concerned only with the temperature of the land and the atmosphere, latent heat flux from the ground, that is the evaporation from the land into the air also involves moisture of the land. Therefore, modelling of the former is regarded as easier than that of the latter. However, the results shown in Figures 7 and 8 are opposite. This may be attributable to the land's arid characteristics.

## Conclusions

The purpose of this project was to increase the modelling capacity of Asian drylands and develop a "land surface modelling community" in Asia for future cooperation.

Asian scientists, including young scientists, were gathered to build an international project ADMIP, Asian Dryland Model Intercomparison Project, which aimed

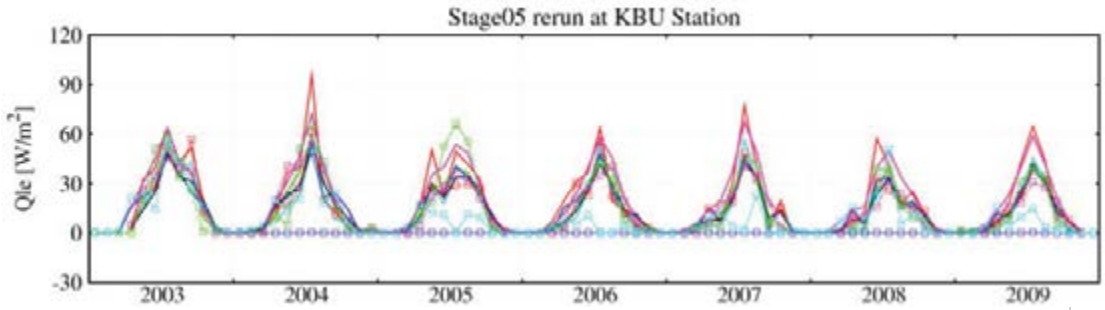



**Figure 7.** Comparison between Qle, latent heat flux, computed by different models (Yorozu et al., 2012)

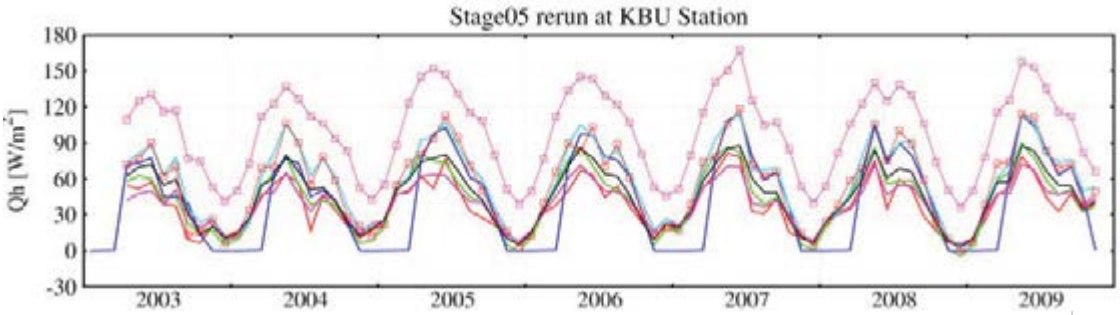



**Figure 8.** Same as Figure 7 but with comparison between Qh (Yorozu et al., 2012)

to intercompare numerous land surface process models. The project protocol of ADMIP, which states the details of model runs and the methods of intercomparison of the model outputs, were composed through discussion among project members.

To date, the project protocol that describes the model intercomparison methodologies were composed and the first model intercomparison was completed.

## Future Directions

At the time of writing, stage 0.5 comparison has been completed and Stage 1 is about to get underway.

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## ARCP2011-03CMY-ASANUMA

### PROJECT TITLE

**Intercomparison of Land Surface Process Modelling in Asian Drylands**

### COUNTRIES INVOLVED

Australia, China, Japan, Mongolia, Pakistan, Republic of Korea, USA

### PROJECT DURATION

2 years

### APN FUNDING

US$ 105,800

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ARCP2011-20NSY-MCEVOY

# Supporting Local Climate Change Adaptation: A Participatory Assessment Process for Secondary Cities in Bangladesh and Viet Nam

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**ABSTRACT:** Viet Nam and Bangladesh are vulnerable to weather-related extreme events. Climate change and changes to climate variability will increase risks for both countries in the future. This article reflects on the lessons learned from a collaborative research activity carried out jointly in the Vietnamese city of Huế and the Bangladeshi city of Satkhira (the focus on secondary cities was intentional as they face unique challenges – a combination of rapid growth and development, climate impacts, and in many cases less institutional adaptive capacity to respond than primary cities). Whilst numerous assessment toolkits already exist, these have typically been developed for rural contexts. The objective was, therefore, to develop a flexible suite of assessment methodologies targeted specifically to the urban environment; as well as being suitable for use by local practitioners at city and neighbourhood scales. The article summarizes the stages of the assessment exercise and highlights the main findings from each of the case study cities. It also critiques the assessment process to determine what worked well and what was less successful in order to distil some recommendations for future climate assessment activity in secondary cities in the Asia-Pacific region.

***KEYWORDS:*** *climate change, urban assessment tools, adaptation, Viet Nam, Bangladesh*

## Introduction

Whilst many different agencies and organizations have developed their own climate risk assessment toolkits (see for example: ICLEI Oceania, 2008; UNDP, 2010), attention has tended to focus on rural areas, often relating to natural resources management and the promotion of sustainable livelihoods. Few assessment tools have been developed to explicitly consider the urban dimension of climate risks and the particular challenges that face rapidly developing secondary cities in the Asia-Pacific region.

In response to this knowledge deficit, a multi-country collaborative research project was conducted to develop a participatory assessment toolkit in two rapidly-growing cities in Bangladesh and Viet Nam. The toolkit, comprising a portfolio of participatory assessment approaches, was tested in close collaboration with key stakeholders and community representatives in Satkhira (Bangladesh) and Huế (Viet Nam).

### *Case Study I: Satkhira, Bangladesh*

Satkhira is a municipal town with a population of over 450,000, situated in southwest of Bangladesh. The region is part of the High Ganges River Floodplain, with the lower parts and the basin margins commonly shallow-flooded on a seasonal basis. The region is subject to pronounced seasonal rainfall patterns — the winter season is very dry and accounts for only 2–3% of the total annual rainfall, the pre-monsoon hot season sees around 15% caused by convective thunderstorms or nor'westers (called Kalbaishakhi locally), whilst three quarters of all annual rainfall occurs during the rainy season.

As with much of Bangladesh, agriculture provides the main employment and income source; with key agricultural products including shrimp, rice, jute and wheat. Saline intrusions, however, have led to a significant shift in agriculture away from crop-based products (predominantly rice) towards the cultivation of "bagda" shrimp (GFDRR, 2011). Drainage obstruction for shrimp beds, however, acts to reinforce problems of waterlogging and salinity (Ahmed, 2008).

### *Case Study II: Huế, Viet Nam*

Situated in central Viet Nam with a population of 338,000, Huế is the largest city in Thua Thien Huế Province. Within the city boundaries the average height of land is 3–4 m above sea level; however some areas are more than one metre below sea level and hence are highly exposed to flooding and water logging. Impacts are further exacerbated by upstream riverine flooding during storm surge events.

**HIGHLIGHTS**

- The assessment toolkit proved to be a useful platform for integrating local knowledge with scientific expertise in order to identify and prioritize local vulnerability issues and potential adaptation options.
- The toolkit adopted a hybrid methodology which integrated bottom-up "vulnerability-led" and top-down "climate risk" approaches. The emphasis on vulnerability resonated more strongly with local stakeholders as they were able to make sense of current day variability more so than the impacts of future changes to the climate.
- Field testing of the resource highlighted the need for flexibility in the design of toolkits to ensure they can be easily used by local stakeholders.
- An incremental approach to adaptation which tackles existing climate risks in the first instance through "win-win" and "no regrets" responses will not only have the benefit of addressing more immediate development needs but can also help to build community resilience in the longer term.
- Knowledge sharing and the cross-fertilization of expertise and ideas within and between case studies helped to raise awareness of the climate change issue as well as contributing to a strengthening of local adaptive capacity in both cities.

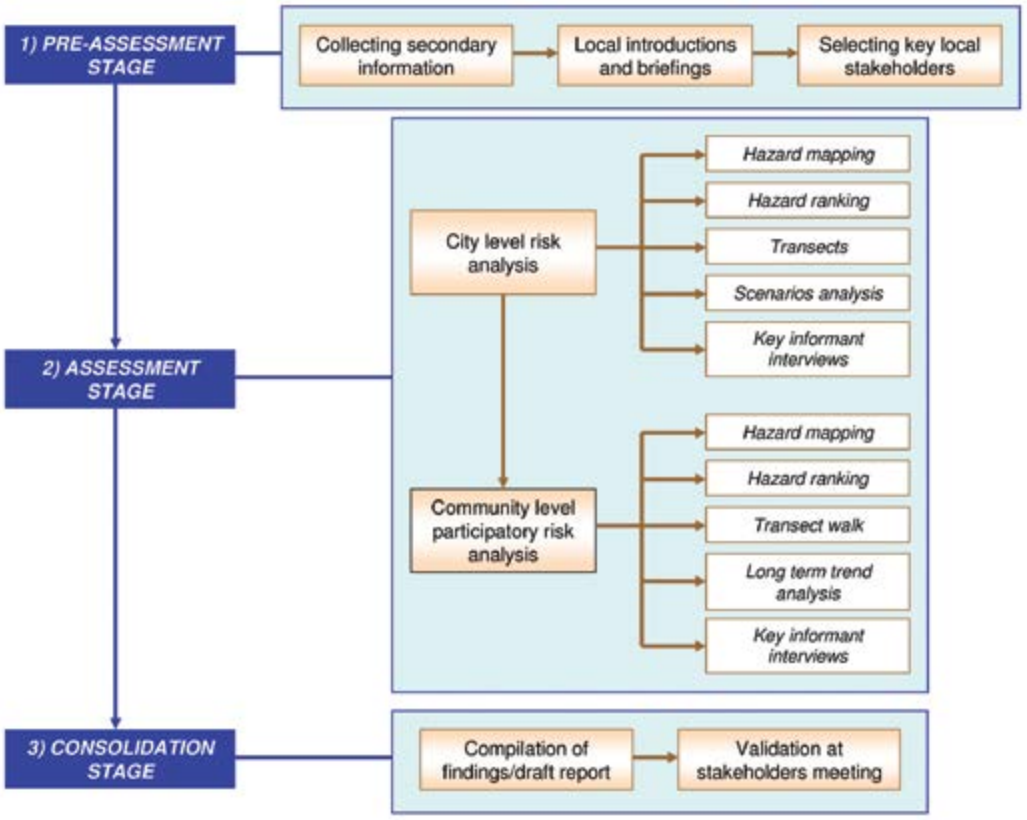


**Figure 1.** Context setting and local assessments

The annual rainfall rate is 2,500 mm, the majority of this falling between September and February. Resultant floods (1977–2010) have averaged 3.5/year, with over a third of these rated as serious or extremely serious (local experience indicates that the period of flood inundation can last up to a week). Saline intrusion is an additional problem for the surrounding agricultural areas, which provide much of the city's income and food production.

## Methodology

The overarching methodology was framed by the principles of Participatory Action Research (PAR), where the purpose is not only to conduct research but also to facilitate action for positive change. The main research product, an assessment toolkit, was developed specifically for application in an urban context. It was underpinned by two discrete, though connected, assessment stages: firstly, context setting and local assessments (Figure 1); and secondly, future risk analysis and evaluation. These stages were embedded in a broader support framework for those carrying out the local assessment activity.

The operational stages of the assessment toolkit comprised:

- Pre-assessment (collecting secondary data, local introductions and briefings, identifying key local stakeholders);
- Local assessment (city and community-level risk analysis);
- Consolidation (draft report, with subsequent validation at stakeholder workshops);
- Climate change scenarios (integration of a top-down expert approach with bottom-up vulnerability assessment).

## Results

The discussion is structured according to four headings: the design of the toolkit, case study findings, the integration of different approaches, and adaptation options.

***Toolkit design and application***: The toolkit proved to be a useful platform for local stakeholder input to be integrated with

the expert knowledge of scientists; with the output from the different exercises providing valuable information for identifying and prioritising local exposure/sensitivity to climatic hazards. This resource provided a solid basis for consideration of adaptation options.

Although the assessment toolkit was deliberately designed to be flexible and easy to use, some of the activities still had to be improvised by the local teams when carrying out the ground surveys. These "modifications" further emphasized the need for flexibility in the design of toolkits intended for use by non-experts. One major finding was that the focus on current-day hazards led to the unintended consequence of people equating disaster risk reduction with climate change adaptation. Hence, clarity of purpose needs to be addressed when assessing local climate risks.

***Case study findings***: It was found that more time and effort was needed to prepare for the stakeholder engagement stages. This relates not only to comprehensive stakeholder mapping, and establishing contact with different groups, but also to the time needed to explain and contextualize the tools and activities; and sometimes to provide education on climate science.

It is not just future climate risks that need to be addressed — both cities face much more immediate development needs and local adaptation responses need to be cognisant of the broader sustainable development context. An important issue raised was the difficulty in separating climate-related impacts from those compounded by human action and intervention; sometimes referred to as "pseudo natural" hazards (UNDP, 2002). This can be challenging in practice as illustrated by the impact of flooding and water-logging which is undoubtedly being influenced by human drivers.

***The integration of different approaches***: This study set out to integrate a bottom-up vulnerability assessment with a top-down expert-led climate risk approach; however, for practical reasons the local assessment process relied heavily on the community's personal experience of climate-related hazards. This focus resonated more with the local stakeholders as they were able to make sense of variability and extreme events much more so than longer-term climate change. Given the socioeconomic conditions, and the rapid changes to demographics and the built environment, more chronic day-to-day concerns have greater immediacy for local communities than some point in the distant future. As such, it is important to note that more climate science and higher resolution scenarios are not all that is required to move towards more climate-resilient communities; targeting existing vulnerabilities framed by shorter time periods, including better integration with disaster risk reduction activities, would be an equally valuable approach.

***Adaptation options:*** For each of the case studies, an incremental approach which tackles existing climate risks in the first instance through "win-win" and "no regrets" adaptation responses will not only have the benefit of addressing more immediate development needs but can also strengthen community resilience in the longer term. Furthermore, by focusing on existing problems it is likely to be easier to garner policy support than dealing with much longer time frames, which are made more complex by issues of uncertainty.

Inadequate infrastructure was identified as an issue in both cities, with engineering options identified as a major adaptation response; however institutional barriers to change were also emphasized by stakeholders. Indeed, a strong statement from the Satkhira workshop was: "It is not that we don't know the problems, or the solutions, rather the issue is institutional." Adapting to climate change is therefore not only about engineering outcomes; it is also important to recognize adaptation as a social learning process that enhances local adaptive capacity.

## Conclusions

The primary goal was to develop and test an assessment toolkit that would enable communities in fast-growing secondary cities in the Asia-Pacific region to identify local climate risks, and to begin the process

of adaptation planning. A secondary, though equally important, goal was to actively promote participatory approaches that would ensure that a diversity of perspectives was considered. The toolkit was shown to act as an important mechanism for promoting inclusiveness; highlighting the value of effective stakeholder engagement and the considerable benefits that can arise from knowledge sharing and a cross-fertilization of expertise and ideas. This was a central tenet of the activity undertaken.

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**ARCP2011-20NSY-MCEVOY**

### PROJECT TITLE

**Assessment of Climate Change Risks and Adaptation Options for Secondary Cities in Southwestern Bangladesh and Central Viet Nam**

### COUNTRIES INVOLVED

Australia, Bangladesh, Viet Nam

### PROJECT DURATION

1 year

### APN FUNDING

US$ 40,000

### PROJECT LEADER

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# Capacity Building in the Asia-Pacific Region: The Young LOICZ Forum

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**ABSTRACT:** In order to build strategic capacities for sustainable coastal zone management and effective responses to global environmental change in the Asia-Pacific region, the Land-Ocean Interactions in the Costal Zone project (LOICZ) organized an interdisciplinary capacity building programme for early-career scientists and young coastal managers: the Young LOICZ Forum *Capacities for Global Change Mitigation in Asia-Pacific Coastal Zones*. During the week, senior scholars and young scientists and coastal managers from 21 countries met for structured training on scientific techniques and soft skills. Emphasis was placed on common learning in multi-cultural settings to provide social learning opportunities through peer interaction, as well as on joint social activities to create sustainable working relationships and individual friendships. The design and organization of such an event requires temporal, spatial, human, and financial resources, but is a valuable investment in developing future capacities.

***KEYWORDS:*** *capacity building, land-ocean interactions, global environmental change, science-policy-practice interface, Asia-Pacific, youth forum*

## Introduction

Having the capacity to conduct high quality research that provides scientific support for decision makers and decision-making processes is vital for least-developed and developing countries in the Asia-Pacific region and crucial to improve the scientific and technical capabilities of these nations. There are still considerable gaps in the knowledge base at the regional level owing to the lack of capacity among regional stakeholders in accessing, interpreting and producing regionally relevant information. Particularly in the Asia-Pacific region, societies require knowledge and practices that will allow them to simultaneously reduce vulnerabilities and risks from global environmental change (GEC) while also meeting socio-economic development needs.

Emerging literature specifically points to barriers at the science-policy-practice interface that inhibit efficient co-production of knowledge, hinder transfer into action, and aggravate implementation of policy measures that are win-win situations for different societal actors (Weichselgartner & Kasperson, 2010; Naustdalslid, 2011).

Thus, it is critical to systematically organize and prioritize knowledge and explore efficient ways to turn knowledge effectively into sustainable actions (Weichselgartner & Marandino, 2012). In addition, young scientists and future decision makers in policy and practice increasingly require a solid background in GEC processes and highly developed soft skills. However, these are rarely included in the academic curricula and most research institutes are limited in their delivery of the type of interdisciplinary knowledge needed to address the challenges of GEC. Various authors just examined the necessary changes in education and capacity building to effectively respond to actual environmental and social challenges (O'Brien et al., 2013). They confirm that such changes will require more than adjustments in current educational systems, research funding strategies, and interdisciplinary collaborations, but transdisciplinary approaches to research and education, as well as the development of new capabilities, including humility and openness toward other systems of thought and sources of knowledge.

In acknowledging the need for transforming education and capacity building in response to GEC, the Land-Ocean Interactions in the Costal Zone project (LOICZ) decided to target capacity building with regard to necessary tools and skills to better understand GEC processes, dynamics, and impacts, as well as to test new designs and innovative modes of promoting transdisciplinary social learning with practical, "real-world" problems. The project's Open Science Conference (OSC) in September 2011 in Yantai, China, provided an excellent opportunity and venue to build strategic capacities for sustainable coastal zone management and effective responses to global environmental change in the Asia-Pacific region. In collaboration with the Yantai Institute of Coastal Zone Research (YIC), a special format was designed to offer early-career scientists and young coastal managers an advanced training programme in a cross-disciplinary and multicultural learning environment: the Young LOICZ Forum (YLF) *Capacities for Global Change Mitigation in Asia-Pacific Coastal Zones*. The following paragraphs briefly describe some of the challenges associated with scheduling such an event.

**HIGHLIGHTS**

- Meeting the challenge of translating GEC knowledge into effective actions.
- Bridging gaps between young scientists, policy makers and practitioners using a joint training programme.
- Designing and organization of an interdisciplinary training programme requires temporal, spatial, human and financial resources.
- Designing specific youth-related activities that are capable of providing both practical knowledge and soft skills necessary to address GEC processes, impacts, and mitigation and adaptation efforts is vital.

## Methodology

When designing the YLF, the organizers took into account the experience of past capacity building activities and results from international studies, clearly demonstrating the importance of teaching and learning environments. Thus, the aim was to create an occasion for combining understanding from multiple sources and providing mechanisms for linking solutions proposed by research with articulated needs of policy makers and practitioners in order to produce more timely and context-appropriate solutions. After formulating the objectives, the format was selected and implementation methods were determined accordingly.

The format and thematic composition took into account that young scientists and managers, particularly in developing countries, lack opportunities to access research networks and obtain supervision from international experts. Important planning tasks are the specification of the audience, selection of the forum venue and setting, and the design of a balanced programme of lectures, interactive training, practical exercises, social activities, field trips, and selected OSC sessions (Figure 1). Emphasis was placed on (i) obtaining a balanced mix of excellent academic candidates and young decision makers, (ii) providing solid

scientific training and applicable techniques, (iii) advancing soft and communicative skills, (iv) common learning in multicultural settings to provide social learning opportunities through peer interaction, as well as (v) joint social activities to build a network of creative sustainable working relationships and individual friendships. A range of diverse activities were initiated (Table 1) with the intention to rearrange the hierarchy of social relations and to promote a wide range of soft skills.

One key feature was the designation of so-called "YLF mentors." Based on the scope of research and geography, each junior participant was appointed an appropriate senior scientist to facilitate the exchange of ideas and scientific networking. An organized field trip along the Shandong coast provided the opportunity to interact with mentors for an entire day. Likewise, visits to the Rongcheng Ocean and Fisheries Bureau and a local fishing village offered the chance for cultural exchange and the time to discuss issues of interest with representatives of the coastal community. Although it is often difficult to obtain funding, social components — such as an initial icebreaker to engage in early conversation with peers and trainers, field visits, culinary occasions, a badminton and bowling tournament — were intentionally included in order to reduce power structures and to reshuffle social hierarchies and the participants' portfolio of different types of abilities and qualities. Moreover, these activities were valuable

**Table 1.** Selected activities of the YLF 2011

| | |
|---|---|
| **Training Seminars** | |
| » Proposal Development Training Workshop (A. Takemoto) | » Risk and Vulnerability: From Theory to Capturing Key Factors through Questionnaires (F. Renaud) |
| » Why not Become an Influential Scientist? Scientific Writing and Publishing (J. Weichselgartner) | » How to do Integrative Science? Addressing Environmental Challenges (A. Ignaciuk) |
| » Integrated Coastal Management: Learning from Practice (R. Ramesh) | » Economic Valuation of Coastal Ecosystems: A Fad or Reality? (J. Roy) |
| » Coastal Challenges: Monitoring Human Impacts on Coastal Zones (F. Colijn) | » Indicating Adaptive Capacity in Urban Risk Management Systems (M. Pelling) |
| **Social Activities** | |
| » Icebreaker and YLF Inception Dinner | » Welcome Reception OSC |
| » Badminton and Bowling Tournament | » OSC Dinner and YLF Award Ceremony |
| » Field Trips and Institutional Visits | |
| **Scientific Sessions** | |
| » Linking Regional Dynamics in Coastal and Marine Social-Ecological Systems to Global Sustainability | » Planning and Governance in Coastal and Marine Areas |
| » Arctic Coastal Processes, Peoples and Societies | » Megacities and Resilience in the Coastal Zone |
| » Changing Land Use in the Coast: Present and Future | » Coastal Hazards, Vulnerability, and Adaptation |
| » Small Island Developing States | » Bridging the Science-Policy Gap |
| » Ecosystem Goods and Services and Environmental Economics | » Plant Biodiversity in Coastal Zone Area and Intensive Utilization |
| » Coastal and Marine Sectors: Managing Change | » Case Studies of Long Term Change or Stability in Coastal Ecosystems |
| » Nutrient Accounting in Coastal Waters and Watersheds | » Coastal Eco-Environments from a Microbial Perspective |
| » Catchment-Estuary: Nature and Human Interaction | » The Application of Remote Sensing and GIS in Coastal Zones |
| » Observation, Monitoring and Modelling | » The Application of Isotope to Track Pollution Source from Land to Ocean |
| » Estuarine and Coastal Ecohydrology | » Climate Extremes and Carbon Biogeochemistry in Large-River Delta-Front Estuaries |
| » Coastal Biogeochemical Cycles and Climate Change | » Estuaries and Coastal Seas: Interactions, Fronts and Climate |
| » Eutrophication, Hypoxia and Algal Bloom | |

**Figure 1.** The design and organization of an interdisciplinary training programme requires temporal, spatial, and financial resources: The YLF organizers inspecting the location (photo: J. Weichselgartner)

**Figure 2.** Sharing different local knowledge: YLF participants discussing global environmental change aspects in group work (photo: J. Weichselgartner)

occasions to reinforce the YLF objectives and ensure that participants enjoyed their training week.

## Results and Discussion

The YLF brought together senior scholars and 25 young coastal scientists and managers from 21 countries and proved to be a successful capacity building activity in many aspects. During the week, the participants had the opportunity to study scientific techniques and tools and establish links and networks for their future research, to share interdisciplinary knowledge from different parts of the world, and to develop a set of skills vital for their future career (Figure 2).

Complementing the OSC, the composition and format of YLF strengthened interactions among scientists, policy makers, and practitioners, as well as supported regional cooperation in GEC research on issues particularly relevant to the region. The trainees took the opportunity to learn from their trainers, mentors and colleagues, and by exchanging local experiences in a multicultural learning environment they added value to their own future work. Clearly targeted training seminars on scientific skills supported improving the scientific and technical capabilities of the next generation of coastal scientists and decision makers. The Proposal Development Training Workshop provided by APN was an important component of the YLF with regard to sharing knowledge on proposal development, submission and selection process.

Another milestone was the YLF award ceremony during the OSC dinner, in which four excellent young coastal scientists and managers were honoured for their outstanding performance and contribution (Figure 3). Appropriately, the exclusive

**Figure 3.** Multi-disciplinary and international: the YLF award winners, from left to right, Pronab Kumar Halder (Centre for Global Change, Dhaka, Bangladesh), Guangzhe Jin (Hiroshima University, Japan), Christine Omuombo (University of Nairobi, Kenya), and Elizabeth Shadwick (CSIRO, Australia) (photo: J. Weichselgartner)

**Figure 4.** 25 participants, 15 trainers, 21 nationalities at YLF in Yantai, China: Participants with some of their mentors (photo: J. Weichselgartner)

prizes themselves were capacity building investments, for example, attendance to the "*Planet under Pressure*" Conference 2012 in London. However, the most important capacity development outputs are often the least tangible: the opportunity to expose own research and experiences to international peers and the networking effects that an event such as the YLF creates and fosters. For that reason, a Young LOICZ Alumni Facebook network was launched to maintain programmatic and substantive ties among participants, with the project, and between participating institutions. It also provides the possibility to follow-up with specific surveys and monitoring the significance of the YLF and the career development of trainees.

## Conclusions

The YLF went beyond traditional training of scientific skills and provided a unique learning opportunity for acquiring transferable scientific tools and soft skills, as well as to engage and cooperate with relevant networks and organizations. With training seminars, social activities, and scientific sessions, the youth forum together with a scientific congress was an ideal format for participants, both early-career and senior scholars, to discuss global change issues and strengthen regional collaboration (Figure 4). Although it is vital to design specific youth-related activities that are capable of providing both practical knowledge and soft

> "The diverse backgrounds of the participants in the YLF provided insights on some of the key challenges that may be unique to each country, region, research themes and profession. Although interaction among the participants was during a short period of time, this forum provided an avenue for networking on similar research themes that assists the career advancement and professional development of the participants. One of the most important training on soft skills focused on writing research proposals targeted at funding bodies. In this activity, participants were able to formulate research themes, objectives, and strategies that were later peer-reviewed by them. This exposure to critical research thought processes and feedback from their peers and senior scientists in the review process equipped the participants with the necessary skills and confidence for future successful proposal delivery. As a follow-up activity, the participants were exposed to soft skills on academic writing and publishing, which is crucial for having impact on research, science, policy and practice. The interaction between the young scientists and their mentors was a unique opportunity to discuss, elucidate and clarify priority and emerging issues that shape the science-policy interface in the context of global environmental change issues that are taking centre stage in their areas of interest.
>
> — *Christine Omuombo, YLF participant*

skills necessary, one should bear in mind that the design and organization of an interdisciplinary training programme requires temporal, spatial, and financial resources. Building the capacity to cope with, adapt to, and actively influence GEC processes requires polycentric efforts that facilitate transformative learning, improve "key competencies," and generate "responsible thinkers."

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**CBA2011-06NSY-LOICZ**

**PROJECT TITLE**

**Young LOICZ Forum 2011: Capacity Building in the Asia-Pacific Region**

**COUNTRIES INVOLVED**

China, Australia, India, Japan, New Zealand, Philippines, Singapore, USA, Viet Nam

**PROJECT DURATION**

1 year

**APN FUNDING**

US$ 30,000

**PROJECT LEADERS**

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# Balancing $CO_2$ in the School Campus: A Strategic Entry for Greening School Communities

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**ABSTRACT:** As anthropogenic carbon dioxide is being singled out as one of the culprits of global warming and climate change, there is an urgent need to increase and maintain vegetation and to educate the young generation about low carbon dioxide science economy, which will pave the way for a greener and more sustainable community. This paper describes two-fold activities, which are the learning process and the learning content (scientific). The learning process dealt on a problem/project-based learning approach developed by teachers in pilot project sites which focused on the integration approaches across curricula in the context of real-life scientific issues. The learning content, on the other hand, focused on calculation of carbon dioxide and other pollutants sequestration by trees. An experiential and discovery learning approach is a significant driver for shifting one's perspectives and helps to develop responsible citizens who can manage a more sustaining environment.

*Keywords: GHGs, sequestration, experiential and discovery learning*

## Introduction

Energy consumption of school campuses have dramatically increased, caused primarily by modernization of school facilities such as computerization programmes, which aim to enhance the 21st century skills of students so that by the time they join the 21st century labour force they can cope with the demands of the labour market. As technological modernization continues, the education landscape drastically changes, transforming into a more energy-based learning process. Though we may claim that an energy-driven learning process offers good benefits, we leave behind its carbon footprint unnoticed. An average of 0.4–0.7 kg of carbon dioxide ($CO_2$) is emitted for every kilowatt hour of electricity consumption depending on the fuel used to produce such energy. Our learning system has failed to provide learning activities that reveals to our students and teachers how much $CO_2$ exactly is emitted on a daily basis. It is a well-known fact that the main culprit of

global warming is the build-up of greenhouse gases (GHGs) in the atmosphere and $CO_2$ occupies the largest parts per million (PPM).

Although schools have increased their carbon footprint, there are still opportunities to balance it out. Schools usually have considerable land area but only about 50–60% are utilized for buildings, pavements, and open grounds, while the rest is used for perhaps landscaping or forest gardens. Open playgrounds can absorb $CO_2$ and other GHGs but the exact figure is still uncertain.

Discovering the fact that trees play an important role in balancing $CO_2$ storage and emission through experiential learning is something that students and teachers will not forget for a lifetime. Identifying a species of tree, as a woody plant that has many secondary branches supported clear of the ground on a single main stem or trunk with clear apical dominance, is primarily the work of the biology students under the leadership of a science teacher. Measuring the diameter at breast height (DBH) of a tree is the work of the same group of students guided by a mathematics teacher, while interpreting the scientific implication of the investigation is usually done by students guided by the science, mathematics and even economics teachers.

## HIGHLIGHTS

- Students and teachers came to realize when electronic machines and electrical appliances are run, energy is utilized and anthropogenic $CO_2$ is emitted. They also learned how $CO_2$ builds up in the atmosphere and causes the greenhouse effect.
- Through integrated learning, teachers and students understand that photosynthesis is not simply about absorbing $CO_2$ and releasing oxygen but rather it has a significant role in balancing ecological systems.
- Students and teachers learned that about 0.4–0.7 kg of $CO_2$ is emitted for every kilowatt hour of electricity depending on the fuel used to produce such energy.
- Students learned about theeconomic, environmental, and social benefits of trees, and discovered common species endemic to their locality.
- Students enhanced their mathematical skills by measuring tree DBH and calculating $CO_2$ absorbed, $O_2$ released and removal of other pollutants.
- Given the monthly electrical consumption bill, students calculated the amount of $CO_2$ produced and correspondingly determined the number of trees needed to sequester such amount of $CO_2$.
- With the understanding of carbon footprinting and sequestration, students and teachers could be a potent force to initiate green projects in their communities, such as tree planting, seedling culture, adopt-a-park or hill, establish partnerships with GOs and NGOs to create public awareness and tangible actions towards a sustainable environment.

## Benefits and Values of Trees

Students need to discover and experience that trees absorb $CO_2$ from the atmosphere and release oxygen in the process of photosynthesis whereby technically reducing the $CO_2$ build-up in the atmosphere. Furthermore, trees remove gaseous pollutants by absorbing them with normal air components through the stomata in the leaf. Some of the other major air pollutants are sulphur dioxide ($SO_2$), ozone ($O_3$), nitrogen oxides ($NO_x$), and small particulates. Trees act as natural pollution filters. Their canopies, trunks, roots, and associated soil and other natural elements of the landscape filter polluted particulate matter out of the flow toward the storm sewers. Reducing the flow of storm water reduces the amount of pollution that is washed into a drainage area. Trees use nutrients like nitrogen, phosphorus, and potassium, by-products of urban living, which can pollute streams. The most important ecological function of trees is protecting the land against erosion, the washing away of topsoil due to wind and water. The trunks and branches of trees provide protection from the wind, and tree roots help solidify soil in times of heavy rain. They help cool down the temperature during summer thus reducing the use of air conditioners and energy. In addition, trees and forests store water reserves that act as buffers for the ecosystem during periods of drought. So, this article presents how the researchers provide the technical support; monitor the teachers' learning journey and experience on the process of balancing $CO_2$ in the school campus.

## Objectives

The study itself aimed to:

- Audit school's energy consumption against $CO_2$ emission and sequestration by trees through a school-based student learning project;
- Demonstrate development of computational skills among students in calculating the amount of $CO_2$ sequestered, oxygen released and other pollutants removed by trees; and
- Describe how this energy auditing learning project can trigger and push for green initiatives in the school and in the community.

## Methodology

The study involved the following activities: (a) gathering energy consumption information, (b) identifying tree species, and (c) measuring the DBH.

The data on the schools energy consumption from the calendar year 2011 was obtained, upon request, from the power provider office. Students, guided by teachers, were able to convert the energy consumption in kWh per unit to $CO_2$ equivalent per unit.

Species were identified during the ocular survey. Each species was described at the species level. Plant characteristics such as inflorescence, colour and shape of leaves and root systems were noted to help in the identification process (Medecilo et al., 2007).

The DBH of trees was determined using a tape measure and was expressed in centimetres. The measurement of the DBH was taken at 1.3 metres above ground. Data gathering was conducted from April to May 2012. The sites were located at a forest park and at the perimeter inside the school campus as shown in Figures 1 and 2.

## Results and Discussion

Table 1 shows how much energy is consumed by 1,300 students and 96 teachers and staff and its equivalent $CO_2$ emission. The total kWh energy consumption was 37,203 in one year (2011) multiplied by its factor of 0.7 kg/kWh of $CO_2$ since the electricity was produced by a machine fuelled by diesel (http://timeforchange.org). Therefore, the total $CO_2$ emission in one year alone is equivalent to 26,042.10 kg or roughly 26 tonnes.

Table 2 shows that Secondary School that has a total of 826 planted trees with an average DBH of 44.6 cm capable of absorbing about 5,014.80 kg of $CO_2$, 113.486 kg of other pollutants and with a released volume of oxygen amounting to 6,951.10 kg.

From the total energy consumption of 37,203.00 kWh by 1,300 students and 96 teachers and staff 26,042.10 kg of $CO_2$ is produced from 826 trees, capable of

**Table 1.** Secondary school energy consumption for 2011

| Bill No. | Period | Amount (Peso) | Energy (kWh) | *$CO_2$ emission (kg) |
|---|---|---|---|---|
| 5699873 | 1/1/2011 | 18,920.78 | 2,300.00 | 1,610.00 |
| 5883746 | 1/2/2011 | 763.43 | 83.00 | 58.10 |
| 6068607 | 1/3/2011 | 40,486.27 | 4,900.00 | 3,430.00 |
| 6170888 | 1/4/2011 | 14,329.22 | 1,600.00 | 1,120.00 |
| 6237451 | 1/5/2011 | 11,082.06 | 1,280.00 | 896.00 |
| 6371595 | 1/6/2011 | 25,601.85 | 2,980.00 | 2,086.00 |
| 6502438 | 1/7/2011 | 35,664.6 | 4,080.00 | 2,856.00 |
| 6485528 | 1/8/2011 | 25,683.98 | 3,040.00 | 2,128.00 |
| 6644267 | 1/9/2011 | 33,215.89 | 3,680.00 | 2,576.00 |
| 6753376 | 1/10/2011 | 30,435.78 | 3,520.00 | 2,464.00 |
| 6875502 | 1/11/2011 | 59,050.44 | 6,500.00 | 4,550.00 |
| 6990388 | 1/12/2011 | 30,643.59 | 3,240.00 | 2,268.00 |
| TOTAL | | 325,877.89 | **37,203.00** | **26,042.10** |

* For diesel fuelled power grid, conversion factor is 0.7; http://timeforchange.org/offline-carbon-footprint-calculator

**Figures 1 & 2.** Students measuring tree trunk circumference to calculate diameter and determine how much $CO_2$ can be absorbed or sequestered

sequestering about 5,014.8 kg $CO_2$ from the atmosphere. Thus, about 21,027.30 kg of $CO_2$ still remains in the atmosphere (Table 3). More trees should be planted and more green spots created inside the school campus to help sequester $CO_2$.

## Conclusions

The school-based $CO_2$ sequestration learning project provided an avenue, space and real-time reflection, not only for the students but for the teachers as well; as most of the teachers remarked that they didn't know anything about it until the project was implemented.

The activity showed that $CO_2$ balance through sequestration can be investigated, researched, learned and integrated into the learning system. It was also observed that hands-on activities provided an opportunity for students to undertake self-learning processes by engaging in real issues that matter to their real-life experience.

Based on the analysis conducted by the teachers and students in science and mathematics, from the data that the students have gathered, the 826 trees with an average diameter of 44.6 cm were not enough to absorb the 26 tonnes of $CO_2$ emitted due to power consumption in the school for one year (Table 1) and more forest or fruit trees are needed, thus planting of trees are rationalized, not just for scholastic requirement.

## Recommendation

Schools need to develop a strategic plan

**Table 2.** Total number of trees by species and their diameter at breast height (DBH). Amount of $CO_2$ absorbed, amount of oxygen released and other pollutants removed (kg/yr)

| Name | Number of trees | **Average DBH (cm) | *$CO_2$ sequestered by trees (kg) | *Oxygen eleased by trees (kg) | *Pollutants removed by trees (kg) |
|---|---|---|---|---|---|
| Mahogany | 603 | 9.55 | 2,653.20 | 1,748.70 | 12.663 |
| Mabolo | 53 | 29.18 | 498.20 | 1,197.80 | 8.798 |
| Gemelina | 41 | 25.81 | 385.40 | 926.60 | 6.806 |
| Narra | 8 | 69.39 | 276.80 | 728.80 | 8.000 |
| Ipil-ipil | 57 | 8.00 | 57.00 | 165.30 | 57.000 |
| New Guinea labula | 33 | 26.06 | 310.20 | 745.80 | 5.478 |
| Mango | 13 | 51.33 | 248.30 | 592.80 | 5.538 |
| Talisay | 13 | 26.62 | 122.20 | 293.80 | 2.158 |
| Rubber Tree | 5 | 155.47 | 463.50 | 551.50 | 7.045 |
| TOTAL | 826 | 44.60 | 5,014.80 | 6,951.10 | 113.486 |

* Nowak, 1994 and Nowak et al., 2007

** Actual measurement done by the students (tree circumference at breast height or 1.3 m above the ground)

| Energy consumption (kWh) | *Equivalent $CO_2$ (kg) | Total No. of trees in school campus | Total equivalent $CO_2$ sequestered by trees (kg) | Excess $CO_2$ not sequestered by trees (kg) |
|---|---|---|---|---|
| 37,203.00 | 26,042.10 | 826 | 5,014.80 | 21,027.30 |

**Table 3.** Summary of balancing $CO_2$ in school for energy consumption with diesel as fuel for the power plant

to increase the awareness of teachers, students and the school-community about levels of $CO_2$ they are emitting; as well as action plans to reduce $CO_2$ emission and power consumption by using energy-efficient facilities. It is recommended that the idea of carbon footprint be integrated not only in science and mathematics, but across the school curriculum. One of the most practical and scientific approaches to sequestering $CO_2$ on school campuses is to plant more trees.

Education Ministries could create a policy for all schools to monitor their carbon footprint through energy consumption and $CO_2$ emission so they can develop alternative plans or curricula that integrates climate change issues and considers the planting of trees, flowers, vegetables and any other kinds of vegetation that absorbs $CO_2$.

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## Acknowledgements

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**CBA2011-09NSY-ALIGAEN**

**PROJECT TITLE**

**Climate Change-Integrated Education Model: Building Adaptive Capacity for the Next Generation**

**COUNTRIES INVOLVED**

Indonesia, Lao PDR, Malaysia, Philippines, Thailand

**PROJECT DURATION**

1 year

**APN FUNDING**

US$ 40,000

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CBA2011-13NSY-TOLENTINO

# Climate Change Adaptation Strategies of Selected Smallholder Upland Farmers in Southeast Asia: Philippines and Indonesia

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**ABSTRACT:** Research was undertaken to assess the awareness of selected smallholder farmers on climate change issues, its effects on their agricultural production, and how they cope and/or adapt to climate change impacts. This article confirms that climate change impacts are already being observed and experienced by smallholder upland farmers in Indonesia and the Philippines. Farmers in the Philippines have observed stronger and more frequent rainfall and typhoons, while high temperatures have been prevailing in the upland areas of Indonesia. Among the observed effects include a higher incidence of pests and diseases, low crop productivity/yield, stunted growth, delays in fruiting and harvesting and a declining quality in the produce. The incidence of pests and diseases, including the growth of noxious weeds has also caused increase in labour costs. These circumstances have led to lower farm income. Results revealed that farmers make use of their local knowledge in addressing the effects of climate change. These include changing of their crops that would suit the changing rainfall pattern, integrating more crops to maximize the production, rejuvenation of trees, enrichment of crops, practice of agroforestry and rituals. Few farmers opted to get engaged with off-farm and non-farm activities. The results also point out the need to capacitate local institutions so that they could effectively communicate or disseminate information about the different climate change adaptation strategies that are appropriate in the farming communities within their respective areas, and strengthen the local knowledge of the upland farmers in adapting to the impacts of climate change.

***KEYWORDS:*** *agroforestry, climate change, adaptation strategies, impacts*

## The Research

This research was undertaken to assess the understanding and awareness of agroforestry practitioners and upland farmers on the issue of climate change and its impacts in agricultural development; identify indicators and evidence of climate change based on farmers' experiences and observations; analyse the different mechanisms and strategies that are being employed by upland farmers in coping with the impacts of climate change; and formulate recommendations for national and local development organizations for the adoption of appropriate climate change mitigation and adaptation strategies.

The research covered 56 smallholder respondents representing three major islands (Luzon, Visayas and Mindanao) in the Philippines; and upland farmers in the Forest Park, Wan Abdur Rahman Forest Park, Register 22 Way Waya, and People's Forest in Lampung Province in Indonesia.

## Results

### *Climate Change Observed by the Smallholder Farmers*

Upland farmers have already been experiencing climate change (Visco et al., 2011). All farmers noted considerable changes in climate compared with prevailing climate of the past. They recalled that, in the past, they could accurately plan their agricultural production because of predictable rainfall patterns. But 43% of the respondents have observed changing climatic patterns in recent years, particularly since 2000. Specifically, 39% observed that heat is more intense, while 36% mentioned strong and frequent typhoons especially in year 2010 and 2011 (Figure 1). Specifically, in Northern Mindanao area and Eastern Visayas, the classified Type IV climate should result in an even distribution of rains throughout the year. However, farmers perceived longer rainy seasons to the extent that heavy rains are still observed during the summer season. This was also the claim of farmers in Northern and Southern Luzon.

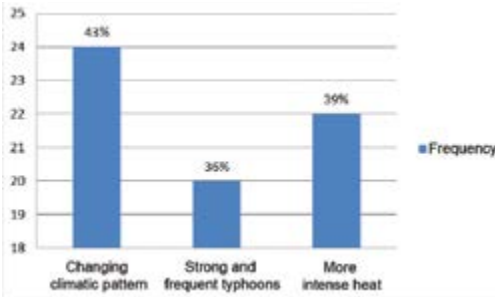



**Figure 1.** Indications of climate change as observed by the respondent-farmers in the Philippines

In Indonesia, on the other hand, 79% of the respondents considered the change in temperature as an indication of climate change (Wulandari et al., 2011). At present, the climate is much hotter compared to the

## HIGHLIGHTS

- Climate change is already being experienced by smallholder upland farmers in Indonesia and the Philippines, as evident by the changing and abnormal rainfall and temperature patterns.
- Agricultural crop production has been greatly affected by climate change. Major effects include higher incidence of pests and diseases, low crop productivity/yield, stunted growth, low farm income, delays in fruiting and harvesting, declining quality of produce. The incidence of pests and diseases, including the growth of noxious weeds, has also resulted in increased labour costs.
- Smallholder farmers utilize local knowledge to cope with/adapt to the impacts of climate change. These include changes in cropping patterns, change of crop, crop diversification, agroforestry practices, among others.
- 70% and 100% of respondents in Indonesia and the Philippines, respectively, believed that agroforestry is a key strategy in climate change adaptation because of the diversity of direct and indirect benefits from the system, and the diversity of crop products. The loss of one crop can be compensated by another crop, particularly woody perennials.

past. Also, in the past, they could easily predict rainy and summer seasons, but now, fluctuating climatic patterns are observed.

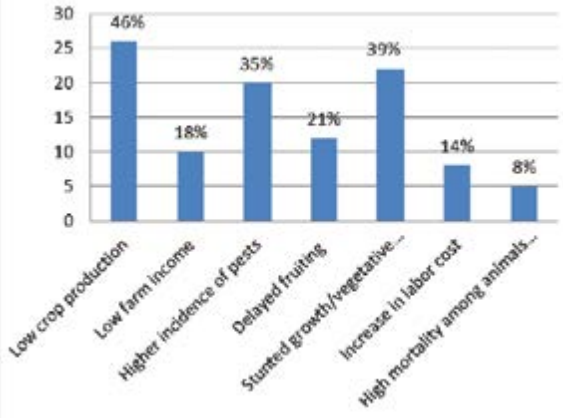



**Figure 2.** Observed effects of climate change in agricultural production of respondent-farmers in the Philippines

### *Observed Impacts of Climate Change in Agricultural Crop Production*

Climatic changes have affected the agricultural production of respondent-farmers, simply because agriculture is influenced largely by rainfall and temperature. Visco et al. (2011) noted that generally, there has been a decline in the crop production of the respondents in the Philippines. Figure 2 shows that the decline in crop production is attributed to higher incidence of pests and diseases (35%), stunted growth (39%), and increased labour costs (14%). In addition, delayed fruiting (21%) and livestock mortality (8%) were also observed. In Indonesia, on the other hand, among the effects of climate change in agricultural crop production include delays in crop harvesting (82%), declining crop yields (77%), declining quality of produce (66%); and increasing incidences of pests and diseases (51%) (Wulandari et al., 2011).

### *Climate Change Adaptation Strategies of Smallholder Farmers*

Results revealed that farmers make use of their local knowledge in addressing the effects of climate change to their agricultural production in both countries (Visco et al., 2011; Wulandari et al., 2011). Most of them mentioned changing their crops to suit the changing rainfall patterns, integrating more crops to maximize production, and a few practice rituals to prevent crops from pest infestation, while most of the respondents would not only plant the crops, but also engage in off-farm and/or non-farm activities, leaving their farms uncropped (Figure 3). Perhaps the lack of resources and motivation to address the impacts of climate change has resulted in the engagement in off-farm and non-farm activities.

Meanwhile, in Indonesia, climate change adaptation strategies employed by the respondents include rejuvenation of trees, enrichment of crop species using local knowledge, textbook studying, or radio broadcasts. These strategies, according to 70% of the respondents, were effective in addressing the impacts on fruit crops, crop yield, water management and soil conditions (Wulandari et al., 2011). However, these did not address the problem of increased pest and disease incidences. About 74% of the respondents believed that agroforestry could be a best alternative land-use management system that could address the impacts of climate change.

### *Institutional Support for Climate Change Adaptation*

The results also suggest a lack of information dissemination or communications from local development organizations on relevant climate change issues and strategies for climate change adaptation that could be employed by the farmers in the study sites in the Philippines (Figure 4).

Meanwhile, in Indonesia, 89% of the respondents noted that the absence of assistance or programmes to mitigate or adapt to the impacts of climate change, particularly in the farming communities. Meanwhile, 11% of the respondents mentioned that the Forestry Sub-department had provided information about climate change, but this did not extend to mitigation and adaptation strategies. Thus, farmers believe that proper information dissemination and strengthening of community organizations are necessary to enhance their capacities to adapt to the impacts of climate change.

It is apparent, therefore, that local government organizations need to be equipped with the knowledge and skills pertaining to climate change and options for mitigation and adaptation, so these could be transferred to upland farmers within their area.

## Conclusion

Climate change is being experienced by upland farmers, and observations include higher incidences of pests and diseases, low crop productivity/yield, increasing labour costs, low farm income, and delays in fruiting and harvesting. Results also confirm earlier research highlighting the role of local (traditional) knowledge of the smallholder farmers in climate change adaptation.

**Figure 3.** Climate change adaptation strategies of smallholder farmers in the Philippines

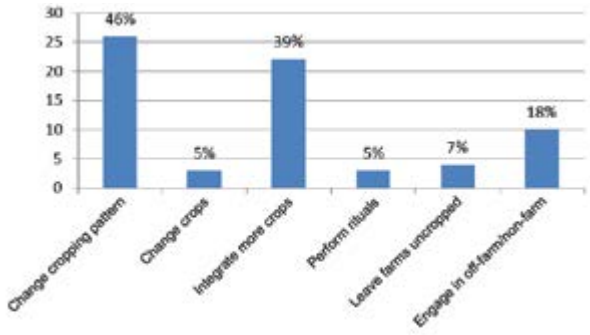
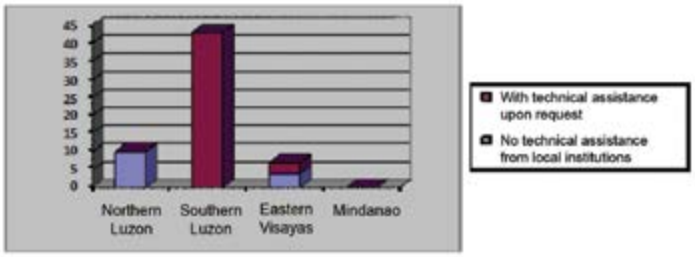



**Figure 4.** Availability of technical assistance at the local level among the study sites in the Philippines




These practices are employed because of their ingenuity and lacking technical assistance from external organizations. Finally, the results suggest the need to capacitate local institutions for effective communication and dissemination of information on appropriate adaptation strategies for these farming communities, and strengthen the local knowledge of upland farmers in adapting to the impacts of climate change.

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**CBA2011-13NSY-TOLENTINO**

**PROJECT TITLE**

**Institutionalizing Agroforestry as a Climate Change Strategy via Local Policy and Capacity Development in Southeast Asia**

**COUNTRIES INVOLVED**

Indonesia, Lao PDR, Malaysia, Philippines, Thailand, Viet Nam

**PROJECT DURATION**

1 year

**APN FUNDING**

US$ 40,000

**PROJECT LEADER**

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# ARCP PROJECTS 2

*Regional research projects funded under the*

# Annual Regional Call for Research Proposals (ARCP)

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ARCP2012-01CMY-PATRA/CANADELL

# Greenhouse Gas Budgets of South and Southeast Asia

P. K. Patra, J. G. Canadell, K. Ahmed, T. Machida and H. Mukai

The project aims to establish the mean greenhouse (GHG) budget and variability of South Asia and Southeast Asia for the period between 1990 and 2009. This objective is achieved by analysing atmospheric GHG inversions and bottom-up estimates based on terrestrial biogeochemical models, remote sensing data, and flux and forest inventory data sets.

The GHG balance of a region and attribution to its natural and anthropogenic flux components is a necessary step to understand the role of a region in driving human-induced climate change. The analysis also provides an assessment of the potential of a region for climate mitigation upon which climate polices can be developed. For example, improved estimates of the contribution of emissions from various types of fires and peat decomposition to total anthropogenic GHG emissions can inform about which climate policies can harvest the highest climate benefits.

The aims of the project are being achieved through cooperation between scientists from South and Southeast Asia, and experts from other parts of the world.

**PROJECT SUMMARY**

The project has estimated carbon sources ($CO_2$ and $CH_4$) and sinks from the South Asia region: India, Bangladesh, Pakistan, Sri Lanka, Nepal and Bhutan. Major carbon fluxes from terrestrial ecosystems, land-use change, riverine export, and fossil fuel burning are estimated and compared with top-down atmospheric $CO_2$ and $CH_4$ inverse model estimates. A GHG measurement site has been established in Comilla, Bangladesh, and has been operational since June 2012.

## Work Undertaken and Results to Date

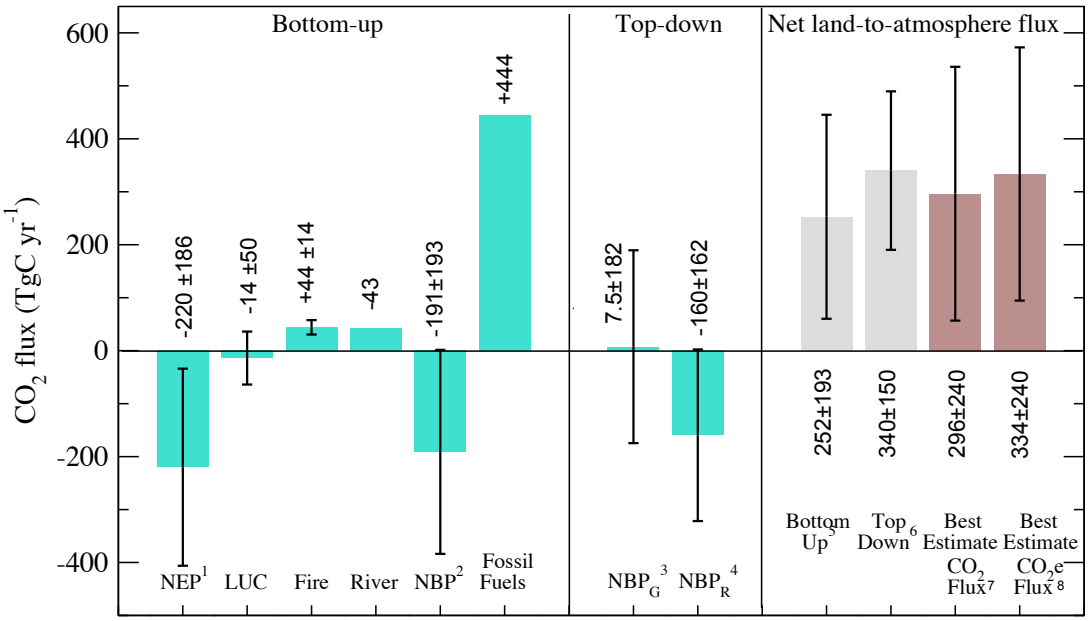
We have established a flask-sampling site in Comilla, Bangladesh, for measurement of GHGs in cooperation with Dhaka University (DU), Bangladesh and the National Institute for Environmental Studies (NIES), Japan. Each week a glass flask is filled with ambient air by DU personnel, which is shipped between Japan and Bangladesh at monthly intervals. The air samples have been undergoing analysis for $CO_2$, $CH_4$, CO, $N_2O$, $SF_6$ and $H_2$ at NIES since June 2012.

The first assessment of carbon fluxes into and out of the South Asian domain has been completed (Patra et al., 2013). The results show various flux components exchanged between the terrestrial and marine ecosystems and the atmosphere. Although the top-down and bottom-up values are in fairly good agreement for the South Asia region, large uncertainties exist in each of the flux components.

Work is in progress for assessing the carbon budget for the Southeast Asia region, and will be completed in 2013. Towards the later half of 2013 and first half of 2014, many of the estimated flux components will be revised based on updated model results and newly acquired observations and, if possible, extended to the whole Asia region.

## Project Publications

Patra, P. K., Canadell, J. G., & Lal, S. (2012). The rapidly




(1) Net Ecosystem Productivity (NEP) = NPP – heterotrophic respiration
(2) Net Biome Productivity = Sum of NEP, LUC, Fire, River (NBP = NEP – disturbances and lateral transport)
(3) Equivalent to NBP based on global $CO_2$ atmospheric inversions ($NBP_G$)
(4) Equivalent to NBP based on region-specific $CO_2$ atmospheric inversions ($NBP_R$)
(5) Bottom Up = $NBP^2$ + Fossil Fuel emissions
(6) Top Down = Weighted mean of $NBP_G{}^3$ and $NBP_R{}^4$ + Fossil Fuel emissions
(7) Best estimate $CO_2$ flux (mean of bottom-up[5] and top-down[6] estimates)
(8) Best estimate $CO_2$-equivalent ($CO_2$eq) flux that includes $CO_2$ and $CH_4$ fluxes

changing greenhouse gas budget of Asia. *Eos, Transactions American Geophysical Union , 93* (25), 237–237.

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## ARCP2012-01CMY-PATRA/CANADELL

### PROJECT TITLE

**Greenhouse Gas Budgets of South and Southeast Asia**

### COUNTRIES INVOLVED

Australia, Bangladesh, China, Indonesia, India, Japan, The Netherlands, Singapore, Thailand, UK, USA

### PROJECT DURATION

3 years

### APN FUNDING

US$ 150,000

### PROJECT LEADERS

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ARCP2012-02CMY-FORTES

# Seagrass-Mangrove Ecosystem: Bioshield Against Biodiversity Loss and Impacts of Local and Global Change Along Indo-Pacific Coasts

Takashi Asaeda, Miguel D. Fortes, Gregory King, Wawan Kiswara, Hiroshi Mukai, Ramesh Ramachandran, Eric Wolanski and Masumi Yamamuro

The project aims to provide (1) an ecosystem model that enables testing of scenarios of various decisions on human impacts combined with climate change; (2) a framework for a local Marine Emergency Contingency Policy (MECP); and (3) a system to support and enhance local governance. The products include students trained in practical, state-of-the-art techniques for water quality monitoring and trophic dynamics, and peer-reviewed publications. Student mentoring will ensure that, after training, expertise would be available to continue critical aspects of the project. The MECP will be translated into policy regulations through an Integrated Decision Support System, which will be developed in collaboration with other projects at the sites.

The project relevance resides in its intent to identify, explain and predict impacts of coastal changes on seagrass and mangrove ecosystem goods and services via a science-based understanding of the systems' strengths and vulnerabilities. This knowledge will be used as a base of an integrated decision support system to promote research on habitat response to local and global change. The support system, in turn, is the framework of capacity development and policy decisions to enhance ecosystem integrity and sustainable use.

In this report, the most significant results of the Science Establishment Phase of the project are presented. They also form the base of the next Capacity Building Phase. We analysed 15-month data on seagrass species composition, cover, shoot density, biomass and leaf growth rates from four 50x50 m quadrats established along a 5-km gradient in nutrients, chlorophyll-a, and siltation in the area. Results show that some definite biological reactions (or bioshield functions) along the gradient can be summed up as follows: From low levels of the "stressors" ("less stressed" condition) to high levels ("more stressed" condition): (1) There was a marked decrease in the number of seagrass species; (2) In terms of cover and density, *T. hemprichii* and *E.*

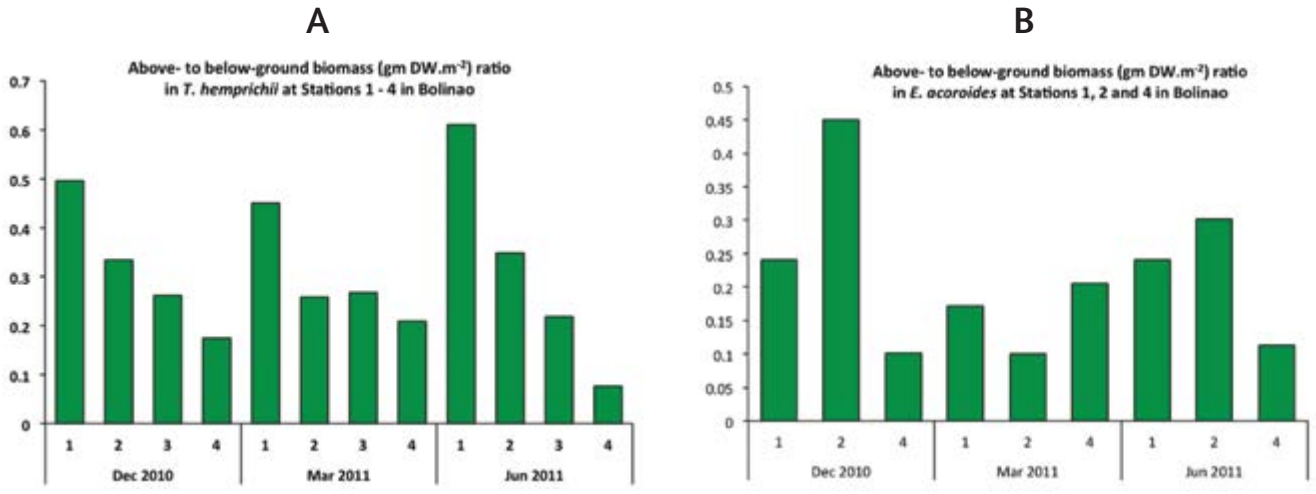


**Figure 1.** Above- and below-ground biomass (g DW $m^{-2}$) ratio in *T. hemprichii* (A) and *E. acoroides* (B) at Stations 1–4 in Bolinao (Dec 2000 – June 2011)

*acoroides* exhibited opposite responses, with *T. hemprichii*, showing marked decreases in both parameters, while *E. acoroides* showed increases; (3) In terms of biomass, ratios between the above- and below-ground biomass in each of the two species showed a general (*E. acoroides*) but marked (*T. hemprichii*) increase (Figure 1); and (4) In terms of leaf growth rate (cm $day^{-1}$), growth of both species was faster under "more stressed" than in "less stressed" conditions. However, under both conditions and regardless of the period, *T. hemprichii* consistently had much slower rate of growth than *E. acoroides*. Based on increasing sensitivity (decreasing resistance) to a combined effect of nutrients, chlorophyll-a and siltation, we propose the following sequence of the species: *Enhalus acoroides* > *Thalassia hemprichii* > *Cymodocea rotundata* > *Halodule uninervis* > *C. serrulata* > *Halophila ovalis* > *Syringodium isoetifolium*.

The results are a collective response of the seagrass ecosystem to a combined effect of eutrophication and siltation. They support earlier studies on the impact of fish farming on seagrass (Holmer et al., 2002; Marbà et al., 2006; Rountos et al., 2012) or of siltation from the rapid changes in land-use patterns in the coastal zone (Fortes, 2001; Short & Burdick, 1996; Terrados et al., 1999), or its induction of changes in the sediments by increasing the concentration of nutrients, organic matter and water content (Kamp-Nielsen et al., 2002, Halun et al., 2002), changing the redox condition of sediments favourable for benthos (Marba et al., 2010), or affecting indirectly the trophic structure of the community by enhancing an increase in grazer population density (Rountos et al., 2012). These results point directly to the inherent ability of the seagrass ecosystem to act as a bioshield, hence, they protect nearby reefs and coastal communities dependent upon them from the undesirable impacts from fish cage and fish pen effluents (for example, nutrients and silt). Despite the presence of the stressors, this protection can be translated into the ecosystem's ability to support high seagrass, fish and macroinvertebrate biodiversity and, in the case of *E. acoroides* and *T. hemprichii*, selectively sustain the ecosystem functions even at the most stressed part of the gradient. On the other hand, this is based on the assumption that the nutrients are taken up by the benthos, so that increase in dissolved oxygen away from the aquaculture may not necessarily be a bioshield effect; it could also be due to primary production consuming the extra nutrients as well as dilution in the water column. Differentiating between the two effects will be undertaken with a model to predict which is dominant (or minor).

In addition, the bathymetry of Bolinao has been done. This is required in developing a dispersion model of the effluents from the source (fish cages and fish pens) to the Seagrass Reserve (Station 4) and reef flats.

In Davao Oriental (southern Philippines) and using the acoustic video camera

**Figure 2.** The DIDSON acoustic video camera deployed to observe the behaviour of dugongs. With slight modification, the equipment was also used to develop 3D images of the seagrass bed


## PROJECT SUMMARY

In the Philippines and along nutrient, chlorophyll-a and siltation gradients, we determined the biodiversity, plant and macroinvertebrate and fish density, plant biomass and growth rate in the seagrass beds. The results indicate a potential collective response of the ecosystem to act as bioshield, protecting and sustaining the productivity of the communities from the negative impacts of fish cage effluents. This potential will be confirmed by a dispersion model, among others, once data are available. In addition, using the acoustic video camera DIDSON, we observed the underwater behaviour of the *Dugong dugon* (dugong) and obtained 3D video images of the bottom, giving rough estimates of seagrass density and distribution. In the case of mangroves, mono-specific plantation of *R. stylosa* significantly reduces species richness and variety of the mangrove vegetation. The policy implication of this finding is worth looking into in the light of massive financial and institutional support the current mangrove reforestation programme of the Philippines and Indonesia get, using only Rhizophora. Thus, we argue in favour of a growing consensus, which places seagrass-mangrove system conservation as priority, developing a model of the ecosystems focusing on their "bioshield" functions in mitigating local and global changes along Indo-Pacific coasts.

"DIDSON" (Figure 2), we observed the underwater behaviour of the *Dugong dugon* (dugong) and its habitat in terms of seagrass density and distribution. Seamless images of seafloor were captured as the survey boat cruised slowly along the planned survey lines, even in turbid or dark water.

Prospectively, a part of this study utilizes the metabolomic approach in assessing both anthropogenic and environmental impacts on the seagrass species *Halophila ovalis*. This will offer seagrass researchers an additional analytical tool for use in seagrass monitoring. If successful, this study will provide a wealth of information regarding the response of seagrasses to environmental stressors. In addition, the metabolites identified in this study will also enable further exploration into seagrass biology and physiology. On a wider scale, utilizing genomics, transcriptomics and proteomic data together with metabolomics data can lead to the development of a biological model for seagrasses in the future.

In the case of mangroves, *Rhizophora stylosa*, planted for surge protection and for fuel in Olango island (Central Philippines), was chosen for the study. At natural stands, the main species at the most outer edge were *Sonneratia alba* and *Avicenia marina*. Due to dense plantation and higher survival rate of *R. stylosa* seedlings, trees grew densely in comparison with natural stands of *R. stylosa*, tangling proproots among individuals. It was observed that following introduction in natural stands, *R. stylosa* occupies free space between trees and leave no room for propagation and extension of *S. alba* or *A. marina*, while also depriving other species of solar radiation and altering the current and sedimentation patterns. It seems, therefore, that the mono-specific plantation of *R. stylosa* significantly reduces species richness and variety of the mangrove vegetation. The policy implication of this finding is worth looking into in light of the enormous financial and institutional support the current mangrove reforestation programme of the Philippines and Indonesia receive, using only *Rhizophora*.

## Project Publication

Fortes, M. D., Go, G. A., Bolisay, K., Nakaoka, M., Uy, W. H., Lopez, M. R. . . . Edralin, M. (2012). *Seagrass response to mariculture-induced physico-chemical gradients in Bolinao, northwestern Philippines*. Proceedings of the 12th International Coral Reef Symposium, Cairns, Australia, 9–13 July 2012. Retrieved from http://www.icrs2012.com/proceedings/manuscripts/ICRS2012_15B_3.pdf

## Acknowledgments

Our sincere gratitude goes to APN for the financial support and to the Philippine-Japan CECAM Project for the use of the equipment. We greatly appreciate the logistical support provided by the Bolinao Marine Laboratory of the University of the Philippines, Davao Oriental State College of Science and Technology and the Southern Philippines Agro-Marine School of Science and Technology.

**ARCP2012-02CMY-FORTES**

**PROJECT TITLE**

**Seagrass-Mangrove Ecosystems: Bioshields Against Biodiversity Loss and Impacts of Local and Global Change Along Indo-Pacific Coasts**

**COUNTRIES INVOLVED**

Australia, Japan, India, Indonesia, Philippines

**PROJECT DURATION**

3 years

**APN FUNDING**

US$ 121,750

**PROJECT LEADER**

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ARCP2012-03CMY-HERATH

# Developing Ecosystem-Based Adaptation Strategies to Enhance the Resilience of Rice Terrace Farming Systems against Climate Change

Srikantha Herath, Luohui Liang, Jintana Kawasaki, Yuanmei Jiao, Peter Paul Macariola Castro and Yi Wang

## Water Management

Water management systems in Hani and Ifugao rice terraces have developed over the centuries to cope with variations in water supply due to seasonal and annual rainfall changes. In Hani rice terraces, the stream water in the upstream is diverted directly into canals to irrigate the terraces, and some of the remaining water is diverted to the villages for daily water consumption. The Hani community developed an efficient water-allocation system based on carved wooden barriers in the cannel to divide water among rice terraces downstream. The Hani community ownership of water rights and the irrigation infrastructure encourage a harmonious partnership among the villagers to govern canal construction and water distribution management. The water management system in Ifugao rice terraces has used the concept of a "water district," with each water district having its own agricultural leader and workgroup. The workgroup is organized for the construction and maintenance of irrigation canals. The Ifugao community developed intricate irrigation and drainage systems for their rice terraces. The water is gradually released into the paddies using bamboo or log flumes.

## Water Balance Model Analysis and Results

A single-terrace water balance model characterized by water use at the paddy-level water supply and water demand was developed for the initial investigation. In rice production, water balance is associated with applying the minimum amount of water required for growth of rice and irrigation usage. According to the water cycle study of the Ifugao rice terrace in the Philippines, the monthly effective rainfall for normal, dry, and wet-year scenarios and their average in Ifugao rice terraces are shown in Figure 1. The monthly reference evapotranspiration $ET_o$ from historical climate data, and actual evapotranspiration $ET_c$ reflecting the effect of the rice crop, is shown in Figure 2. As proof

**PROJECT SUMMARY**

This project aims to develop ecosystem-based adaptation measures to enhance the resilience of rice terrace farming systems against flood and drought, and investigate alternative water management schemes in the future to cope with the risk of water cycle change. Two study sites were selected in the sub-watersheds representative of forest and grassland, one each in the Hani rice terrace, China (Quanfuzhuang Administrative Village and the Quanfuzhuang watershed), and the Ifugao rice terrace, Philippines (Poitan terrace clusters and Bangaan terrace clusters and sub-watersheds in Banaue). At Quanfuzhuang village in Hani rice terraces, two water weirs and water level gauges to analyse hydrologic characteristics, and two water meters to analyse the paddy field water balance were installed. In the past year, the project has made substantial progress in completing the installation of hydrological equipments, collecting daily weather data in the study sites, developing a hydrological model, and preparing for the analysis of economic and social sustainability factors in Hani and Ifugao rice terraces. In this article, the water management systems in both study sites, the water balance model analysis in the Ifugao rice terrace, and an integrated model for maintaining resilience in the Hani rice terraces are presented.

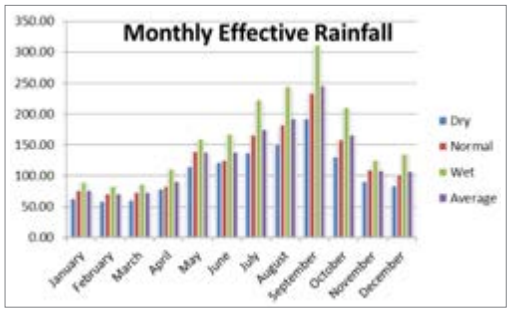


**Figure 1.** Monthly effective rainfall

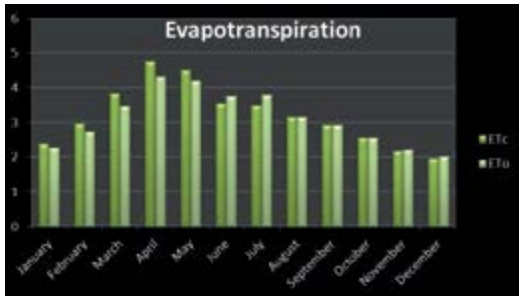


**Figure 2.** Reference ($ET_o$) and actual ($ET_c$) evapotranspiration

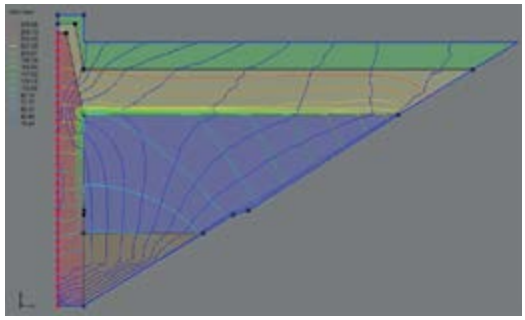

**Figure 3.** Flownet for a terrace with vertical wall and 30° mountain slope

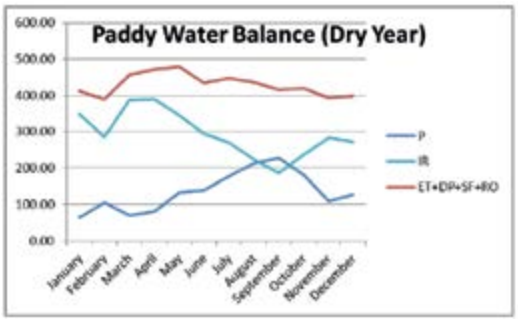


**Figure 4.** Water balance results for a dry-year scenario

of concept, the water balance model was run on a small hypothetical terrace with the geometry shown in Figure 3. The average monthly water balance for a dry year run is shown on Figure 4, and the monthly irrigation requirement for all four scenarios is shown in Figure 5. It can be seen that the single-terrace water balance model may be used for testing various scenarios. It is not a very complex model but flexible enough to alow additional information gathered to be infused for more accurate simulation. The geometrical configuration of the terrace may be modified to comply with field survey results. Likewise, material properties are based on core samples with associated laboratory analyses, augmented by detailed site investigations. Implementing the water balance model to an Ifugao terrace site entailed the collection and processing of local data. Local entities that would participate in the pilot study give advice and strongly influenced the selection. Installation of additional equipment such as an automated rain gauge is now undergoing reliability tests before installing in the Ifugao project sites.

## An Integrated Model for Maintaining Resilience in Hani Rice Terraces

The current threats to Hani rice terraces are rooted in economic motives pursued through tourism promotion and its associated social changes. To maintain a steady flow of incoming tourists, local authorities and land managers have started to widely adopt an system called "pushing grain for water," which has encouraged the retention of water in the upstream villages and reduced the supply of water for rice cultivation in the downstream villages, leading to an expansion of maize cultivation. Apart from this, climate change is also creating new risks as terraces are increasingly susceptible to water shortages and drought during the dry season. This study aimed to explore the viability of local, economically-based models to address shortfalls in ecological and social sustainability of current rice terrace land management trends.

Current ecological challenges are:

- Disruption of coordination between the human landscape and the natural environment;
- Disregard of communal norms through commodification of Hani culture and environmental products, including sacred places.

Current social challenges are:

- Change in intergenerational values from sacred forest landscapes to "modernized" values;
- Preferences for land use driven by livelihood maintenance over cultural/aesthetic/environmental values.

Current economic challenges are the most important and needs to be addressed:

- Introduction of an alternative, more profitable product

(tourism) without meaningful integration of existing economic factors such as labour supply or rice productivity;
- Structural change in the economy through the introduction and promotion of tourism and consequently diminished overall aggregate supply and demand of agricultural products.

In the second year the research will seek to understand the viability of forming a limited liability joint-stock company integrating tourism and agricultural sectors with the local Hani population as shareholders. Analysis of sustainability of rice terrace systems require not only ecological sustainability analysis and solutions, but also the analysis of economic and societal sustainability. Recognizing this need, the research scope is expanded to find ways of integrating rice production with tourism so that they are managed in an integrated manner to complement each other and benefit local communities.

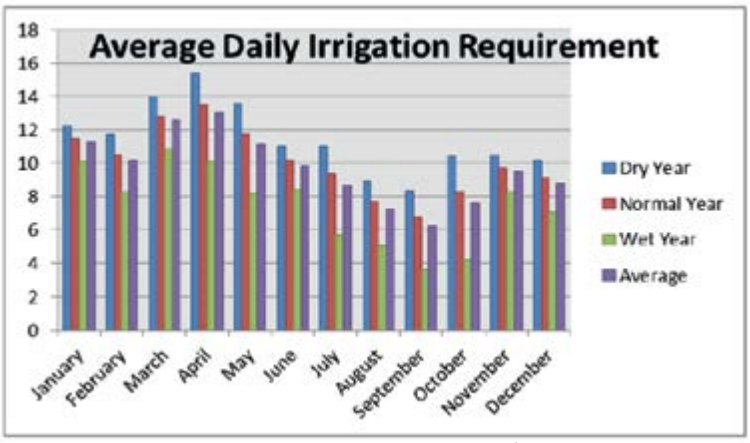


**Figure 5.** Irrigation requirement (mm/day) for four scenarios

## Project Publications

Jiao, Y., Liang, L., Takeuchi, K., & Okuro, T. (2012). Evolution of Satoyama landscape in Japan and its enlightenment for Hani terrace landscape in China. Proceedings of The First Terraced Landscapes Conference. Accepted.

Gu, H., Jiao, Y., & Liang, L. (2012). Strengthening the socio-ecological resilience of forest-dependent communities: The case of the Hani rice terraces in Yunnan, China, *Journal of Forest Policy and Economics*, *22*, 53–59.

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### ARCP 2012-03CMY-HERATH

**PROJECT TITLE**

**Developing Ecosystem-based Adaptation Strategies for Enhancing Resilience of Rice Terrace Farming Systems against Climate Change**

**COUNTRIES INVOLVED**

China, Japan, Philippines

**PROJECT DURATION**

3 years

**APN FUNDING**

US$ 135,000

**PROJECT LEADER**

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ARCP2012-04CMY-SALIK

# Socioeconomic Vulnerability Assessment of Indus Delta under Climate Change: A Case Study of Keti Bandar in Pakistan

Kashif Majeed Salik and Sehrish Jahangir

## Project Objectives

First year Project objectives include:

- To access vulnerability of Keti Bandar in terms of climate change and socioeconomic indicators; while developing links to sustainability of mangroves in Keti Bandar and its associated communities.
- To examine different climatic and hydrological factors under climate change scenarios and assess their linkages and interactions with mangrove ecosystems

All areas of the present study cross-cut the APN's two agendas. The impacts of climate change are primarily being observed on mangroves ecosystems in South Asia (for Pakistan in the present article) and future scenarios are being predicted for changing climate or variability for the 21st century. Mangroves resources utilization is also an important component in this respect.

## Work Undertaken

### *Socioeconomic Vulnerability Assessment under Climate Change*

The Composite Vulnerability Index (CVI) approach is used as it includes both climatic as well as socioeconomic variables (Gornitz et al., 1993; Cooper & McLaughlin, 1998; Boyd, et al., 2005; Heltberg & Bonch, 2011; Szlafstein & Sterr, 2007; William et al., 2012).

**PROJECT SUMMARY**

The communities dependent on mangroves ecosystem of the Indus Delta in South Asia continue to be vulnerable, owing to the sensitive linkage of this ecosystem with decreasing fresh water availability and changing climatic parameters. The research intends to explore the links and to determine the dynamics of mangrove forests in line with the socioeconomic vulnerability. The coastal town of Keti Bandar located in the district of Thatta, Sindh was selected as a study site. To calculate socioeconomic vulnerability due to climate change, the Composite Vulnerability Index (CVI) methodology was used. Three sub-indices of: exposure, sensitivity and adaptive capacity were included in the study. The results were analysed verily; starting from CVI to the bottom of the pyramid. CVI values stood out at 0.55; whereas for exposure, sensitivity and adaptive capacity, the indices were calculated as 0.52, 0.69 and 0.45, respectively.

### *CVI—Sub-indices, Indicators and Variables*

CVI is diverged into three sub-indices that are: sensitivity, exposure and adaptive capacity, which are then segregated into relevant indicators (Box 1).

All the variables of indicators predicting a particular sub-index were normalized by linear transformation using their un-weighted averages.

## Results and Conclusion

Taking the collective note, the study area under

the constant exposure (0.5211) to climatic variables is extremely sensitive (0.697) to climate change with low adaptive capacity (0.396) of the community to cope with these changes.

| CVI | Sensitivity | Exposure | Adaptive capacity | CVI |
|---|---|---|---|---|
| **Composite** | 0.697 | 0.5211 | 0.396 | 0.539 |
| **Fisheries** | 0.698 | 0.5211 | 0.406 | 0.542 |
| **Agriculture** | 0.659 | 0.5211 | 0.342 | 0.547 |

**Table 1.** Sub-Indices and Vulnerability Index (Composite, Fisheries and Agriculture) in Keti Bandar, Pakistan

The communities of coastal areas in Pakistan are highly vulnerable to climate change negative impacts, predominantly those resulting from increasing variability in air temperature, precipitation and sea surface temperature (SST). This will result in poor livelihood conditions due to food and water insecurities and insufficient education and health facilities under climate change.

### *Climate Change Scenarios Development*

The future climate change projections are constructed over mangroves study area (Keti Bundar) in Pakistan. Future projections for A2 and B2 scenarios over the time periods 2020s (2010-2039), 2050s (2040-2069) and 2080s (2070-2100) were developed and are shown in Tables 2 and 3.

## Project Publications

Salik, K. M., & Jahangir, S. (2012). *Socioeconomic and environmental Vulnerability Assessment of Indus Delta: A Case Study of Keti Bandar in Pakistan*. Fifteenth Sustainable Development Conference, 11-13 December, 2012.

Salik, K. M., & Jahangir, S. (2012). *Ecological assessment of Indus Delta in the context of environmental flows*

| Seasons | A2 Scenario | | | B2 Scenario | | |
|---|---|---|---|---|---|---|
| | 2020s (2010-2039) | 2050s (2040-2069) | 2080s (2070-2099) | 2020s (2010-2039) | 2050s (2040-2069) | 2080s (2070-2099) |
| **Annual** | 1.20 | 2.52 | 4.05 | 1.29 | 2.24 | 3.11 |
| **Winter (DJF)** | 1.57 | 3.35 | 5.00 | 1.74 | 3.02 | 3.99 |
| **Spring (MA)** | 1.22 | 2.41 | 4.01 | 1.25 | 2.26 | 3.12 |
| **Summer (MJ)** | 1.11 | 2.06 | 3.29 | 1.11 | 1.71 | 2.62 |
| **Monsoon (JAS)** | 0.90 | 2.02 | 3.45 | 1.02 | 1.83 | 2.49 |
| **Autumn (ON)** | 1.21 | 2.49 | 4.41 | 1.26 | 2.24 | 3.22 |

**Table 2.** Mean Temperature Projections (°C) over study area Keti Bundar, Pakistan

| Seasons | A2 Scenario | | | B2 Scenario | | |
|---|---|---|---|---|---|---|
| | 2020s (2010-2039) | 2050s (2040-2069) | 2080s (2070-2099) | 2020s (2010-2039) | 2050s (2040-2069) | 2080s (2070-2099) |
| **Annual** | 108.31 | 54.76 | 83.40 | 98.72 | 119.23 | 115.40 |
| **Winter (DJF)** | 22.94 | -24.71 | 68.76 | 133.32 | -2.79 | 92.70 |
| **Spring (MA)** | 0.31 | 20.81 | -23.11 | -34.69 | -21.89 | 24.63 |
| **Summer (MJ)** | -13.10 | 24.15 | 21.57 | 5.49 | -19.55 | 13.48 |
| **Monsoon (JAS)** | 124.14 | 56.79 | 73.95 | 121.93 | 142.56 | 140.72 |
| **Autumn (ON)** | 128.64 | 108.94 | 255.02 | 15.14 | 107.99 | 34.06 |

**Table 3.** Precipitation Projections (%) over study area Keti Bundar, Pakistan

## BOX 1: VARIABLE USED AND FORMULAS

**Exposure (E) = ((sdt1 + ... + sdt12)/12 + (rT1 + ... rT12)/12+ (Nhot + Ncold)/2 + Ndry + (sdP1 +... sdP12)/12 + (sdT1 + ... + sdT12)/12)/6**, where,

- sdt — Standard deviation of monthly temperatures between a-b
- rT1 — The range between maximum and minimum average monthly temperatures
- Nhot — The frequency of extreme hot months (above 30°C)
- Ncold — The frequency of extreme cold (below -10°C) months
- Ndry — The frequency of extreme dry month in spring (less than 5 ml total precipitation/month) and summer (0 ml total precipitation/month)
- sdP — Standard deviation of monthly total precipitation
- sdT — Standard deviation of yearly sea surface temperatures between time a and b

**Sensitivity (S) = (s1 +s2 + s3)/3 + (s4 + s5)/2+ (s6 + s7)/2+ (s8+ s9+ s10+ s11)/4+ (s12+ s13+ s14 +s15)/4)/5**, where,

- S1 — Sensitivity of mangroves in Keti Bandar
- S2 — Accessibility to mangroves
- S3 — Mangroves used per month as fuel
- S4 — Share of households relying on unprotected water sources
- S5 — Population deprived of sanitation facility
- S6 — Change in fresh water flows
- S7 — Effect of unavailability of fresh water on agriculture
- S8 — Effect of unavailability of fresh water on fish
- S9 — Frequency of sea intrusion or inundation
- S10 — Frequency of natural climatic disasters
- S11 — Intensity of natural climatic disasters
- S12 — Estimated per capita economic costs of these disasters
- S13 — Percentage of population financially aided by different agencies

**Adaptive Capacity = (a1 + a2 + a3+ a4+ + (a5+ a6)/2+ a7 +a8+a9+ (a10+ a11)/2+ (a12+ a13)/2)/10**, where,

- a1 — Household consumption per capita
- a2 — Herfindahl index of income diversification (higher value, more diversification)
- a3 — Ratio of total number of people and number of people earning in a family
- a4 — People educated above secondary level
- a5 — Percentage share of literate people
- a6 — Access to basic services
- a7 — Nature of dwellings
- a8 — Number of the assets owned by the community members
- a9 — Level of cooperation within the family network within the village
- a10 — Level of cooperation within the family network outside the village
- a11 — Extent of migration due to natural disasters
- a12 — Extent of migration because of material reasons

**Cumulative Vulnerability Index=1/3((Exposure + Sensitivity+ (1-Adaptive Capacity))**

*requirement.* Fifteenth Sustainable Development Conference, 11-13 December, 2012.

Md. Hasan, M., Khan, Z. H., & Akhter, S. (2012) *Salinity Distribution in the Sundarbans Area and Future Threat on this Distribution.* Fifteenth Sustainable Development Conference, 11-13 December, 2012.

Hashmi, M. Z., & Salik, K. M. (2012). *Analysis of hydrological regime in the mangrove forest region of Pakistan.* Fifteenth Sustainable Development Conference, 11-13 December, 2012.

## Acknowledgments

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William W. L., Cheung, J., Sarmiento, L., Dunne, J., Frölicher, T. L., Lam, V. W. Y., . . . Pauly, D. (2012). *Shrinking of fishes exacerbates impacts of global ocean changes on marine ecosystems*. doi: 10.1038/NCLIMATE1691

**Figures.** (1) Mangrove deforestation, (2) Sanitation facility in coastal villages, (3) Polluted water being filled in the tanker to be transported to villages for drinking, (4) Wooden houses in Keti Bandar

**ARCP2012-04CMY-SALIK**

**PROJECT TITLE**

**Impacts of Climate Change on Mangrove Ecosystems in South Asia**

**COUNTRIES INVOLVED**

Bangladesh, India, Pakistan, Sri Lanka, USA

**PROJECT DURATION**

2 years

**APN FUNDING**

US$ 85,000

**PROJECT LEADER**

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ARCP2012-05CMY-ZHEN

# Holistic Assessment of Land-Use Change and Impacts on Ecosystem Services of Wetlands

Lin Zhen, Joeni S. Rahajoe, Giashuddin Miah and Chuanzhun Sun

## Project Objectives

The project aims to provide answers both at the methodological and theoretical levels to tackle issues on sustainable use of land resources and ecosystem services. The assessment criteria, methods and techniques to be developed will contribute to technical capabilities of APN countries. In addition, the project will increase public awareness of wetland issues, which will lead to sound management actions. The policy supporting system (as an outcome of the workshops) will directly address APN's science-policy agenda by providing information on governance regimes and scientific input to policy decision-making, as well as scientific knowledge to the public. The project will also develop networks with IHDP, GLP, IGBP, WETLANDS and other national and international organizations, and will strengthen collaborative research and the exchange of information through case studies.

**PROJECT SUMMARY**

The Giam-Siak Biosphere Reserve in Indonesia, Poyanghu area in China and Tanguar Haor area in Bangladesh are important international wetlands. However, they all experienced intense land-use change in recent years, exerting significant impacts on ecosystem services. In order to understand how land-use change affects ecosystem services, we used the PRA method, questionnaire survery, and InVEST model to identify land-use change, changes in ecosystem services, as well as their inter-connections. Preliminary analyses show that: (1) during the past several decades in Giam-Siak Biosphere Reserve, Indonesia, population pressure on forests has led to a decline of biodiversity in forest ecosystems; (2) policy factor is the main reason of land-use change in Poyanghu area in the past decade, which has led to fluctuations in food supply in the area. The habitat quality of the Poyanghu area generally under good condition, but is affected to a certain degree by urban construction; (3) there has been a significant degradation of ecosystems and conversion of flooded (swamp) forest into fallow, grazing and agricultural land in the Tanguar Haor area, Bangladesh, changing the provisioning of food, fuel wood, fish, fibre and other benefits.

The kick-off meeting was held in Beijing on 29–30 December 2011, and a progress meeting in Dhaka on 23–24 November 2012. Before the kick-off meeting, the project team reviewed literatures related to land-use change and impacts on ecosystem services, particularly those related to wetlands in the study area. During the kick-off meeting, the study areas in three countries were selected and confirmed. Land-use change and its main driving forces in the aspects of natural and anthropogenic factors were analysed and the impacts of land-use change on ecosystem services over the past 20 years assessed.

The progress meeting highlighted that: (1) In order to identify ecosystem services and biodiversity changes of wetland ecosystem in Giam-Siak Biosphere Reserve, Sumatra Island, Indonesia, researchers selected the Temiang (Bukit Batu District) and Tasik Betung (Sungai Mandau District) villages as study sites, and

| Sites | Land-use change | | |
|---|---|---|---|
| | Wetland | Farmland | Forest |
| **China** | increase↑ | decrease↓ | no significant change |
| **Indonesia** | increase↑ | decrease↓ | decrease↓ |
| **Bangladesh** | decrease↓ | decrease↓ | decrease↓ |

**Table 1.** Land-use changes in 3 sites over past 20 years

| Sites | Driving forces |
|---|---|
| **China** | Human intervention, climate change, policy, industrialization, urbanization, dam construction. |
| **Indonesia** | Human intervention, climate change, urbanization , non-agriculture, Industrialization. |
| **Bangladesh** | Human intervention, climate change, forest concession, urbanization. |

**Table 2.** Driving forces of land-use change in 3 sites

adopted the Participatory Rural Appraisal (PRA) approach to identify land-use change and its impacts on ecosystem services. The key result is that during the past several decades in Giam-Siak Biosphere Reserve, population pressure on forests led to the decline of biodiversity in forest ecosystems. (2) Through literature review and PRA work in three typical villages, we found changes in food supply and ecosystems in Poyanghu area, China. We assessed the biodiversity in this area using the InVEST model. Research results in Poyanghu area show that policy is the main reason for land-use change over the past decade in this area, resulting in fluctuations of food supply. Habitat quality in the Poyanghu area is generally in good condition, but is affected to a certain degree by urban construction. (3) Results of a questionnaire survey in the Tanguar Haor area, Bangladesh show that there has been a dramatic degradation of biodiversity and conversion of flooded forest into fallow, grazing and agricultural land in the area. Consequently it has brought changes in the provision of food, fuel wood, fish, fibre and other human benefits.

**Figure 1.** The Poyanghu lake in China

| Site | Type of ecosystem services affected by land-use change | Data required for the assessment | Data collection method and date | Data analysis methods | Scenarios |
|---|---|---|---|---|---|
| **China: Poyanghu** | Biodiversity; Flood regulation; Food provisioning; Carbon sequestration | Land-cover map over time; Biodiversity trend; DEM/soil/climate/ Biomass/hydro data; Socioeconomic data; Demographic data | PRA/FGD; Household survey; Resource person interview | InVEST 2.0; GIS spatial Analysis; Statistics | Agriculture; Industrialization |
| **Bangladesh: Tangual haor** | Biodiversity; Water supply; Flood regulation; Food supply | Land-cover map over time; Biodiversity trend; DEM/soil /climate/ Biomass/hydro data; Socioeconomic data; Demographic data; | PRA/FGD; Household survey; Resource person interview | InVEST 2.0; GIS spatial Analysis; Statistics | Conversion of wetland to agriculture use; Conservation of biodiversity; Protection of wetland |
| **Indonesia: Giam Siak Biosphere Research** | Biodiversity; Water supply; Carbon storage; Land-use changes; Food supply | Land-cover map over time; Biodiversity trend; DEM/soil/climate/ Biomass/hydro data; Scioeconomic data; Demographic data; Oil-palm, timber production; | PRA/FGD; Household survey; Resource person interview; Ecological study | InVEST 2.0; GIS spatial Analysis; Statistics | Carbon trade or mitigation; Conservation of biodiversity |

**Table 3.** Impact of land-use change on ecosystem services and research methods in 3 sites

## Project Publications

Three journal articles, one for each study sites, will be developed and published after data collection and analyses are completed.

## Acknowledgments

Financial support from APN is highly appreciated for the implementation of this project. We are also grateful for the support and assistance from local governments and farmers from each study site during the data collection period.

**ARCP2012-05CMY-ZHEN**

**PROJECT TITLE**

**Holistic Assessment of Land-Use Change and Impacts on Ecosystem Services of Wetlands**

**COUNTRIES INVOLVED**

Bangladesh, China, Indonesia, Japan

**PROJECT DURATION**

2 years

**APN FUNDING**

US$ 90,000

**PROJECT LEADER**

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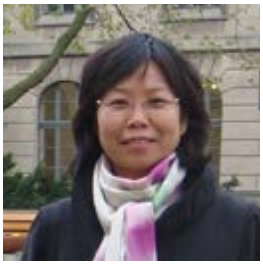

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ARCP2012-06NMY-IGBP

# An IGBP Synthesis on Global Environment Change and Sustainable Development: Needs of Least Developed Countries

Alimullah Miyan, Mohammed Ataur Rahman, M. Shohidullah Miah and Tanvir H. DeWan

## Introduction

The synthesis — Global Environment Change (GEC) and Sustainable Development: Needs of Least Developed Countries (LDCs) is part of an ongoing IGBP synthesis activity formed by several themes. The IGBP-LDCs synthesis theme extends over Africa and is under the leadership of the IGBP Vice-Chair Dr. Opha Pauline Dube at the University of Botswana working with the IGBP Secretariat in Stockholm. This report is for the Asia and SIDS components of the synthesis and covers four sub-components coordinated from Bangladesh and extending over seven countries: Bangladesh, Nepal, Bhutan, Myanmar, Yemen, Lao PDR and Cambodia:

- Droughts in environmental changes and sustainability of Asian LDCs
- Challenges facing Bangladesh and Myanmar in nurturing marine environment for sustainable development
- Flood in the context of environmental changes and sustainability in Bangladesh and Nepal
- Coastal zone management in Bangladesh

The aim is to conduct a cross-scale integrated synthesis on environmental change issues relevant to LDCs in Asia and SIDS using available information at the local, national and international levels to contribute to a better understanding of influential factors in human health and the environment with particular reference to natural hazards and related disasters. The project aims to highlight the potential role of traditional and indigenous knowledge systems in providing solutions to challenges of GEC and, in the course of this, build capacity in cross-scale fertilization of scientific information and enhance networking between LDCs, APN and global scientists from IGBP and its partners. The synthesis is in line with the APN mission in that it strives to contribute towards the larger process of identifying and explaining changes in the context of both natural and anthropogenic forcing; contributing in assessing potential regional vulnerability of natural and human systems with the aim of developing policy options for appropriate responses to GEC that will contribute to sustainable development among LDCs in the Asia and SIDS region.

## Work Undertaken

Team leaders of the four sub-projects carried out two workshops in Bangladesh, one at the Institute of Environment and Forestry, Chittagong University and another at the Department of Disaster Management, Patuakhali University of Science and Technology. These workshops engaged researchers and policy makers to deliver issues covered by the synthesis. In addition, they visited coastal areas to engage stakeholders and researchers of local Disaster Management Training Institutes and collected data on disaster-affected areas and reasons for sharp declining marine and estuarine fish resources. However, most of the available publications lack field-based information. Details of work carried out by the various team members as part of the 2012 activities of the synthesis process are as follows:

Professor Miyan attended the South Asian Association for Regional Cooperation (SAARC) Regional Consultation Meeting on "Engaging SAARC for Disaster

## PROJECT SUMMARY

Least developed countries (LDCs) in SIDS and Asia face serious problems of environmental changes due to natural variability and climate change acting together with development challenges. Up-to-date information on the nature of these problems and potential solutions are required by policy makers and society at large. This IGBP Asia and SIDS LDCs synthesis integrates information gathered from both the published and grey literature and through engaging stakeholders regarding human health and environment, natural hazards and disasters and the potential for traditional and indigenous knowledge systems to establish solutions to environmental challenges experienced. Preliminary findings show that in Bangladesh, basins are rising due to siltation resulting from mismanagement of land and water resources giving rise to flooding. Erratic and reduced rainfall hampers agriculture and delivery of domestic water. Estuarine and marine fisheries have declined sharply. Coastal deforestation and chemical pollution have significantly affected aquatic and terrestrial biodiversity, in turn, which increases the intensity of storm-induced tidal surges. Migration to cities has increased urban slums creating huge problems. In addition to various government disaster risk reduction initiatives, this study reveals that, most of the work conducted earlier lacks adequate field verification, ignoring the potential of tapping into indigenous and traditional knowledge systems.

Resilience," Islamabad, Pakistan, and presented a paper on "Vulnerabilities of the People of Bangladesh to Disasters". He attended the ADB Leadership Programme for Sustainable Development and Climate Change, Manila and presented on NAPA: Case Study — Bangladesh and also participated in the launching of IPCC's Summary Report on "Managing the Risks of Climate Extremes and Disasters in Asia" New Delhi, 2012 and similarly in Karachi, Pakistan, 2012 to evaluate the outcome of the IPCC Special Report: Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation (SREX). Professor Miyan and Dr. Rahman worked as lead and contributing authors, respectively, for preparing the report.

Dr. Miah and Dr. Rahman visited the Marine Academy at Dhaka and Chittagong and collected data on various coastal and marine resources and other environmental challenges including problems faced by Barisal and Patuakhali fishermen, livelihoods of the island dwellers, status of fish resources, effects of recently raised submerged islands, marine biodiversity including shrimps, lobster, crabs and fisheries; the health hazards of the labourers and degradation of the St. Martin coral reef due to tourism.

Mr. DeWan visited Sylhet, Chittagong, Khulna, Barisal, Patuakhali and Rangpur and made contact with researchers, policy makers and stakeholders, and investigated the cause and effects floods and tidal bores. The impacts on agriculture, biodiversity and infrastructures, including industries and city lives, were studied. Traditional adaptation practices and needs for ways to facilitate quick recovery from flood events were explored and the causes of reduction of river-flows and siltation that reduced water-holding capacity of the wet-bodies causing frequent severe flooding were assessed.

Dr. Rahman visited coastal zones, where he organized workshops that engaged researchers, policy makers and other stakeholders; collected information about livelihoods, vulnerabilities of climate change hazards and coping pactices of coastal people. One workshop noted that great migration of hilsa (*Tenualosa ilisa)* towards Myanmar has been observed. Marine hilsa used to breed in the fresh waters of the Ganges, Brahmaputra and Meghna about 100–150 km inside Bangladesh. Further, Sundarbans and Chokoria Sundarbans mangrove forests were noted to be under threat of destruction due to uncontrolled logging, shrimp farming and ship-breaking industries, while coastal agriculture and biodiversity has been seriously affected by salinity intrusion during the tidal surges from cyclones Sidr and Aila. However, salinity-tolerant indigenous crops are being cultivated, for example, salinity-tolerant rice BINA-40, 41 and 44 have been developed and another variety BR-51 that can withstand 15 days in submerged conditions. In addition, chemical pollution particularly from disposal of industrial effluents significantly affects aquatic and terrestrial biodiversity and is a threat to human health (Table 1).

The environmental problems noted above have triggered coastal population migrating to cities, increasing challenges of service delivery and exacerbating vulnerability to natural hazards.

| | Zinc (Zn) | Cadmium (Cd) | Lead (Pb) | Mercury (Hg) | Arsenic (As) |
|---|---|---|---|---|---|
| **Range (in ppb)** | 0.04–0.4 | 0.043–2 | 2.29–18.62 | 0.12–1.45 | 1.15–4.8 |

**Table 1.** Concentration ranges of heavy metals and arsenic in Turag river which forms the upper tributary of the river Buriganga. These levels were determined from different locations during the dry season of 2012

## Future Plan

To facilitate the synthesis work, more visits are in progress and contacts are being made to visit Nepal, Bhutan, Lao PDR, Cambodia and Bangladesh from February to April 2013. Field-oriented case studies will be conducted to supplement available secondary information. This will be followed by an analysis of the gathered data to produce draft synthesis papers that will be presented at a "Write-a-Paper Workshop" to be organized through IGBP during 2013. This workshop will facilitate the production of a special issue based on the integrated synthesis work on GEC issues among the Asia and SIDS LDCs.

## Project Publications to Date

Miyan, M. A. (2012). Vulnerabilities of the People of Bangladesh to Disasters; South Asian Association for Regional CooperationSAARC Regional Consultation Meeting on "Engaging SAARC for Disaster Resilience," Islamabad, Pakistan, 1–2 November 2012.

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## Acknowledgments

The IGBP Asia and SIDS LDCs synthesis is funded by APN. We would like to acknowledge IGBP for initiating and coordinating the implementation of this synthesis, in particular the assistance provided by the IGBP Vice-Chair Dr. Opha Pauline Dube. We are also grateful to the Institute of Environment and Forestry, Chittagong University and the Department of Disaster Management, Patuakhali University of Science and Technology, the Marine Academy of Dhaka and Chittagong for their support.

**ARCP2012-06NMY-IGBP**

**PROJECT TITLE**

**An IGBP Synthesis on Global Environment Change and Sustainable Development: Needs of Least Developed Countries**

**COUNTRIES INVOLVED**

Afghanistan, Bangladesh, Bhutan, Cambodia, Lao PDR, Maldives, Myanmar, Nepal, Yemen

**PROJECT DURATION**

2 years

**APN FUNDING**

US$ 90,000

**PROJECT LEADERS**

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# Impacts of Global Warming on Coastal and Marine Ecosystems in the Northwest Pacific

Sukgeun Jung, Gennady V. Khen, Hiroya Sugisaki, Xianshi Jin, Yongjun Tian, Dohoon Kim, Yury Zuenko, Jürgen Alheit and Ig-Chan Pang

## Project Objectives

The highly-productive western North Pacific has experienced dramatic changes in oceanographic conditions and ecosystem structure, driven by climatic changes and anthropogenic interventions (PICES, 2004). It is intended to conduct comparative studies across NOWPAP countries (China, Japan, Korea and Russia) to evaluate regional differences in the responses of marine ecosystems to the changes in the NOWPAP sea area (33–52°N, 121–143°E) by a working group composed of natural and socioeconomic scientists. This project was realized to provide scientific basis to decision makers in developing policy strategies that incorporate regional differences in 1) marine ecosystems supporting fish stocks, and 2) vulnerability and adaptation of the fisheries industry to climate change. This project was implemented in two phases — phase 1: analyses of spatial and temporal variability in oceanographic conditions and recruitments of major fish species in the NOWPAP sea area for the last 40 years; and phase 2: forecast of changes in potential production of fisheries resources and evaluation of risks and vulnerabilities induced by climate change in fisheries-dependent sectors across NOWPAP countries. In particular, we have been developing an individual based model (IBM) for Pacific anchovy (*Engraulis japonica*) as a first step in establishing predictive models for important commercial species.

This project directly pursues the APN Goals 1 and 2. As the proponent is a lead author of IPCC AR5 (WG II, Chapter 30, Open Oceans) and a member of PICES Fishery Science Committee (FIS), the outcomes and activities from this project are expected to contribute to IPCC, NOWPAP, PICES and IMBER (Theme 4). This project addresses the research areas 1–4 of APN Science Agenda and will be in line with policy strategies APN has

**Figure 1.** Group photo during our 2nd joint workshop with Data Buoy Cooperation Panel (DBCP) for the North Pacific Ocean and Its Marginal Seas (NPOMS) (Jeju National University International Center, Jeju, Republic of Korea, 9–14 July 2012)

committed to: strengthening science-policy interactions and improving cooperation with other institutions and bodies, such as IPCC.

## Work Undertaken

We performed three main activities for phase 1 in 2011–2012: 1) Gathering information available in each country and developing national reports; 2) Compiling four national reports into a regional report; 3) Holding two workshops — the first workshop to introduce the research findings and discuss future activities, and the second workshop (Figure 1) for better understanding by policy makers of possible implications of climate change impacts on fisheries production in the Northwest Pacific and for raising their awareness about possible policy implications.

In particular, we have been developing an individual based model (IBM) (Hinckley et al., 1996) for Pacific anchovy (*Engraulis japonica*) as a first step in establishing predictive models for important commercial species. A numerical ocean model, ROMS (Regional Ocean Modelling Systems) (Shchepetkin & McWilliams, 2005) was used for predicting changes in oceanographic conditions. We tracked the attributes of individual anchovy eggs and larvae responding to spatiotemporal variations in oceanographic environment based on outputs from ROMS and a biophysical coupling model incorporating the derived temperature- or size-dependent response functions of incubation, growth, fecundity and mortality of anchovy (Jung, 2008; Jung et al., 2008). Model outputs were compared with egg and catch distribution observed and reported for spring and summer in 2002 to validate and improve our anchovy IBM. Comparisons tentatively implied that anchovy larvae tend to be aggregated in shallow areas along the Korean and Japanese coastline, especially in summer, and that anchovy catch could have been under-reported in the Yellow Sea. The developed IBM was also used to project long-term changes between 2000s and 2030s in anchovy fishery driven by climatic and oceanic changes based on IPCC AR4 SRES A1B (IPCC, 2007). The results tentatively projected that anchovy biomass will decrease in the Yellow Sea, but increase in the Japanese side of the Korea Strait in 2030s (Figure 2).

In addition to APN funding, the project has received additional research grants from the government of the Republic of Korea from 2011 to 2013, which ensures the continuity of our activities.

## Project Publications


### PROJECT SUMMARY

To conduct comparative studies across NOWPAP countries (China, Japan, Korea and Russia), we have evaluated regional differences in the responses of marine ecosystems to climate changes in the NOWPAP sea area by a working group composed of natural and socioeconomic scientists.This project was devised to provide scientific basis to decision makers in developing policy strategies that incorporate regional differences in marine ecosystems supporting fish stocks, and vulnerability and adaptation of fisheries industries to climate change.We performed three main activities for the phase I in 2011–2012: 1) Gathering information available in each country and developing national reports; 2) Compiling four national reports into a regional report; 3) Holding two workshops. In particular, we have developed an individual based model for Pacific anchovy (Engraulis japonica) as a first step in developing predictive models to project changes in fisheries-important species in the NOWPAP area based on IPCC carbon emission scenarios.



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## Acknowledgments


We thank Professor Suam Kim (Pukyong National University), Dr. Sangjin Lee (NOWPAP), Dr. Young Cheol Park (Ecocean21), Professor Byung-Gul Lee, Professor Sang Rul Park, Mr. Joon Ho Lee, Mr. Hye Ung Ko, Mr. Jaehwan Kwak, Mr. Seok-Beom Hong (Jeju National University) for their contribution and support

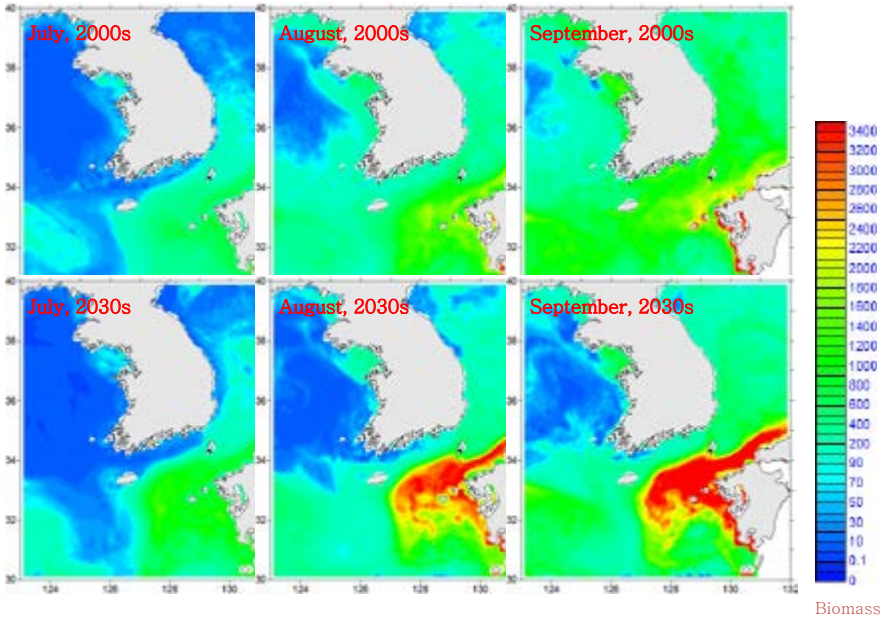


**Figure 2.** Averaged biomass of anchovy larva less than 180-day old in July, August and September for the 2000s vs. 2030s, predicted by our individual-based bio-physical coupling model. The scale of biomass is of relative values

to have the two successful workshops in Jeju National University.

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**ARCP2012-08CMY- JUNG**

### PROJECT TITLE

**Impacts of Global Warming on Coastal and Marine Ecosystems in the Northwest Pacific**

### COUNTRIES INVOLVED

China, Japan, Philippines

### PROJECT DURATION

2 years

### APN FUNDING

US$ 86,000

### PROJECT LEADER

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ARCP2012-09NMY-MEINKE

# Improving the Robustness, Sustainability, Productivity and Eco-Efficiencies of Rice Systems throughout Asia

Holger Meinke and David Parsons

**PROJECT SUMMARY**

The demand for rice is expected to double by 2050, a challenging target in the midst of competing demands for resources, and a changing and variable climate. Required production increases must be achieved sustainably, necessitating a focus on combinations of intervention actions at all levels. This requires systems thinking supported by simulation modelling to integrate disciplinary knowledge and provide proactive evaluation of technologies and policies. A project using modelling to design more efficient rice systems has begun and the inaugural meeting will shortly be held in Sri Lanka. The collaborative project will strengthen a network of researchers from Australia, India, Indonesia, Japan, Pakistan and Sri Lanka and focus on increasing the systems analytical capacities of scientists and organizations. The key outputs from the inaugural meeting will be identification of the key research needs and design of the collaborative research programme.

The project addresses one of the most pressing needs for the region: how to maintain the supply of the most important staple food in the world — rice.

The demand for rice is expected to double by 2050, a challenging target in the midst of competing demands for land and water, and a changing and variable climate. Most of these increases have to come from Asia, a region that currently produces 95% of the world's rice. The required production increases must be achieved sustainably without negatively impacting on people and the environment.

Solutions to raise productivity in rice systems must focus on combinations of intervention actions at all levels. In contrast to the green revolution 40 or so years ago, this time we have no "silver bullets" such as a transition to modern varieties or the introduction of mineral fertilizer. This time the solutions need to be more holistic with an increased emphasis on knowledge generation and dissemination. The next green revolution will be knowledge-based and needs to go beyond production increases. An equal focus on sustainability (for example, resource use) and social issues (for example, land tenure, education and knowledge systems) is now required if the required advances are to be realized.

Recent advances in the understanding of rice systems now make it feasible to research and document in detail the economic, environmental and, to some extent, even the social consequences of the transformational changes that will be necessary to keep up with the rising demand for rice. One such transformational technology is switching from flooded rice systems to aerobic rice. This has huge potentials for water saving and for growing rice in regions previously not suitable for this crop. However, the associated management challenges are daunting.

Scientific communities and policy makers need to be aware of the technological possibilities for better rice systems design, community leaders need to understand the impact these technologies can have at local and regional levels, and key scientists need to be trained in the use of these transformational platforms. Such systems thinking will be the foundation of the next agricultural revolution, which is required to solve the 2050 challenge. For instance, systems analytical approaches based on simulation modelling are ideally suited to integrate disciplinary knowledge and provide proactive evaluation of technologies and policies.

Hence, this project is designed to empower the next

generation of scientists and policy makers in providing the most pertinent advice and making the right decisions when it comes to redesigning current approaches in resource allocation, agronomy and knowledge dissemination.

Under the guidance of a team of experienced systems researchers, this inaugural workshop at the University of Peradeniya will bring together early- and mid-career scientist from Pakistan, India, Indonesia and Sri Lanka. The workshop will involve a field tour of Sri Lankan rice production systems, presentation of past and present rice systems research of each participant, discussion of the issues relating to sustainable and eco-efficient rice production, identification of important regional themes and research needs, and design of discrete activities that will contribute to the overall collaborative research programme. The three-year project will include a mid-project workshop to assess research progress, and a final workshop to focus on results and implications for policy.

## Acknowledgements

We thank the staff of the University of Peradeniya for their efforts and hospitality in hosting the inaugural meeting. We also thank members of a former APN project (APN2003-09) who contributed significantly to the current project, its design and conduct.

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**ARCP2012-09NMY-MEINKE**

### PROJECT TITLE

**Improving the Robustness, Sustainability, Productivity and Eco-Efficiencies of Rice Systems throughout Asia**

### COUNTRIES INVOLVED

Australia, India, Indonesia, Pakistan, USA

### PROJECT DURATION

3 year

### APN FUNDING

US$ 180,000

### PROJECT LEADER

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ARCP2012-10NMY-LI

# Development of an Integrated Climate Change Impact Assessment Tool for Urban Policy Makers (UrbanCLIM)

Yinpeng Li, Peter Urich and Liancong Luo

## Project Objectives

- Develop high resolution climate change projections based on regional climate model (RCM) output from RMIP3.
- Develop an integrated impact assessment system including the major sectors in urban areas through working closely with the urban policy makers and planners, based on the co-evolutionary decision support system FAWSIM and SimCLIM software package applying system dynamics approaches.
- Conduct a training workshop, disseminate results and publish papers (during the latter stages).

## Work Undertaken

A joint project workshop funded by APN and Monsoon Asia Integrated Regional Study (MAIRS) "Development of an integrated climate change impact assessment tool for urban policy makers (UrbanCLIM)," was held in Jinan University, Guangzhou, China, 29–31 October 2012.

This workshop was the first of three in this three-year APN project. More than 30 experts from the following institutions shared their research and application experiences: the International Global Change Institute (IGCI) New Zealand, MAIRS IPO, Institute of Atmospheric Physics (IAP, CAS); Nanjing University; Jinan University; Center for Water Resources Investigation and Planning, MONRE, Viet Nam; USC-Water Resources Center Foundation Inc. Talamban, Cebu City, Philippines; Institute of Geography and Natural Resource (IGNRR, CAS); Centre of Urban Planning Research, Guangzhou Urban Planning & Design Survey Institute, Guangzhou (GZPI), China; State Key Laboratory of Tropical Oceanography, South China Sea Institute of Oceanology (SCSIO, CAS); Guangzhou Institute of Energy Conversion (GIEC, CAS); Southeast Asia START Regional Center, Chulalongkorn University, Thailand; Department of Geography, University of Delhi, India; Department of Atmospheric Sciences, Yonsei University, Republic of Korea.

Presentations covered many themes around climate change risks and adaptation, including urban planning and governance, tools and modelling, Regional Climate Model intercomparison, water resources management, adaptation and mitigation synergy, coastal ocean environment, and freshwater lake environmental modelling. In the third day of the workshop, APN project leader Dr. Yinpeng Li, Dr. Ailikun of MAIRS IPO and key collaborators visited Guangzhou Planning Institute and conducted a seminar with its planners so that they might better understand how UrbanCLIM could assist with planning practice. The action plan for the coming year was discussed and action items were decided.

### *UrbanCLIM Platform Development and Features*

The UrbanCLIM features were described as follow:

- Modular design to build on and link to existing models and related applications;
- Integrated analysis enabling testing of adaptation and mitigation options against socioeconomic

## PROJECT SUMMARY

This project aims to develop a co-evolutionary urban climate change decision support system (UrbanCLIM), to support climate change impact and risk assessment for the major sectors: health, transport and water. A participatory assessment approach will be applied through working with local urban policy makers and planners. The UrbanCLIM platform was built on the system dynamics simulation library, and was designed to support layered applications. The central layer of the system provides the fundamental scientific understanding of climate change and related issues, the graphical user interface (GUI) and the model development environment. UrbanCLIM will allow "in-flight" alteration of models and their data and presentations, the use of a visual coupling tool for data conversion, and dynamic updating of workflows. A series of climate change impact models (flood, storm surge, heat waves and other impact models identified during the project) and cost-benefit analysis tools for adaptation analysis will be developed and incorporated in the UrbanCLIM system. Case studies and capacity building activities will be carried out in China and Viet Nam.

drivers, likely sectoral impacts, and existing goals for sustainable development;
- An open framework, allowing for multi-scale and multi-disciplinary impact assessment, which can be customized case-by-case to suit each city;
- Climate change uncertainty analysis building on GCM and RCM climate change scenarios;
- GIS interoperability;
- Visualization and further analysis options for the assessment of results; and
- Integration of risk and cost-benefit analysis tools.

UrbanCLIM also emphasized on user experiences, including:

- **Step-by-step navigation**. A featured window navigator is provided to support the fundamental understanding of climate change and local climate change context as well as a description of the case studies and demo models in simple language.
- **Model-building and running**. Users can drag "blocks" from the menu for categorized libraries to the canvas, then configure and link the blocks according to the model workflow. The model can be run by clicking the "run" button, and can be paused/stopped during the run.
- **Customizing models**. Users can place their own logos on the canvas, embed documentation in the block, or change the look of the custom function blocks.


- **State-of-the-art visualization tools**. ESRI MapControl and WPF chart control features are embedded, meaning the user can generate high quality visualization of model outputs easily in GENIES.

## Project Publications

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## Acknowledgments

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**ARCP2012-10NMY-LI**

### PROJECT TITLE

**Development of an Integrated Climate Change Impact Assessment Tool for Urban Policy Makers (UrbanCLIM)**

### COUNTRIES INVOLVED

China, New Zealand, Philippines, Viet Nam

### PROJECT DURATION

3 years

### APN FUNDING

US$ 135,000

### PROJECT LEADER

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ARCP2012-11NMY-QUYNH

# Carbon Flux and Emissions from the Red River: Human Activities and Climate Change

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## Introduction

Rivers and streams not only transfer various forms of carbon (dissolved and particular) to oceans, but also evade a significant amount of carbon into the atmosphere, and thus must be considered in strategies to mitigate climate change (Battin et al., 2009; Richey et al., 2002). Carbon fluxes and emission of rivers are impacted by both natural (plate margin tectonics, volcanic deposits, high elevations, steep slopes, high intensive rainfalls, etc.) and anthropogenic factors (high population density, deforestation, reservoir impoundment, intensive agriculture, and urbanization). To obtain a good understanding of the relationship between the natural and human impacts and the global carbon cycle, it has to be examined at a regional scale, where the various climatic and socioeconomical constraints can be taken into account.

In Asian regions, the river water discharge and sediment loads have been altered dramatically over the past decades as a result of reservoir impoundment, land use, population, and climate changes (Walling & Fang, 2003; Lu et al., 2004). Solid sediment loads not only directly contribute organic carbon, but also affect chemical weathering, and biological processes, thereby changing carbon consumption and possible emission.

The Red River (Viet Nam and China) is a good example of a Southeast Asian river system strongly affected by climate and human activities. The present project aims to quantify the spatial and temporal variability of carbon fluxes and emission (outgassing or evasion) from the Red River system and to evaluate their responses to changes in sediment loads and other environmental changes such as land use, intensive agricultural practice, reservoir construction and population. This work will be completed by using the Seneque/Riverstrahler model for relating the carbon transfer at the scale of the whole drainage network to the constraints resulting from human activities and natural conditions in the watershed.

**PROJECT SUMMARY**

The Red River (Viet Nam and China) is a good example of a river system in Southeast Asia that is strongly affected by climate and human activities. The present project aims to calculate the carbon fluxes and carbon emissions from the Red River. This work will be structured around the Seneque/Riverstrahler model for relating carbon transfer at the scale of the whole drainage network and the receiving coastal marine areas to the constraints resulting from human activities and natural conditions in the watershed. The model will be firstly validated to describe the carbon transfer in the whole Red River system for both past and present situations, and then used to explore various scenarios of changes in climate and human activities at the 2050s horizon. The project is planned from August 2012 to August 2015.

## Research Approach

Four main activities will be conducted in the framework of the present project:

**Activity 1:** Complete a database for long-term period, 1960s – present (water and wastewater quality, meteorology, hydrology and human activities) which will be utilized to calculate the carbon fluxes and emissions, and to validate the modelling process under past and present situations.

**Activity 2:** Estimate carbon emissions and flux from the Red River; characterize and identify the variables (geology, rainfall, reservoirs, land use, agriculture, population, etc.) controlling river carbon fluxes and emissions.

**Activity 3:** Apply the Seneque/Riverstrahler model which relates water quality and carbon transfers in the

**Figure 1.** The first international workshop at INPC, VAST in December 2012, Hanoi, Viet Nam

drainage network to the constraints resulting from human activities and natural conditions in the Red River watershed (Billen et al., 2001; Garnier et al., 2002). The model will first be further validated, describing the transfer of both dissolved and particulate carbon for present and past scenarios. Then, it will be used to predict carbon transfer in the drainage network, taking into account the impacts of possible climate and human factors in its watershed in the prospective scenarios (2050s horizon) in four important aspects: (a) climate change; (b) the impoundment of new large dams; (c) population and urbanization increase; and (d) changes in land use and the intensification of agricultural practices.

**Activities 4:** Organize workshops, public forums and training. Three workshops are scheduled: the first workshop has been held in Hanoi, Viet Nam in December 2012; the second workshop will be held in Yunnan in 2013; and the final workshop in Viet Nam in 2015. A project website will be set-up in the last year where the model and selected data on water quality, wastewater quality, meteorology and hydrology will be uploaded for free access, download and use by other academics. Hands-on training on Seneque/Riverstrahler model utilization, carbon emissions calculation and operation of laboratory instruments will be organized.

## Work Undertaken and Some Preliminary Results

In this paper, we present some major activities undertaken at the beginning of the first year (2012).

### *The First International Workshop*

In accordance with the project timeline, the first workshop was held at the Institute of Natural Products Chemistry, Viet Nam Academy of Science and Technology (INPC VAST), in Hanoi, Viet Nam, 17–19 December 2012 (Figure 1). More than 40 multi-disciplinary scientists, including project scientists from four main research teams, invited scientists and observers from different countries such as France, Germany, Singapore, China, Japan and Viet Nam, attended the workshop.

The workshop firstly informed participants about the objectives, main activities and expected outputs of the project. Then, 23 presentations related to the project topics were made by the invited scientists. Finally, the workshop discussed future cooperation and planned activities within the scope of the project, focusing on three main issues:

- Data collection and exchange, water sampling, analysis, and future cooperation with other projects such as the Cau River (a Canada-Vietnamese project), the Dong Cao catchment (a French-Vietnamese project); water quality of North coastal areas in Viet Nam (a national project); and suspended solids and carbon transport of the Large Asian Rivers project.
- Training course for modelling utilization and carbon emission calculation for young scientists from Viet Nam, China and Singapore.
- Website construction: to be connected with other websites, for example, the Piren-Seine for the Seneque/Riverstrahler utilization or new research results from the Piren-Seine programme.

As part of the workshop, a one-day field trip in the Red River system (from Hanoi to Hung Yen province) was organized for people involved in the project. A water sampling campaign was undertaken about 40 km downstream of Hanoi (Figure 2).

In order to strengthen the international scientific exchange and cooperation, some participants of the project participated in the international workshop titled "Sediment Fluxes and Carbon Emission from

**Figure 2.** Field observation and water sampling campaigns

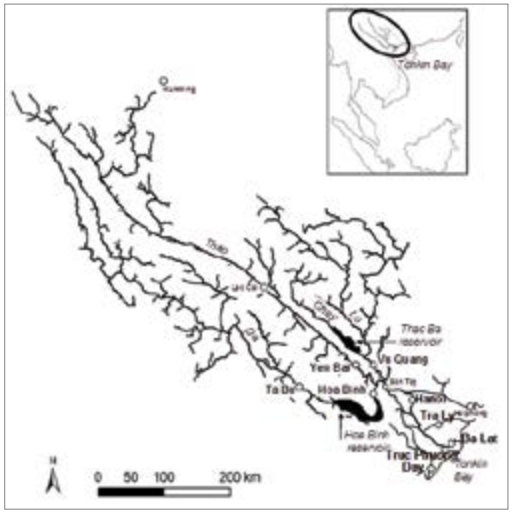


**Figure 3.** The Red River system and water sampling sites

Large Asian Rivers," which was organized by Dr. Lu Xi Xi at the National University of Singapore 20–21 September 2012.

### *Water Sampling and Data Set Collection*

**Water Sampling Campaigns and Laboratory Analysis.** Due to the lack of a complete water quality database for the Red River basin, monthly field campaigns have been organized at nine gauging stations of the Red River system since August 2012 (Figure 3). The physical-chemical variables of the river water quality are given in the Table 1.

About 20 agricultural and industrial wastewater samples in both dry and rainy seasons were taken and analysed for different variables, as presented in Table 1.

**Collection of Available Data Set from Different Sources.** The long-term discrete existent data (since the 1960s) of the Red River, including water quality, land use, population, agricultural and industrial development, hydrological management, and meteorological data are targeted to be investigated (Table 1).

### *Young Scientists Training*

**PhD Students.** Within the framework of the present project, a Vietnamese PhD student, Mrs. Nguyen Thi Mai Huong, is being supported to develop a sandwich thesis under a training cooperation programme between the Pierre and Marie University and the Viet Nam Academy of Science and Technology from January 2013 to December 2015. She is presently being hosted for a three-month period at the Pierre and Marie Curie University for training to use the Seneque/Riverstrahler software.

In Singapore, two PhD students under Dr. Lu's supervision attended the first workshop in Hanoi. The two students specialize in riverine carbon fluxes and outgassing, which are closely related to the APN project.

In Yunnan, the APN collaborator Prof. Zhou recruited a PhD student, who will be dedicated to the APN project.

**Undergraduate University Students.** Within the framework of the project, six undergraduate students have been developing their bachelor thesis at the Centre of Environmental Chemistry, INPC, VAST and Laboratory of Hydro-biology, IET, VAST.

## Future Plan

We plan to hold the second workshop in Kunming, China. The long-term discrete existent data (since the 1960s) of the entire Red River basin in China and Viet Nam terrain has been continuously collected. Data analysis will be used for modelling validation for describing the transfer of both dissolved

| No. | Type of data set | Variables |
|---|---|---|
| 1 | River water quality | pH, temperature, conductivity, DO, DOC, POC, DIC, BOB, COD, N, P, Si, chlorophyll-a, phytoplankton, major ions, coliforms |
| 2 | Wastewater quality and discharge: domestic, industrial and agricultural wastewater release | - pH, temperature, conductivity, DO, SS, DOC, BOB, COD, N, P, Si, coliform.<br>- wastewater discharge with or without treatment |
| 3 | Hydrology | River water level, river water discharge, dams and reservoir characteristics |
| 4 | Meteorology | Daily meteorological data on humidity, temperature, sunshine duration, wind velocity, information concerning climate change scenarios for Viet Nam |
| 5 | Others: land use, population, and human activities | Land-use change, population density, industrial production and wastewater treatment system, agricultural production and practices |

**Table 1.** Collection of data sets for long-term period (1960 – present) of the Red River basin

and particulate carbon for present and past situations in the entire Red River basin.

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**ARCP2012-11NMY-QUYNH**

**PROJECT TITLE**

**Carbon Flux and Emissions from the Red River (Viet Nam and China): Human Activities and Climate Change**

**COUNTRIES INVOLVED**

China, France, Singapore, Viet Nam

**PROJECT DURATION**

3 years

**APN FUNDING**

US$ 120,000

**PROJECT LEADER**


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# Coastal Ecosystems and Changing Economic Activities: Challenges for Sustainability Transition along Chinese and South Asian Coasts

Joyashree Roy, Preeti Kapuria, Satabdi Datta, Indrila Guha, Rajarshi Banerji, Sandhya Rao, Giasuddin Miah, Shang Chen, Jingmei Li, Tao Xia, Janaka Ratnasiri, P.B. Terney Pradeep Kumara and Chinthaka Samarawickrama Lokuhetti

## Introduction

Alteration in coastal ecosystems at any degree, resulting out of either natural forces or human interventions poses threats to the resilience of human and environmental coastal systems (Klein et al., 1998; Turner et al., 1998; Turner & Daily, 2008). In this context the concept of "sustainability transition," which can be characterized as a long term, multi-dimensional and fundamental transformation processes through which systems shift to a more sustainable state (Markard et al., 2012) becomes a relevant yardstick for managing the coastal ecosystem. More than a third of the world's populations live in coastal areas and small islands that comprise 4% of the Earth's total land area (UNEP, 2006). According to the Millennium Ecosystem Assessment Synthesis Report (UNEP, 2005), at the global level, coastal population densities are 2.6 times larger than that of inland areas and the well-being level of coastal communities are on average much higher than their inland counterparts. Coastal zones yield 90% of global fisheries and approximately 38 million people are directly engaged in fisheries and trading of fish products (UNEP, 2006). Tourism, a flourishing sector, provides employment and income-earning opportunities to a substantial number of people residing in these areas.

The specific project objectives are:

- Identification and characterization of the coastal ecosystems.
- Identification and understanding of the traditional and new economic activities and also the actors along the coastline and changing pattern through first hand recall method, and mapping to ecosystem services.
- Preparation of Inventory of ecological functions-based economic activities as well as otherwise and resilience level.
- Generation of historical data on climate parameters in order to predict future scenarios for each specific study site.
- Application of stakeholder behaviour analysis in ecology–economy interaction framework

The project will identify through interaction of scientists, policy makers and other stakeholders the most vulnerable coastal systems based on economic activities in four APN countries, and will identify good and bad practices in selected coastal systems while responding to local and global changes. The project fits into the science agenda as it aims to study changing activities in selected coastal systems, associated communities and their life-style, natural and manmade hazards, risks to ecosystems and human systems and map a database to identify most vulnerable coastal communities. Development of indicators and guidelines will provide information for policy processes on how best to manage these global changes in a coastal ecosystem system to make longer term transition to sustainability.

## Project Plan and Progress

Project planning and execution is progressing by the timeline proposed. The only backlog is that public access to the project website is delayed by a few months due to some technical issues.

## PROJECT SUMMARY

Coastal ecosystems have been altered, induced primarily by anthropogenic interventions. A genuine conflict has occurred between traditional livelihood practices and present day profit augmenting commercial practices. Historically, coastal ecosystems have been altered by humans to harvest provisioning services and cultural and amenity services. Expanding demand for flow of these services is in close contest among these services and across other services: regulatory service and supporting service. This project aims to inventorize economic activities with corresponding ecosystem service flows along with changing resilience level. Resilience will be connected to climate variability. The goal is to assess and create, among multiple actors, the scientific understanding and value of ecosystem services. A decision matrix will be prepared to facilitate the policy-making process for sustainability transition.


### *Concept Note Development*

The project leader developed the concept note based on literature review and work plan in vision and circulated among partners to co-develop and create a shared understanding. The project tries to develop the framework by integrating ecological economics, environmental economics and transition theory literature. Ecosystem services that generate link to economic activities, specific issues relating to coastal ecosystems and sustainability transition are the keywords that need common understanding to carry forward the proposed task. This perfectly set the stage for very lively discussions at the inception workshop where all partners came with their visions and questions, which made the workshop a very productive one.

Any multi-country/multidisciplinary research efforts need to create a shared common understanding and vision about the key words and framework of the study from the very beginning. Given that the proposed research is policy research as well, involvement of policy makers through knowledge sharing has been the primary focus. The participants met a policy-making body in a proposed costal study site location on the first day to have hands-on experience of theoretical framework and get policy makers' perspective and challenges.

The second day was for presentations about the national understanding of the coastal system, through disciplinary lenses and projected climate change within the project perimeter.

On the third day we all worked together in mixed groups to co-design the study scope given the uniform understanding of costal ecosystems through the services lense and sustainability transition lense. In the literature, many global lists of coastal ecosystems exist but are not all applicable for studying country-level coastal characteristics, so, through group work, a list of coastal ecosystems for participating countries was prepared. The group came up with the following list of Asian Coastal Ecosystem Types Identification:

- Asian Ecosystem Types
  - » Estuarine
  - » Deltaic
  - » Mangroves
  - » Intertidal Zones
  - » Sand Dunes
  - » Sand Beaches
  - » Coral Reefs
  - » Spit, Barrier Beaches
  - » Rocky Shoreline
  - » Mud Flat
  - » Muddy Beach
  - » Lagoon
  - » Arid-Terrestrial
  - » Seagrass Bed

The inception workshop was for participation and discussion on: ecosystem services in ecological economics framework; firming up research questions; hypothesis and methodology for analysis; and developing a work timeline with

**Figure 1.** Inception workshop

deliverables. Participants felt that we collaboratively achieved the workshop goals and that the workshop helped in getting closer to a shared understanding of key concepts. Involvement of policy makers and the LOICZ Chairman made them interested in the proposed research output. We have received a request from the Ministry of Environment and Forest, Government of India to share with them the research results.

## Acknowledgments

We thank Dr. Ramesh Ramachandran, Director, National Centre for Sustainable Coastal Management, India, and Purvaja Ramachandran, Scientist, Institute for Ocean Management, Anna University, India, for attending the workshop and for making very positive contributions through presentation on ongoing efforts at the ministry level and comments on possible synergies. We also acknowledge with thanks Dr. Somnath Bhattacharyya, responsible for implementation of ICZM in the State, and Mr. Soumen Pal, the officer at Digha Shankarpur Development Authority for their valuable time to guide the researchers in site selection.

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**ARCP2012-12NMY- ROY**

**PROJECT TITLE**

**Coastal Ecosystems and Changing Economic Activities: Challenges for Sustainability Transition along Chinese and South Asian Coasts**

**COUNTRIES INVOLVED**

Bangladesh, China, India, Sri Lanka

**PROJECT DURATION**

2 years

**APN FUNDING**

US$ 86,000

**PROJECT LEADER**

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ARCP2012-13NMY-DECOSTA

# A study on Loss of Land Surface and Changes to Water Resources Resulting from Sea-Level Rise and Climate Change

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**PROJECT SUMMARY**

The main purpose of the research is to analyse sea-level rise due to climate change using global circulation model and then use it in conjunction with digital elevation maps and GIS information to predict loss of land surface. Also we intend to use the Hydrological River Basin Environment Assessment Model (Hydro-BEAM) and Processing Modflow (PMWIN) to predict salinity intrusion and resulting changes to surface and ground water bodies. At present we are in the process of analysing sea-level rise and loss of land surface. Work on analysing groundwater changes has just begun.

## Objectives

Sea-level variation in the Asia-Pacific region due to global/climate change will be analysed using a global circulation model (GCM) and then, in conjunction with digital elevation maps and GIS information, loss of land surface in coastal zones will be predicted. The forecasted sea levels will also be used in conjunction with Hydro-BEAM model and PMWIN models to predict salinity intrusion and resulting changes to surface and ground water bodies.

This research envisages establishing linkages between changes in climate, changes to catchment characteristics and changes in surface and ground water bodies in selected areas of the Asia-Pacific region. Management strategies will be developed to cope with and mitigate undesirable change, while promoting desired change. The project mainly relates to theme 3 of APN Science agenda as it deals with changes in marine domains, it also directly relates to theme 1 on climate change and variability and theme 2 on ecosystems, biodiversity and land use.

Scientists and engineers from institutions in five countries are collaborating under this project. Further workshops will provide scientific input to policy- and decision-making and strengthen ties between scientists, policy makers and the wider professional stakeholder base at both regional and global levels. Policy-making must consider scientific manifestations of the environment, the people, interactions between the people and the environment and future impacts.

Most collaborators have created links with relevant policy makers and organizations in the study locations and investigating their requirements in the study area. As work progresses, workshops in each study location will involve participation of policy makers for project output dissemination. As the aim of the study is to develop a management model so that policy and decision makers are better equipped to make decisions, the relevance to policy makers are high as well. We expect that this participatory approach from the outset, and through

workshops at each study location with policy maker participation.

## Work Undertaken

- Literature review and data collection is well under way.
- Establishing links/inputs with policy makers has commenced.
- Analysis work on sea-level rise and loss of land surface is underway. Work on analysing groundwater changes has just begun.
- Met with Indian and Sri Lankan collaborators.

The project is running according to schedule.

The collaborators acknowledge APN for the financial support as well as the organizations affiliated with the collaborators for the in-kind support and assistance.

**ARCP2012-13NMY-DECOSTA**

**PROJECT TITLE**

**A Study on Loss of Land Surface and Changes to Water Resources Resulting from Sea-Level Rise and Climate Change**

**COUNTRIES INVOLVED**

India, Indonesia, Japan, New Zealand, Sri Lanka

**PROJECT DURATION**

2 years

**APN FUNDING**

US$ 79,000

**PROJECT LEADER**

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ARCP2012-14NMY-CARTER

# Water and Coral Reef Quality in the East Gulf of Thailand

R. W. (Bill) Carter, Kath Kelly, Neil Tindale, Harriot Beazley, Suchai Worachananant and Pasinee Worachananant

**PROJECT SUMMARY**

Knowledge of the status of coral reefs in the east Gulf of Thailand is incomplete, along with trends in fishery take and the status and influence of water quality on reef productivity. Available evidence suggests declining quality of reefs, unsustainable fisheries and increased anthropogenic impacts on water quality, which cascades through trophic levels resulting in reef degradation. This paper reports the rationale for amassing both scientific and community data and understandings as input to integrated marine resource management. The research process seeks to engage policy makers and communities in clarifying reef status and threats, and provide impetus to discussions of transnational management of coral reefs and the threats across Thailand, Cambodia and Viet Nam.

## Coral Reef Status and Threats in the East Gulf of Thailand

The coastal waters of the eastern Gulf of Thailand (Trat Province, Thailand to Kien Giang Province, Viet Nam[1]) include over 200 islands, ranging in size from small rocky outcrops to Phu Quoc island, Viet Nam (57,400 ha)[2]. Fishing communities/families inhabit many of the larger islands, and some include low-key tourist facilities as well as luxury accommodation. Almost all of the islands are surrounded by fringing coral reefs with occasional off-shore patch reefs. The health of the coral reefs is reported to be generally poor, with low species diversity with the average live coral cover for the whole coastline being 23% to 58% (Rizvi & Singer, 2011). Most corals are of the robust massive or encrusting life forms. *Porites*, *Diploastrea* and *Heliopora* species dominate, and the lack of more sensitive life forms possibly indicates the effects of sedimentation. Tabulate and branching life forms, important for many juvenile fish species, are rarely observed (van-Bochove et al., 2012). Thus, many reef areas are dominated by dead coral and under continued degrading pressures, although quality reefs do exist, largely away from the coast and around the smaller islands. However, the status of these reefs has not been assessed.

### *Threats*

The major threats to the reefs are from direct attrition of the biota from destructive and overfishing as well as diving (Worachananant et al., 2008), and the less direct, but more impacting effects of coastal development, pollution and sedimentation (van-Bochove et al., 2011). Coral reefs in the Gulf of Thailand are adapted to wet-season high turbidity levels; however, the additional sediment and pollutant loads from rivers, resulting from poor upstream land management, increased light attenuation, which constitutes a major limitation for reef growth. In addition, nutrients in untreated sewage in marine outfalls from domestic and tourism development adds to the pressure on corals into the dry season, when tourist visitation is highest (Reopanichkul et al., 2010; Reopanichkul et al., 2009).

### *Protected Areas*

Few marine national parks have been established to protect coral reefs, although a number of proposals exist (van-Bochove et al., 2012). In most cases, a multiple use

1 Trat Province, Thailand has around 184 km of coastline, Cambodia, 435 km, and Kien Giang Province, Viet Nam, 200 km.

2 Ko Chang (42,900 ha.) is the third largest island in Thailand, while the off-shore island of Koh Rong (7,800 ha.) is the second largest to the in-shore island of Koh Kong in Cambodia.

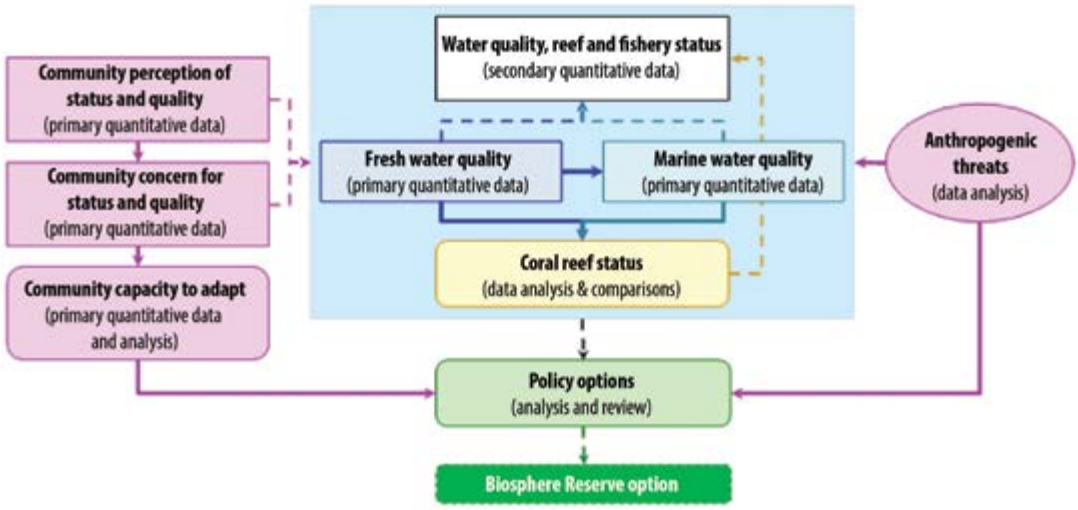


**Figure 1.** Research elements and their contribution to policy options

zoning approach has been proposed. The marine national parks that do exist in the three countries have all been assessed as having medium management effectiveness (UNEP, 2008). The dynamics of marine systems do not reflect national boundaries; neither does anthropogenic activity that impacts the reefs. The East Gulf of Thailand is an integrated system that requires a holistic and adaptive management approach that extends beyond national boundaries.

### *Best Knowledge and Towards a Co-Management Model*

In the absence of complete scientific knowledge, multiple lines of evidence, including community experiential knowledge, are needed to inform management decisions. This knowledge, which can be longitudinal, may be the best available for application to adaptive management of marine areas. The process of acquisition also represents an opportunity to engage stakeholders and foster greater community stewardship for marine resource management (Carter & Ross, 2012).

### *Project Objectives*

This project seeks to:

- build on the existing scientific understanding of coral reef status in the east Gulf of Thailand;
- complement these data with local community knowledge;
- clarify the influence of anthropogenic causes of marine pollution and fishing practices;
- encourage community reflection on their role in contributing to (declining) water and reef quality; and
- define a more integrative approach to the management of marine resources that crosses national boundaries (Figure 1).

## Work Undertaken

Literature review and collection of fishery data have commenced, along with preparation of research protocols for the first round of data collection in February–March 2013.

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## ARCP2012-14NMY-CARTER

### PROJECT TITLE

**Coral Reef and Water Quality Status and Community Understanding of Threats in the East Gulf of Thailand**

### COUNTRIES INVOLVED

Australia, Cambodia, Thailand, Viet Nam

### PROJECT DURATION

2 years

### APN FUNDING

US$ 60,000

### PROJECT LEADER

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ARCP2012-15NMY-YOO

# Toward a Fire and Haze Early Warning System for Southeast Asia

Jaepil Cho, Jin Ho Yoo, Saji Hameed and Robert Field

## Project Objectives

The project aims to (1) assess forecast skill and downscale seasonal forecasts over fire-prone regions in Southeast Asia; (2) develop new fire management decision triggers based on seasonal forecasts; (3) create a prototype fire danger early warning system for Southeast Asia; (4) formulate guidelines on integrating advanced climate information into standard operating procedures of fire management agencies; and (5) train stakeholders on understanding seasonal forecasts, downscaling, and the early warning system prototype.

## Work Undertaken and Results to Date

The project kick-off meeting was held on 15 August in Singapore. Collaborators from the APEC Climate Center, the University of Aizu, Columbia University, the Malaysian Meteorological Department, the Indonesian National Institute of Aeronautics and Space, the Indonesian Ministry of Forestry, and the Indonesian Agency for Meteorology, Climatology and Geophysics were in attendance (Figure 1). During the meeting, topics for discussion included strategic planning, downscaling strategies and skill assessment, and an overview of current fire danger rating systems in Malaysia, Indonesia, and Republic of Korea.

Following the meeting, forecast skill assessment and downscaling research began. Two different seasonal forecast products provided monthly by APCC were considered in the skill assessment: the six-month CCSM3 forecast and the three-month Multi Model Ensemble (MME) forecast. Hindcast simulations by CCSM3 (1983–2010) and MME (1983–2003) were compared to NCEP reanalysis data and CAMS_OPI for temperature and precipitation, respectively, in order to assess the skill of the models over the maritime continent. The three-month forecast during the summer season (June, July, and August) was chosen for analysis because the dry season in the project area generally ranges from April to September, with the driest season occurring from July to August. A common domain (12°S–30.5°N, 80°E–130°E) was selected for both the dynamic and statistical downscaling approaches and Temporal Correlation Coefficients (TCC) were calculated for surface temperature and precipitation, which are known to be critical variables for Southeast Asia's forest fire index (Figure 2).

The results from the MME over-performed CCSM3 for both

**PROJECT SUMMARY**

Smoke haze from forest fires is among Southeast Asia's most serious environmental problems and there is a clear need for a fire and haze early warning system (EWS) for the region. Research has led to a concrete understanding of the human and climatic causes of these forest fires. However, measures to prevent these fires and mitigate their impacts remains limited by the absence of long-lead EWSs. The project builds upon current fire danger rating systems by providing forecasts at a longer lead time, a time-scale that is more relevant and useable for decision makers. This two-year project consists of three parts: 1) a forecast skill assessment of current and downscaled products supplied by the APEC Climate Center (APCC); 2) the development of a prototype fire danger EWS; and 3) training to mainstream forecasts into standard fire management operating procedures. In 2012, project activity began with a kick-off meeting of all collaborators. An assessment of forecast skill over fire-prone regions in Southeast Asia was performed and both dynamic and statistical downscaling studies were initiated. Further downscaling experiments and fieldwork and interviews with resource managers will be conducted in 2013, culminating with the development of the prototype EWS and training workshop.

temperature and precipitation variables. However, CCSM3 provides two types of data sets, based on 6-hourly and monthly time intervals, while MME provides only a monthly data set. As a result, only CCSM3 forecasts can be used in further dynamic downscaling processes. In addition, the predictability of the models was higher for temperature in comparison to precipitation. However, MME precipitation data in the region between 5°S–5°N and 115°E–130°E had a TCC above 0.5.

Seasonal climate predictability over the tropics is essentially higher than that of mid-latitude regions and the MME has the highest advantage over the tropical western Pacific region. However, due to the coarse resolution of the global models participating in the MME, issues such as land-sea interaction over the maritime continent, complex topography, and changing land cover need to be resolved to produce finer resolution forecasts for the region of interest. Accordingly, this project will conduct both statistical and dynamical downscaling of forecasts over fire-prone regions in Southeast Asia. Downscaling studies are currently underway at APCC and results will be published in the next report.

**Figure 1.** Group picture of the collaborators at the kick-off meeting

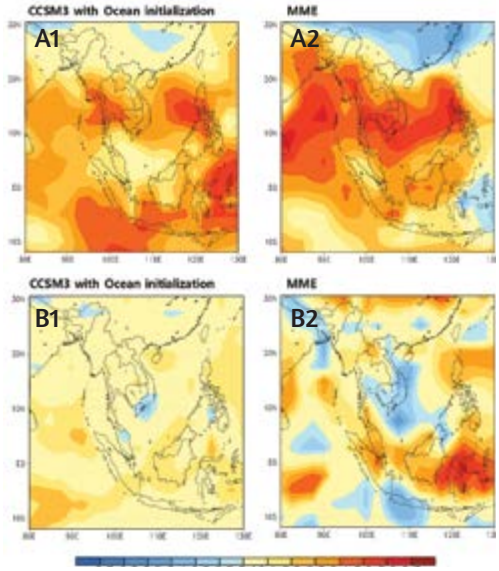


**Figure 2.** (A) temporal correlation coefficients (TCC) for temperature at 2 m anomalies with the observed counterpart (NCEP reanalysis II); (B) TCC for precipitation with the observed counterpart (CAMS_OPI)

agencies responsible for fire prevention and management.

## Project Publications

Scientific manuscripts for journal publication will be prepared during year 2 of the project, once more results have been obtained. Policy briefs and operational guidelines will also be prepared for distribution among Southeast Asian government

## Acknowledgements

The APEC Climate Center would like to express its deepest thanks to the Asia-Pacific Network for Global Change Research for its support of this project under the ARCP Programme.

**ARCP2012-15NMY-YOO**

**PROJECT TITLE**

**Towards a Fire and Haze Early Warning System for Southeast Asia**

**COUNTRIES INVOLVED**

Indonesia, Japan, Republic of Korea , Malaysia, Singapore, USA

**PROJECT DURATION**

2 years

**APN FUNDING**

US$ 73,000

**PROJECT LEADER**

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ARCP2012-16NMY-OCHIAI

# GEOSS/Asian Water Cycle Initiative/Water Cycle Integrator (GEOSS/AWCI/WCI)

Osamu Ochiai, Akiko Goda, Petra Koudelova and Toshio Koike

**PROJECT SUMMARY**

Water is key to linking the climate processes in the atmosphere, oceans, cryosphere, terrestrial carbon cycle, ecosystems and sea-level rise to socioeconomic areas, including agriculture and forestry, health, energy, human settlement and infrastructure, as well as the economy. Based on a well-coordinated regional cooperative effort, the GEOSS Asian Water Cycle Initiative (AWCI), supported by APN, aims, under the present project, to converge and integrate data collected from Earth observation satellites, fields, model cases at major Asian river basins, and undertake research on impact assessment and adaptation measures for climate change using these data.

This project puts the river management system for Asian rivers to the test and builds capacity by involving research institutes and government-affiliated organizations working on river management from 18 Asian countries: Bangladesh, Bhutan, Cambodia, India, Indonesia, Japan, Korea, Lao PDR, Malaysia, Mongolia, Myanmar, Nepal, Pakistan, Philippines, Sri Lanka, Thailand, Uzbekistan and Viet Nam. By conducting research on impact assessment and adaptation measures for climate change, it contributes to advancing the APN Science Agenda and the policy process.

The major objective of this project is to support the development of a Water Cycle Integrator (GEOSS/AWCI/WCI) by setting up "workbenches" where partners can share data, information and applications in an interoperable way, exchange knowledge and experiences, deepen mutual understanding and work together effectively. A workbench is a virtual space where experts and managers work together to use information to address a problem. To build resilience to climate change and variability, it is important to develop effective interdisciplinary collaborations for working together based on coordinated and integrated efforts, which will subsequently lead to both mitigation and adaptation benefits.

In order to establish a well-designed workbench, this project provides a platform for researchers, data experts and representatives of government organizations from Asian developing countries to meet, discuss, and exchange ideas and arrive at agreements on necessary steps to achieve the required features. It is planned that such communication will be realized through a series of meetings of GEOSS/AWCI International Coordination Group (ICG) and workshops for developing GEOSS/AWCI/WCI, which will be complemented by teleconferences.

It is expected that there will be a large increase in the volume and diversity of earth observations from inhomogeneous data sources during the next decade. In addition, natural science data and information are being translated into socioeconomic impacts which are easily understood by non-experts, thereby increasing public awareness of environmental problems. By using the core system of the Data Integration Analysis System (DIAS), we will apply the supporting functions of life cycle data management, data search, information exploration, scientific analysis, and partial data downloading. Furthermore, we will use the ontology system for identifying the relationship between data and the cross-sectoral search engine for various databases of the DIAS. Through a series of planned meeting events,

the AWCI country representatives will learn about new capabilities of the DIAS system and its advantages and will be encouraged to cooperate by providing their data and processing them using the new DIAS functions as much as possible. Usually, dedicated training sessions on the DIAS use have been, and are planned to be, performed during the meetings. Similarly, the possibility of exploitation of the established workbenches will be demonstrated at the meetings. This will be followed by specific guidance between the DIAS (represented by the University of Tokyo team lead by Prof. Toshio Koike) and the user (a national team of an AWCI country working on a specific project). AWCI demonstration projects were also conducted in this way during the first phase.

### *Project Workshop on the Occasion of the 6th GEOSS Asia-Pacific Symposium (25–27 February 2013) and AWCI ICG Meeting (October 2013)*

**Accomplishment 1:** Complete workbench prototyping and continue demonstration workbench performances at the selected basins;

**Expected accomplishment 2:** Complete data collection, quality check, metadata development;

**Expected accomplishment 3:** Continue river basin model development in AWCI demonstration basins.

### *Project Workshop (February 2014) and Final Reporting to APN*

**Expected accomplishment 1:** Complete demonstration workbench performances;

**Expected accomplishment 2:** Complete river basin model development in AWCI demonstration basins, publications, presentations and demonstration to the policy makers in participating countries;

**Expected accomplishment 3:** Preparation for shifting to more operational phase.

The project leaders and all collaborators sincerely thank the Asia-Pacific Network for Global Change Research for the financial and other forms of support, without which the initiation and implementation of the proposed work would not have been possible.

## ARCP2012-16NMY-OCHIAI

**PROJECT TITLE**

**GEOSS/Asian Water Cycle Initiative/ Water Cycle Integrator (GEOSS/AWCI/ WCI)**

**COUNTRIES INVOLVED**

Bangladesh, Bhutan, Cambodia, India, Indonesia, Japan, Korea, Lao PDR, Malaysia, Mongolia, Myanmar, Nepal, Pakistan, Philippines, Sri Lanka, Thailand, Uzbekistan, Viet Nam

**PROJECT DURATION**

2 years

**APN FUNDING**

US$ 90,000

**PROJECT LEADER**

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ARCP2012-17NMY-BURNETT

# Nutrient Sources to Tonle Sap Lake, Cambodia

William C. Burnett, Gullaya Wattayakorn, Veasna Kum and Khamfeuane Sioudom

## Introduction

Floods are the primary drivers in determining the structure and function of tropical, lowland river-floodplain ecosystems, as encapsulated by the "flood pulse concept" presented originally by Junk et al. (1989). This concept highlights the importance of lateral connections in the functioning of river-floodplain systems. Regularity is central to the importance of the flood pulse in tropical systems, allowing biota to evolve adaptations that enable exploitation of newly accessible habitat and the "pulse" in nutrient availability and primary productivity associated with floodplain inundation. The pulse is thus seen to stimulate a chain-reaction of increased productivity, which is transferred up the food chain. Junk et al. (1999) observed that periodic floodplain inundation increases the availability of nutrients and rates of organic matter recycling, increasing the potential for primary and hence secondary production. The floodplain is thus able to support an increased biomass and diversity of biota, which have adapted to exploit this periodically available habitat and resource, producing a characteristic community structure.

Tonle Sap, the largest freshwater lake in Southeast Asia (Figure 1), is a classic flood-pulse system and hosts one of the most productive inland fisheries in the world, accounting for more than 75% of Cambodia's inland fish catch and about 60% of the country's protein needs (Lamberts, 2006). Because there have been relatively few scientific studies, details are lacking concerning the mechanisms that supply nutrients to maintain the high biological productivity that is characteristic of the lake. In addition, accelerating development of dams and diversion projects in the Lower Mekong Basin now pose unknown threats to the lake's ecosystem. Our primary objective is to examine the cycle of the key limiting nutrient, phosphorus (P), and its relationship to the unusual surface hydrology of this lake. Particular attention is being paid to the possible influence of groundwater as a nutrient source in this system.

Tonle Sap Lake has a very unusual hydrologic cycle. During the dry season (~October to May) water from the lake flows south through a tributary (Tonle Sap River) and discharges to the Mekong River near Phnom Penh. This flow is significant, representing about 50% of the discharge to the Mekong Delta, Viet Nam. By the end of the dry season, the lake reaches its lowest level, with an average depth of less than 1 m (Table 1). When the monsoon rains begin (~May to June), Mekong River flow increases dramatically, forcing a reversal of

**PROJECT SUMMARY**

We are investigating the relationships between Mekong River hydrology, dissolved and particulate phosphorus (P) cycle, and aquatic productivity in the contiguous Mekong Region countries Thailand, Lao PDR, and Cambodia. Emphasis is on the Tonle Sap Lake, the largest and most productive lake in Southeast Asia. As the limiting nutrient, P controls the primary production and ultimately determines productivity. Geochemical measurements and modelling will be used to determine P sources to the lake and its relationship to the hydrologic stage of the river and lake. We are particularly interested in evaluating the role of groundwater to the P cycle. Our approach consists of combining continuous measurements of radon, a groundwater tracer, with our nutrient measurements. The overarching objectives are to assess and model nutrient and productivity impacts in response to climate change, dam construction or other development activities in the Mekong River basin that will affect river flow.

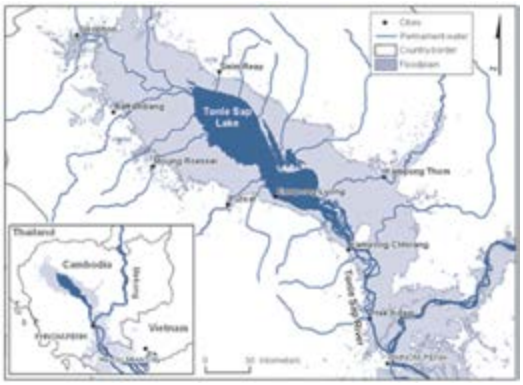


**Figure 1.** Map of Tonle Sap Lake, the dark colour represents the permanent lake; lighter colour shows the extent of the floodplain

flow direction in the connecting tributary, resulting in addition of huge volumes of water back into the lake. The result is a ~6-fold increase in lake surface area, a water depth approaching 10 m, and a net change in volume from ~1.6 $km^3$ (dry season) to 60–80 $km^3$ (wet season) depending on the intensity of the flood each year (Sarkkula et al., 2003).

The sources and mechanisms of nutrient supply to the Tonle Sap lake, and how fluctuations in the supply and bioavailability of nutrients are related to the hydrologic cycle, and to groundwater inputs in particular, are not well understood. Identification of the mechanisms and processes that control P supply and bioavailability in this system will provide valuable insights that can be extrapolated to other flood-pulse systems worldwide.

## Methodology

We are running sampling trips both on the Mekong and Tonle Sap rivers to characterize the amount and the form (particulate, dissolved, etc.) of P being delivered to the lake. We have already completed two sampling trips on the Mekong River in Thailand along the border with Lao PDR, between Vientiane and Mukdahan, and in the stretch of the river in southern Lao PDR between Pakse and the border with Cambodia. Both filtered and unfiltered water samples were collected for laboratory analysis of phosphorus speciation (Figure 2). In addition to collecting water samples, we also deployed a customized sediment trap developed at Chulalongkorn University at selected stations to collect suspended sediment samples for analysis.

Our first survey in Tonle Sap Lake is planned for late January 2013, a period when the lake level is dropping. The second survey of the lake this year will be in June or July 2013, when the lake level is rising. A final lake survey will be performed during the second year of our project at a different point in the hydrologic cycle. During the upcoming lake surveys, expected to be over 100 km long each, we will make continuous measurements of radon, conductivity, temperature, GPS coordinates, and water depth. We will also look for the natural very short-lived thoron isotope ($^{220}Rn$; $T_{1/2}$ = 56s), which has recently been shown to be a particularly sensitive groundwater tracer for "prospecting," as one must be close to a source to detect this very short-lived radionuclide (Burnett et al., 2007; Dimova et al., 2009; Chanyotha et al., 2011). Discrete water samples will be collected at regular intervals (approximately every 5–10 km) for chl-a, major nutrients and P speciation studies. Depth profiles for certain parameters (temperature, conductivity, $O_2$, pH, $^{222}Rn$ and nutrients) will be taken at selected stations.

| Parameter | Low Water Level (Apr) | Flood Stage (Oct/Nov) |
|---|---|---|
| **Area ($km^2$)** | 2,240 | 13,220 |
| **Length (km)** | 120 | 250 |
| **Width (km)** | 35 | 100 |
| **Volume ($m^3$)** | 1.6 x 109 | 59.6 x 109 |
| **Depth (m)** | 0.5 | 7 |

**Table 1.** Average characteristics of Tonle Sap Lake at low water level and flood stage (Kummu et al., 2008)

Standard colorimetric methods will be used to determine concentrations of dissolved nutrients and chl-a (for example, Koroleff, 1983; Monaghan & Ruttenberg, 1999). Continuous radon measurements will be made using an automated system that continuously measures and logs radon, conductivity, temperature, GPS coordinates and water depth (Burnett et al., 2001; Dulaiova et al., 2005). Groundwater discharge into the lake will be calculated based on the measured radon inventories and groundwater concentrations from nearby wells using a mass balance method (Cable et al., 1996). The phosphorus cycle will be examined using a systems dynamic model based

**Figure 2.** Students from Chulalongkorn University and the National University of Laos filtering samples collected in the Mekong River immediately after collection

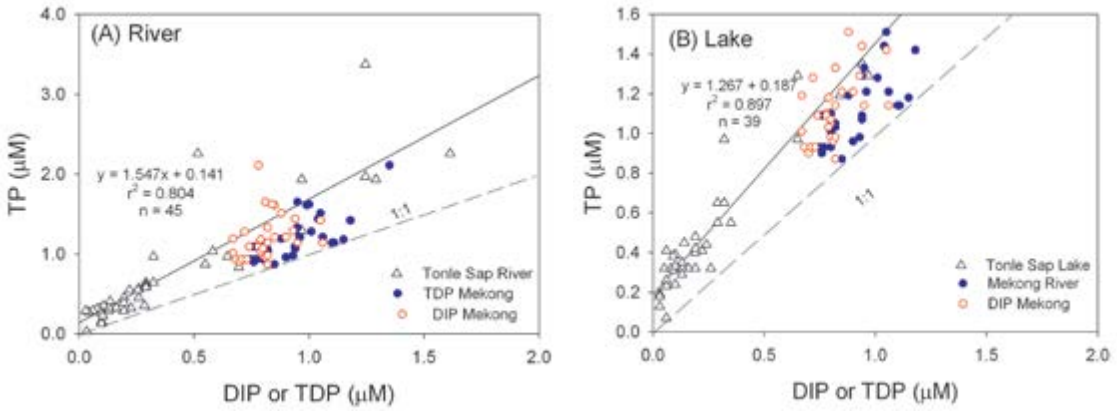


**Figure 3.** (A) Black triangles: historical data for total phosphorus (TP) versus dissolved inorganic phosphorus (DIP) for a station (KCH1) in the Tonle Sap River near Phnom Penh. Circles: our data for TP versus DIP (red) and total dissolved phosphorus (TDP, blue) from the Mekong River in Lao PDR. (B) Black triangles: TP versus DIP at a station (KGL1) in the south central part of Tonle Sap Lake. Red and blue circles same as in "A." All historical data were taken from Sarkkula et al., 2003. Regression lines are drawn through the historical data. Note different y-axis scales in (A) and (B)

on a preliminary version already constructed as part of this project (Kum & Burnett, 2013).

## Preliminary Results

As of this writing, we have not performed the Tonle Sap Lake surveys as yet but have completed two sampling trips on the Mekong River in Thailand and Lao PDR. We present some of our preliminary phosphorus findings by comparing our results to those reported by Sarkkula et al. (2003) who collected monthly data from stations on the Tonle Sap River and Lake during 2000–2002. We observed that when plotting their total phosphorus (TP) to dissolved inorganic phosphorus (DIP) data that river samples had a substantially higher TP:DIP ratio than lake waters sampled during the same period (Figure 3). The TP is on average 55% higher than DIP at the river station while only ~27% higher at the lake station. Presumably, this higher TP is a reflection of particulate P loading, and the lower ratio in the lake implies either that P is released from the river suspended particulate matter once it enters the lake, or that differential particle settling causes this effect. DIP is the most biologically available form of phosphorus so is generally considered the most important form. The extent to which imported particulate-P becomes bioavailable is currently unknown as is the amount of phosphorus delivered to the lake via river or groundwater pathways.

When our results from the Mekong River are included in the same plots, we see that all the TP and total dissolved P (TDP; blue circles in Figure 3) fall between the 1:1 line (samples on this line would contain no particulate P) and the regression lines based on the earlier results from Tonle Sap River and Tonle Sap Lake. However, the DIP results (red circles) from the Mekong River have generally higher concentrations of both TP and DIP and a ratio that is more similar to what was observed in the Tonle Sap River (Figure 3A). When our DIP results from the Mekong River are compared to those from Tonle Sap Lake (Figure 3B), the TP:DIP ratios are very similar and the Mekong River concentrations of both TP and DIP are at the high end of what was reported for the lake. The somewhat lower TP:DIP ratio in the Mekong River compared to the Tonle Sap River may imply that there is less particulate P in the Mekong River than in the Tonle Sap River. If this is the case, than there may be local sources of particulate-P in the Tonle Sap River. Sampling in the Cambodian portion of the Mekong River will help to determine the extent that particulates are an important source of P to the Tonle Sap system. Concentrations of dissolved P in our Mekong River samples are higher than most of the historical values from the Tonle Sap River as well as the lake. We will soon have our own results from the Tonle Sap Lake to compare to those from the early work of Sarkkula et al. (2003) as well as the historical data collected by the Mekong River Commission.

## Acknowledgments

We are thankful to the graduate students (Ratsirin "Prae" Supcharoen and Pongit "Tarn" Jaiboon from Chulalongkorn University; and Dalasack Saiyasouk from the National University of Laos) that assisted us in the field and completed the laboratory phosphorus measurements. In addition, we thank Ms. Butsawan Bidorn, Dr. Anurak Sriariyawat and other personnel from the Faculty of Engineering at Chulalongkorn University for allowing us to use their sediment trap for collection of suspended

particulate matter in the Mekong River.

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**ARCP2012-17NMY-BURNETT**

### PROJECT TITLE

**Assessing the Impact of Climate Change and Development Pressures on Nutrient Inputs into the Mekong River and Tonle Sap**

### COUNTRIES INVOLVED

Cambodia, Lao PDR, Thailand, USA

### PROJECT DURATION

2 years

### APN FUNDING

US$ 74,000

### PROJECT LEADER


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ARCP2012-18NMY-SASE

# Dynamics of Sulphur Derived from Atmospheric Deposition and its Possible Impacts on East Asian Forests

Hiroyuki Sase, Tsuyoshi Ohizumi, Naoyuki Yamashita, Thiti Visaratana, Bopit Kietvuttinon, Hathairatana Garivait and Nik Muhamad Majid

**PROJECT SUMMARY**

The effect of sulphur deposition on terrestrial ecosystems is one of the important issues to be investigated in East Asia. Scientists from the community of Acid Deposition Monitoring Network in East Asia (EANET) will investigate the dynamics of sulphur derived from atmospheric deposition in forest catchments in Niigata, Japan, Nakhon Ratchasima, Thailand, and Sabah and Sarawak, Malaysia. In order to determine sulphur dynamics in the forest ecosystems, analysis of sulphur isotopic ratio is applied for rainwater, soil water and stream water in addition to measurement of the fluxes. The data obtained in the project will explain the possible impacts of sulphur deposition on the forests. Since nitrogen deposition is also quite high in the region, its relation to acidification/eutrophication could also be discussed.

## Project Objectives

Since sulphur deposited on ecosystems may be retained in soil and/or cycled in the soil-plant system, manifestation of its effects may be delayed (for example, Mitchell & Likens, 2011; Kobayashi et al., 2012). Moreover, several rivers/lakes for monitoring inland aquatic environments in East Asia have shown declining pH trends with increasing $SO_4^{2-}$ (EANET, 2011). Sulphur deposition effects on terrestrial ecosystems is an important issue for East Asia that requires investigation. In this project, sulphur dynamics in forest ecosystems will be investigated with the following objectives:

- To determine sulphur dynamics in ecosystems in East Asian forests.
- To evaluate the combined effects of sulphur and nitrogen on acidification and eutrophication in East Asian forests.

The project is being undertaken with scientists from Thailand, Malaysia and Japan under the regional framework of EANET (Acid Deposition Monitoring Network in East Asia). The main project focus is on atmospheric deposition and its effects on forest ecosystems.

## Outline of the Project

The study sites were established in four forest catchments in Japan, Thailand and Malaysia, as shown in Table 1. Field surveys and data analysis are being conducted in the selected forests to address the following issues:

1. Flux determination of sulphur and nitrogen;
2. Analysis of sulphur isotope ratio of rainwater and stream water;
3. Speciation of sulphur compounds in soil layer; and
4. Trial application of biogeochemical simulation model.

The data obtained from the topics 1–3 above will be utilized for a trial application of a biogeochemical simulation model. The outcomes from the project will be informative for evaluating possible impacts of sulphur deposition on the forests. Since nitrogen deposition is also quite high in the region, its relationship to acidification/eutrophication will also be determined.

| Site | Kjikawa | Sakaerat | Danum Valley | Bintulu |
|---|---|---|---|---|
| **Country** | Japan | Thailand | Malaysia | Malaysia |
| **Forest type** | Japanese cedar | Dry evergreen forest (DEF) | Tropical rainforest | Rehabilitated forest |

**Table 1.** Study forest catchments in Japan, Thailand and Malaysia

## Progress of the Project

Ion flux studies, including $SO_4^{2-}$, were undertaken in previous projects up until 2011 and are being reactivated under the present project for 2012 and beyond.

Resin sampling techniques were employed for sulphur isotopic analysis. A resin column, in which an ion-exchange resin was packed, was installed with a plastic funnel to collect rainfall outside the forest canopy and throughfall below the canopy. The ion-exchange resin in the column traps $SO_4^{2-}$ in rainwater. This technique was also applied to collect soil water and stream water.

The project leader also attended a meeting with representatives of the EANET relevant agencies in Malaysia, including Malaysian Meteorological Department (MMD), Ministry of Natural Resources and Environment (NRE), Department of Environment (DOE), Department of Chemistry (DOC), Universiti Teknologi Mara (UiTM) and Universiti Putra Malaysia (UPM) and introduced the outcomes of the new APN project. It was agreed that a workshop would be held in Kuala Lumpur possibly in June or July 2013 to share outcomes/progress of the project with relevant agencies.

## Acknowledgments

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**ARCP2012-18NMY-SASE**

**PROJECT TITLE**

**Dynamics of Sulphur Derived from Atmospheric Deposition and its Possible Impacts on the East Asian Forests**

**COUNTRIES INVOLVED**

Malaysia, Thailand, Japan

**PROJECT DURATION**

2 years

**APN FUNDING**

US$ 88,000

**PROJECT LEADER**

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ARCP2012-19NSY-KAMAL

# Assessing Climate Change Impacts on Salt Marsh and Seagrass Ecosystems in South and Southeast Asian Coasts

The impacts of climate change have been demonstrated by various scientific evidences worldwide. It is speculated to be harsher on the marginal communities who inhabit some of the biologically rich but ecologically fragile coastal areas and who are dependent on their resources for their livelihoods. Mangrove, salt marsh and seagrass ecosystems are among the most productive ecosystems in the world, including South Asia and Southeast Asian countries. However, these resources and their ecosystems are the least studied coastal habitats in these regions. They are the source of livelihoods of a third of the region's population since these ecosystems provide shelter, food and habitat for economically important fisheries, and control coastal erosion that helps to increase marine productivity via reducing coastal suspended pollutants. More recent research findings suggest that they are an effective line of defence against the impacts of climate change. But due to their shallow (<10 m) existence in the inter-tidal and sub-tidal zone, these two ecosystems are being affected by rising sea level, and increasing temperature and $CO_2$ levels.

The present project investigates how these climate change variables and their impacts, will affect the sustainability of the goods and services of coastal communities derived from salt marsh and seagrass ecosystems. This project will focus on: (1) collecting and examining the available data and information on climate change variables and patterns in the selected locations; (2) gathering the potential evidence on changes in salt marsh and seagrass ecosystems and their adjacent habitats including the livelihoods of the coastal communities who depend on these renewable coastal resources in the proposed areas; (3) collecting previous information related to climate change and ecosystem services of these resources in terms of life, living and livelihoods; (4) proposing an synthesis report of current salt marsh and seagrass ecosystems in countenance of climate change and sea-level rise; and (5) proposing mitigation and adaptation strategies in the face of climate change and sea-level rise.

The project activities will be achieved by connecting scientists from participating countries of Malaysia, Bangladesh, India, Philippines, Thailand and Viet Nam, who will conduct research on these themes. Experts from USA, Japan and Republic of Korea will also participate in the scientific activities of this project. The results of the project will be useful as a base for a more issue-based, action oriented, conservation and management research programmes, guidelines and policies. Since salt marsh and seagrass diversity are intricately linked to resilience of ecosystems, adaptation strategies linked to their conservation would safeguard livelihoods of communities depending on them. An outcome of the project would help to reduce the gap between science and policy to initiate the protection and sustainable utilization of coastal resources in the region.

ARCP2012-19NSY-KAMAL

**PROJECT TITLE**

**Assessing Climate Change Impacts on Salt Marsh and Seagrass Ecosystems in the South and Southeast Asian Coasts**

**COUNTRIES INVOLVED**

Bangladesh, India, Japan, Korea, Malaysia, Philippines, Thailand, Viet Nam, USA

**PROJECT DURATION**

15 months

**APN FUNDING**

US$ 45,000

**PROJECT LEADER**

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ARCP2012-20NSY-MUSAFER

# Sustainable Biochar Systems in Developing Countries

Namiz Musafer and P. K. G. T. Shashinkamali

This project explores whether biochar can be integrated to selected regional settings as an effective long-term climate mitigation and adaptation tool in terms of sustainable resource/waste management, carbon storage and agricultural improvement under different climatic, environmental, socioeconomic conditions, and policy drivers. Some of the key objectives are to assess availability and suitability of feedstock and select suitable technology, as well as to assess agronomic benefits of biochar for a range of crops, soil types and growing conditions, making economic and environmental evaluation of the biochar system.

As this research looks for low-cost sources of feedstock for biochar production without displacing existing markets or land uses, it falls under one of the APN's research priority areas, i.e. resources utilization and pathways for sustainable development. The work will cover the broader aim of APN by helping to make rural communities more climate resilient with improved fuel or energy security and agricultural productivity as well as helping them to be key players in climate change mitigation by putting carbon back into the soils in a stable form.

The first step of the project was to assess biomass availability and suitability to produce biochar in Sri Lanka, and second was to explore available and appropriate technology for biochar production. Availability of feedstock and technology was assessed during the literature survey of the project. To assess suitability of available feedstock and select appropriate technology, two groups of scientific advisory panels at the national (National Scientific Advisory Panel, NSAP) and international (International Scientific Advisory Panel, ISAP) levels were established. The NSAP and ISAP consist of specialists in crops, soil, technology, environment and social impacts. After the first NSAP meeting, agricultural residues, non-hazardous industrial waste, energy crops and invasive species (sugar cane, rice husk, saw dust, juliflora, king coconut shell and maize stalks) were selected as the most suitable. Since one of the objectives of the project is to involve rural communities on biochar production, technology should be selected targeting small-scale convenient operation. Considering biochar production efficiency and sustainability, slow pyrolysis was selected as the appropriate technology. A physical model of about 0.2 $m^3$ (barrel size) has been developed for biochar production with the assistance of National

## PROJECT SUMMARY

Biochar is a carbon rich solid produced by heating biomass in an oxygen depleted environment for use as a soil amendment (Lehman and Joseph, 2009). Chemical and physical alternation takes place in biomass during the conversion process into biochar. Biochar carbon can remain in soil for long periods of time providing agricultural benefits and mitigating climate change. This project will carry out original (qualitative and quantitative) research in biochar deployment opportunities in rural Sri Lanka in parallel with Nepal and Thailand. The main five steps of the project are; 1) Assess biomass availability and suitability; 2) Assess availability of low cost appropriate technologies to produce biochar; 3) Biochar production and applications; 4) Field testing; and 5) Full assessment of biochar value chain by life cycle analysis. Suitability assessment based on chemical composition of biomass and competition for biomass as an energy source will be conducted in each of the countries. Biochar can be produced by using conventional methods or modern methods. But emission of gases and soot must be controlled by conventional methods to ensure sustainability of production. Considering efficiency, easy operation either by pyrolysis or gasification can be used as suitable production technology.

Engineering Research and Development Centre.

With the aid of NERC-developed model, biochar will be produced using selected feedstock. Parallel to these, initial characteristics of soils on selected areas will be analysed. After producing biochar, field trials will be undertaken at selected areas on selected crops. Field and laboratory work will include pH testing, nutrient uptake of each crop, electrical conductivity test, total nitrogen, phosphorus, potassium and organic testing, carbon exchange capacity, crop yield and physical and chemical characteristics analyses of biochar. Testing and analysis will be accomplished over 2 seasons in the same location. Finally, environmental and socioeconomic aspects will be assessed.

NSAP will continue to work until the end of the project through fieldwork and lab analyses and providing knowledge at irresolute points. From time to time ISAP members will voluntarily advise on important issues related to biochar work in Sri Lanka. The first meeting of NSAP was held on 17 December 2012 and terms of reference for each panel member devised. As agreed at this meeting a project profile was released on 31 December 2012.

## Project Outputs

- Project profile has been released.
- NSAP terms of reference have been drawn and finalized.
- Two reports: "Availability and Suitability of Feedstock for Biochar Production in Sri Lanka" and "Suitable and Appropriate Technology for Biochar Production in Sri Lanka," have been drafted.

## Acknowledgments

We are thankful for additional funding from other sources to carry out the project. We appreciate the timely assistance provided by members of NSAP and ISAP that contributed to fruitful research results.

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**ARCP2012-20NSY-MUSAFER**

**PROJECT TITLE**

**Sustainable Biochar Systems in Developing Countries**

**COUNTRIES INVOLVED**

Nepal, Sri Lanka, Thailand, UK

**PROJECT DURATION**

2 years

**APN FUNDING**

US$ 45,000

**PROJECT LEADER**

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ARCP2012-21NSY-SISWANTO

# Spatial and Temporal Variations of Phytoplankton Biological Production in the East and South China Seas

Eko Siswanto, Joji Ishizaka, Katsuhisa Tanaka, Anukul Buranapratheprat and Tong Phuoc Hoang Son

**PROJECT SUMMARY**

Preliminary results on spatial and temporal variations of satellite-derived phytoplankton biomass (Chl-a) in the East and South China Seas are reported. For the East China Sea (SCS), preliminary study was carried out to investigate seasonal patterns of phytoplankton primary production (PP) derived by applying previously published Chl-a algorithm and PP model. The seasonal pattern of PP estimated by satellite observations resembled that of measured PP reported, implying that the Chl-a algorithm and PP model used are applicable for elucidating spatially long-term PP in the ECS. For the SCS, besides seasonal variation, inter-annual variation of satellite-derived Chl-a was also investigated. Seasonal variation was remarkable, but there was no obvious long-term trend of Chl-a in the SCS. Inter-annual variation analysis indicated that natural climatic anomaly of ENSO influenced Chl-a variation in the SCS. In the future, the pixel basis analysis will be conducted to understand biogeochemical spatial responses to climatic anomalies not only ENSO, but also the Indian Ocean Dipole (IOD) phenomenon.

## Introduction

The East China Sea (ECS) and South China Sea (SCS) are the two marginal seas (hereafter ESCS) in the western Pacific that suffer most from human activities as they are geographically surrounded by the world's most populated developing countries. The ECS largely consists of vast shelf area (bottom depth < 200 m) surrounded by Japan, Korea, China and Taiwan, whereas the SCS largely consists of deep sea (bottom depth > 200 m) surrounded by China, Viet Nam, Philippines, Taiwan and Malaysia (Figure 1). The SCS also covers the shelf area in the southwest part, which is connected to the Gulf of Thailand. Human activities in the coastal land of the countries mentioned inevitably change the ocean environment of the ESCS. In addition, climatic changes such as El Niño/Southern Oscillation (ENSO) and Pacific Decadal Oscillation (PDO) are also known to directly or indirectly modify the ocean environment, including ocean phytoplankton biomass (Chl-a) and primary production (PP) which are key variables responsible for ocean biogeochemical processes in the ESCS (for example, Zhao & Tang, 2007; Siswanto et al., 2008).

However, a complete record of long-term variations of Chl-a and PP that may be associated with changes in ocean physics, chemistry, and atmospheric forcing related to climatic perturbation has not been well documented. It is therefore important to understand spatially long-term variation of biological productions including Chl-a and PP in the marginal seas of the ESCS in connection to human activities and global climatic changes.

The only feasible way to deal with the long-term variation over the large spatial scale of the ocean surface is by utilizing satellite remote sensing techniques due to its synoptic observation capability. As a preliminary result, this article addresses the spatial and temporal variations of Chl-a in the SCS and PP in the ECS using ocean colour data archived within 13-year full mission of Sea-viewing Wide Field-of-view Sensor (SeaWiFS) and previously published algorithm/model.

## Methodology

The SeaWiFS Chl-a data archived within the 13-year SeaWiFS full mission (September 1997 – December 2010) were used to study Chl-a variation in the SCS. They were acquired from the NASA Ocean Biology Processing Group (OBPG, http://oceancolor.gsfc.nasa.gov). The Chl-a data used are SeaWiFS Level 3 processed based on the SeaWiFS re-processing 2009 with spatial resolution

of 9 km$^2$. The Chl-a was derived using the NASA OC4v4 standard Chl-a algorithm (O'Reilly, 1998). Because Chl-a data has global coverage, a sub-setting to the study SCS and ECS regions was conducted using the SeaWiFS Data Analysis System (SeaDAS) version 6.2 (http://seadas.gsfc.nasa.gov).

The ECS study was more focused on the seasonal variation of PP. Rather than standard SeaWiFS Chl-a, we applied the ECS Chl-a algorithm developed by Siswanto et al. (2011) to produce new Chl-a product. To assess PP in the ECS, we applied previously published PP model (Gong & Liu, 2003) with the satellite data inputs of new Chl-a product, SeaWiFS-derived light attenuation coefficient (Kd), and Advanced Very High Resolution Radiometer (AVHRR)-derived SST.

Both SeaWiFS and AVHRR images have missing data due to cloud coverage, which hampered further spatial and temporal variation analysis. Therefore, before conducting spatial and temporal variation analysis on the satellite data, pixel base interpolation with monthly time series as an independent variable was conducted by applying the cubic spline interpolation method to fill the no-data pixels.

## Preliminary Results and Discussion

### *Seasonal Variation of Phytoplankton Primary Production in the East China Sea*

Seasonal variations of SeaWiFS Chl-a (new product), SeWiFS Kd, and AVHRR SST were remarkably observed as shown in Figure 2. In the coastal region near the Changjiang river mouth, Chl-a was low during winter (January), increased gradually to spring (April), and peaked in summer (July) (Figures 2a–2d). Such as seasonal Chl-a variation in the ECS is a well-known phenomenon of strong phytoplankton growth dependency on SST (see Gong et al., 2003; Siswanto et al., 2006). As observed by AVHRR, SST was lowest and highest during winter and summer, respectively (Figures 2i–2l). During summer, Kd was the lowest (Figures 2e–2h), which was attributed to the low non-living suspended matter due to summer calm sea surface winds.

The PP estimated by employing PP model and satellite data mentioned above is shown in Figure 3. PP was low during winter (Figure 3a), and reached its highest during summer (Figure 3c). Such a seasonal variation of PP seemed to be caused by a combination of the

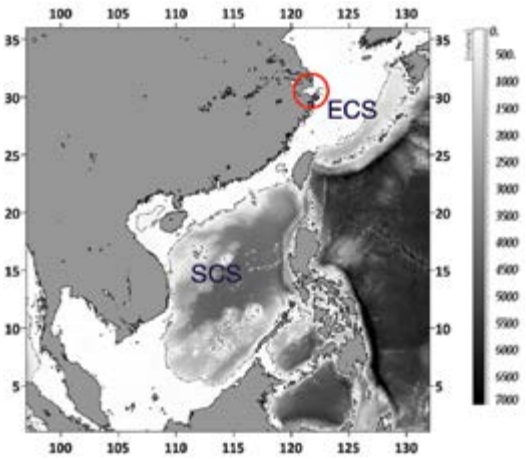


**Figure 1.** Bathymetry map showing two marginal seas, the ECS and SCS. The black contour denotes the 200 m isobath. Red circle indicates Changjiang river mouth

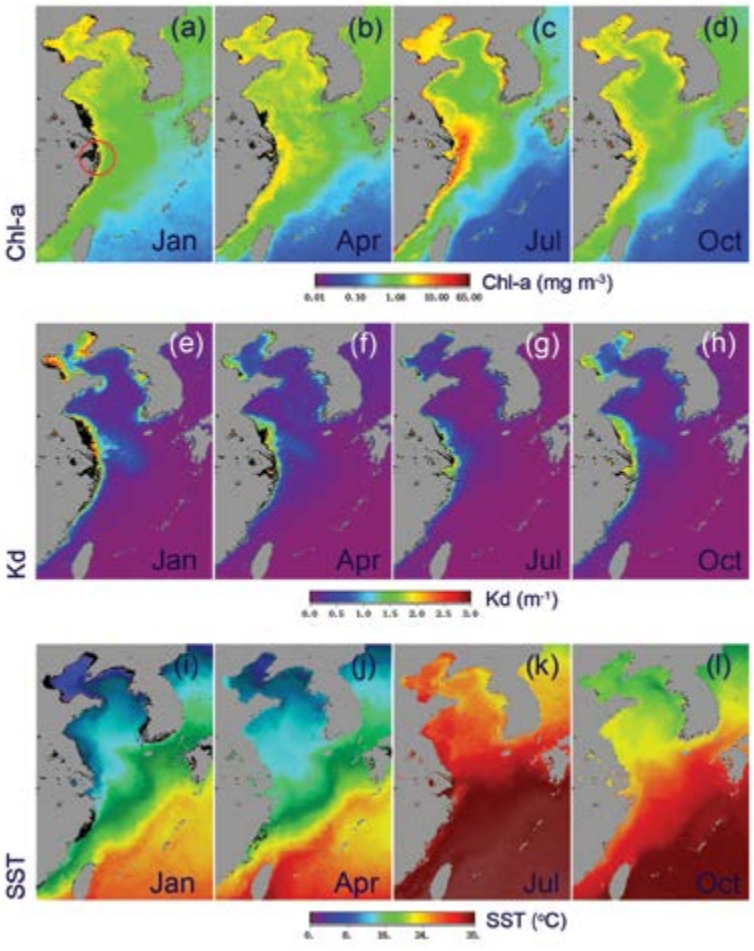


**Figure 2 (right).** Thirteen-year mean of seasonal variations of SeaWiFS-derived Chl-a (a–d), Kd (e–h), and AVHRR-derived SST (i–l) in the ECS. Red circle in (a) indicates Changjiang river mouth

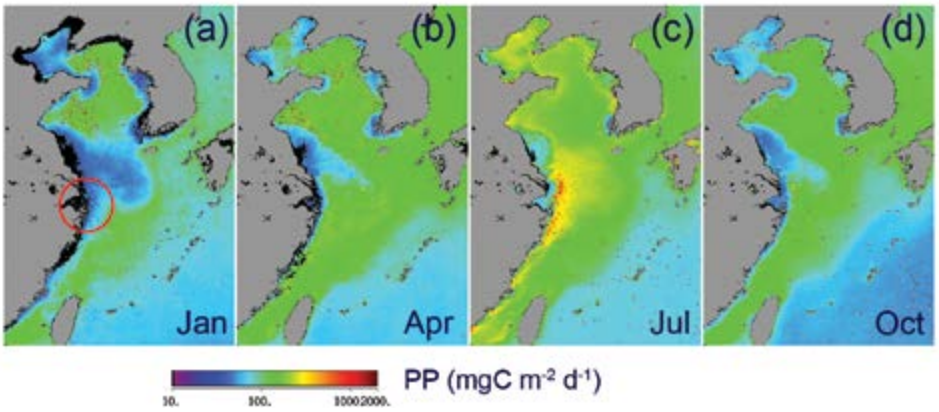


**Figure 3.** Thirteen-year mean of seasonal variation of satellite-estimated PP in the ECS. Red circle in (a) indicates Changjiang river mouth

influences of multi-factors of Chl-a, SST, and Kd. Low PP during winter seemed to be attributed to low SST and high Kd. The high Kd implied that less sunlight would be intercepted by phytoplankton, hence resulting in a low photosynthetic process or low PP. During summer, high SST, high Chl-a, and low Kd seemed to be optimum environmental conditions for the intense growth of phytoplankton, and hence PP in the ECS.

The seasonal variation of satellite-based PP resembled to that measured PP as previously reported by Gong et al. (2003, see their Figure 9). This implied that the Chl-a algorithm by Siswanto et al. (2011) and PP model by Gong and Liu (2003) seemed to be reliable combination tools to assess PP in the ECS, hence they will allow further research in the future to elucidate spatially long-term PP in the ECS.

### *Spatial and Temporal Variations of Phytoplankton Chlorophyll-a in the South China Sea*

Unlike in the ECS, Chl-a in the SCS both in the coastal and off-shore regions were relatively higher during winter (Figure 4l) than during other seasons. Chl-a was in the low level during the period from April to June (Figures 4d–4g). During summer (July–September), Chl-a enhancement was observed along the coast of Viet Nam and extended to middle/off-shore region of the SCS (Figures 4g–4i). This coastal Chl-a enhancement was associated with summer coastal upwelling driven by prevailing along shore southerly wind (Zhao & Tang, 2007). In winter on the other hand, another Chl-a enhancement was observed northwest of Luzon Island, Philippines. This Chl-a enhancement started to develop from November and lasted till March (Figures 4a, 4b, 4c, 4k, and 4l). During this period, winds over the SCS blew from north to south to induce winter upwelling.

Upwelling occurred along the coast of Viet Nam during summer and northwest of Luzon Island during winter brought nutrient-rich deep water to the surface layer. Nutrients in the surface layer were then replenished, which in turn would be available for phytoplankton growth resulting in high phytoplankton Chl-a.

As an initial attempt to understand the impact of global climate change on the Chl-a variation in the SCS, we plotted the long-term archived SeaWiFS Chl-a averaged over the entire region of SCS superimposed on Nino 3.4 SST anomaly commonly used as an index to represent El Niño/Southern Oscillation (ENSO) event. It was observed that Chl-a in the SCS tended to decrease during El Niño years, but increase during La Niña years (Figure 5). The impact of ENSO on Chl-a variation in the SCS was already known from previous studies (for example, Zhao & Tang, 2007). However, which part of the SCS was more vulnerable to El Niño and La Niña, which environmental factors co-varied with ENSO and probably determine inter-annual variation of Chl-a associated with climate change, are less documented. Therefore in the future, pixel base analysis on the relationship between Chl-a and climatic variations (not only ENSO, but also Indian Ocean Dipole

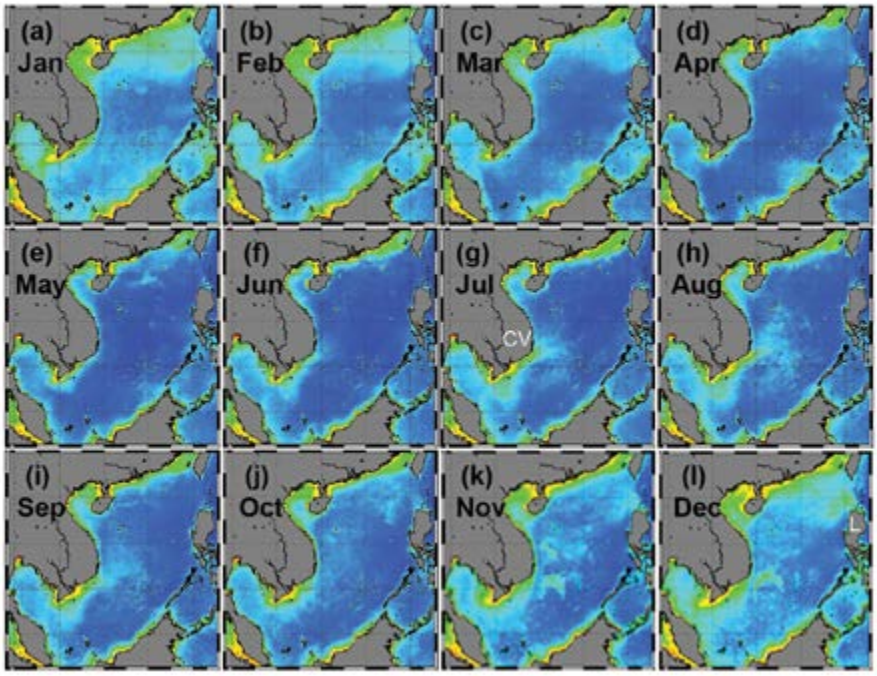


**Figure 4.** Thirteen-year mean of seasonal variation of SeaWiFS-derived Chl-a in the SCS. CV in (g) indicates coast of Viet Nam, whereas L in (l) indicates Luzon Island

(IOD)), Chl-a and other satellite-derived environmental variables (for example, winds, SST, rain rate, aerosol) will be investigated.

## Conclusions

The preliminary results on the study of spatial and temporal variations of biological production in the ECS and SCS can be pointed out as follows: 1) employing satellite data and previously published algorithm/model, seasonal variation of PP in the ECS could be reconstructed; implying that 2) the PP estimation approach as discussed above can be applied in the future to elucidate spatially long-term PP variation in the ECS in response to global climate changes; 3) besides remarkable seasonal variation, phytoplankton Chl-a in the SCS also showed distinct inter-annual variation associated with ENSO, i.e., tendency of low Chl-a durig El Niño, but high Chl-a during La Niña years; 4) pixel base response of Chl-a to climate changes (not only ENSO, but also IOD) will be investigated in the future research programme.

## Project Publications

The project results were presented in a poster session during the 2nd Conference for Regional Cooperation in Ocean and Earth Science Research in the South China Sea held from 22–26 October 2012 in University of Malaya, Kuala Lumpur. In the future, we also plan to present the full research results under APN support in the Japan Oceanographic Society (JOS) fall meeting 2013 (September 2013), and GODAE Ocean View Symposium (November 2013).

## Acknowledgments

This preliminary analysis is supported by APN under ARCP2012-21NSY-Siswanto, and partly by Universiti Teknologi Malaysia (UTM) Research Grant (RUG) with Vote No. 03H21. We wish to thank the Ocean Biology Processing Group (Code 614.2) at the GSFC, Greenbelt, Maryland, USA, for the production and distribution of the ocean colour data. We also acknowledge the Remote Sensing Systems and Physical Oceanography-Distributed Active Archive Center (PO.DAAC), Jet Propulsion Laboratory for processing and distributing sea surface temperature and microwave sensor-retrieved satellite data, respectively.

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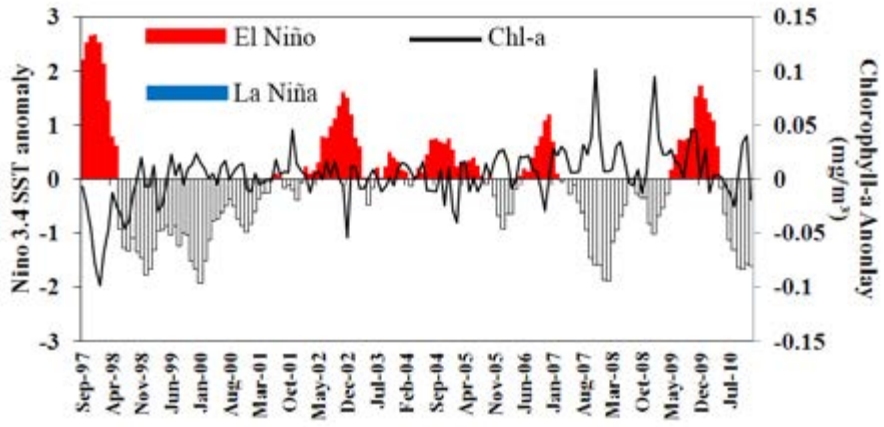


**Figure 5.** Long-term plot of SeaWiFS Chl-a anomaly over the entire region of the SCS, superimposed over the Nino 3.4 SST anomaly. The time series period was 13-year SeaWiFS full mission from September 1997 to December 2010

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## ARCP2012-21NSY-SISWANTO

### PROJECT TITLE

**Spatial and Temporal Variations of Biological Production in the Asia-Pacific Marginal Seas**

### COUNTRIES INVOLVED

Japan, Korea, Malaysia, Thailand, Viet Nam

### PROJECT DURATION

1 year

### APN FUNDING

US$ 43,000

### PROJECT LEADER

Dr. Eko SISWANTO

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ARCP2012-22NSG-PRAYITNO

# Scoping Workshop to Develop Proposal: Vulnerability Assessment on the Impact of Climate Change on Mangroves Biodiversity in Southeast Asia

Joko Prayitno, Kristine Garcia, Kok Foo Kwan, Titin Handayani and Ety Parwati

## Introduction

Southeast Asia (SEA) harbours 35% of the world's total mangroves on earth (Giri et al., 2011). Mangroves are unique ecosystems found in estuaries, sheltered bays and coastlines within tidal areas. Mangrove ecosystems are host to various kinds of marine organisms such as fishes, crabs, zooplanktons and phytoplanktons. SEA's mangroves are the most species-diverse in the world with 52 species endemic to SEA's mangrove habitat including 42 trees and shrubs (Giesen et al., 2007). Other important functions of mangroves include protecting coastal areas from abrasion, storm surge and tsunamis (McLeod & Salm, 2006). Because of their significant role, conservation of mangroves is vital to socioeconomic development including sustainable fish production.

Located in archipelago countries, mangroves in SEA are vulnerable to sea-level rise and ocean warming resulted from climate change. Sea-level rise and ocean warming affect mangrove biodiversity and fishery sectors (Gilman et al., 2008), although the scale of this has yet to be determined. Increase in sea level will lead to inundation of mangroves and reduce available areas for recruitment of associated fauna that have fisheries value (Boquiren et al., 2010). Increase of sea surface temperature will affect most of the fisheries target species through disruption in timing of reproduction and decrease in reproductive output, leading to changes in fisheries productivity (Boquiren et al., 2010). As a consequence, climate change may also have impacts on socioeconomic of local people living close to mangrove ecosystems.

**PROJECT SUMMARY**

A scoping workshop on vulnerability assessment of mangrove biodiversity in Southeast Asia to climate change has been conducted in Denpasar Bali, Indonesia from 24–27 September 2012. The workshop was intended to gather information among collaborators from Indonesia, Philippines and Malaysia on data collection and methodologies for proposal development to be submitted to APN in 2013. Outline of proposed activities includes assessment of mangrove ecosystem sensitivity and adaptability to climate change in Southeast Asia by studying the past and current biodiversity status in selected sites in Indonesia and Philippines, and gathering of data on climate change factors such as sea-level rise, temperature, precipitation and $CO_2$ concentration and their scenarios for 40 years based on regional climate models. Furthermore, impacts of climate change on the sustainability of fish production in selected mangrove ecosystems will be investigated through historical data collection. Finally, socio-economic dependency on the sustainability of fish production in mangrove ecosystems will also be analysed. Results of the study will help decision makers in formulating climate change adaptation strategies for maintaining mangrove ecosystem biodiversity and sustainability of fish production.

## Objectives

Studies on the impacts of climate change on mangrove ecosystems have been conducted in SEA region (PEACE, 2007; Boquiren et al., 2010), however its impact on the sustainability of fish production is not known. The aim of this scoping

workshop was to gather information on what has been studied and to formulate the best methodologies to further study the vulnerability of mangrove biodiversity and fish production in surrounding areas to climate change in SEA. Results of this scoping workshop will help the research team to develop a proposal to assess the vulnerability of mangrove biodiversity to climate change in the region in terms of habitat sensitivity, biodiversity and sustainability of fish production.

The scoping workshop is relevant to the APN science agenda on supporting regional cooperation by involving three Southeast Asia countries — Indonesia, Philippines and Malaysia, to conduct research on the vulnerability of mangrove biodiversity to climate change in the region and adaptation strategies for its sustainability. It will contribute significantly to the APN scientific agenda on climate change and biodiversity, and for making policy recommendations in the Southeast Asia context.

## Results

As part of the seed grant activities, two meetings among Indonesian participants were held in Jakarta in August and September 2012 to discuss the topic to be included in the proposal and the preparation of a scoping workshop to develop the proposal. The first meeting, held in the Agency for the Assessment and Application of Technology (BPPT), Jakarta on 23 August 2012 was attended by 4 participants to discuss data availability and research methodology on fish production at particular mangrove sites in Indonesia. The second meeting at the National Institute of Aeronautics and Space (LAPAN), Jakarta on 7 September 2012 was attended by 7 participants to discuss methodology on GIS, remote sensing and field data collection on species diversity and distribution.

The scoping workshop was held from 24–27 September 2012 in Denpasar, Bali. The workshop was attended by 13 participants including collaborators from the Philippines and Malaysia and APN's Scientific Planning Group (SPG) members for Indonesia and Malaysia (Figure 1). In the workshop, each collaborator presented on a relevant topic for the proposed future activities related to climate change, mangrove biodiversity and fish production. Dr. Erna S. Adiningsih, the SPG member for Indonesia, presented on APN and proposal development. After the presentations, intensive discussions among participants were undertaken to improve the weight of the proposal. As part of the workshop activities, we undertook a half-day site visit to a mangrove forest located in Denpasar, Bali (Figure 2).

**Figure 1.** The scooping workshop in Denpasar, Bali, Indonesia, 24–27 September 2012

Major outputs of the workshop include a draft summary proposal, outlined activities of the proposal and selection of proposed project sites in Indonesia and the Philippines. The final summary proposal was completed in October 2012 and a draft of the full proposal is being developed for further discussion during the final meeting in Bali by Indonesia collaborators in February 2013. The outline of the proposed activities includes kick-off meeting, scenario development, assessment of mangrove ecosystem sensitivity and adaptability to climate change, vulnerability

**Figure 2.** Participants of the scooping workshop in Denpasar, Bali, Indonesia, 24–27 September 2012

**Figure 3.** Site visit to mangrove forest in Denpasar, Bali

assessment of mangrove-ecosystem dependent communities/sectors and final workshop for sharing results and policy recommendations.

The current habitat and biodiversity status of important mangrove ecosystems in selected sites in Indonesia and Philippines will be assessed through primary and secondary data gathering. Data on climate factors such as sea-level rise, extreme weather, temperature, precipitation and $CO_2$ concentration and their scenarios for 40 years based on several regional climate models will be used for the impact assessment. We will consider the components and measures of exposure, sensitivity, and adaptive capacity of mangrove ecosystems to impacts of climate change and then assess their vulnerability. The impacts of climate change on the sustainability of fish production in selected mangrove ecosystems will be investigated and analysed through historical data collection and will include the degree that it is exposed to socioeconomic demand.

It is anticipated that the results of the study will help decision makers in formulating climate change adaptation strategies for maintaining mangrove ecosystem biodiversity and sustainability of fish production.

## Acknowledgment

We would like to thank Dr. Erna S. Adiningsih and Dr. Subramaniam Moten for their advice and guidance as well as their valuable contributions during the workshop. We would also like to show our appreciation to Mr. Murdoko of Mangrove Forest Management Center, Ministry of Forestry, Jl. By Pass Ngurah Rai, Denpasar, Bali, Indonesia for facilitating the mangrove forest site visit and discussion room.

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**ARCP2012-22NSG-PRAYITNO**

**PROJECT TITLE**

**Scoping Workshop to Develop Proposal: Vulnerability Assessment on the Impact of Climate Change on Mangroves Biodiversity in Southeast Asia**

**COUNTRIES INVOLVED**

Indonesia, Malaysia, Philippines

**PROJECT DURATION**

1 year

**APN FUNDING**

US$ 15,000

**PROJECT LEADER**

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ARCP2012-23NSG-CRAWFORD

# Scoping Workshop: Human Responses to Catastrophic Monsoon Events in South Asia: Designing a Spatially Explicit Model in Low-Lying Coastal Areas

Thomas Crawford, Ahmed Salahuddin, Scott Curtis, Ahsan Ahmed, Thomas Allen, Donald Bradley, Giashuddin Miah, Ashok Mishra, Anuradha Mukherji and Kehellela Premalal

A team of international researchers from Bangladesh, India, Sri Lanka and the USA conducted scoping work to help develop a research initiative aiming to investigate human responses to coastal hazards in low-lying coastal areas. Team members hold expertise in a range of disciplines including meteorology, hydrology, agriculture, climate science, geography, sociology, economic development and geospatial technologies. The overarching goal was to share knowledge among assembled experts, and to listen to and learn from the various topical and regional expertise about the best strategies to develop a larger-scale research project.

## Project Objectives

- Plan and execute a one-day expert workshop attended by the research team and 20 local scientists.
- Establish relationships with local science agencies and universities.
- A field trip to conduct scoping interviews with village leaders and residents.

## Progress and Results

The expert workshop was held at the Hotel Eastern Residence in Dhaka, Bangladesh on 18 September 2012. Following presentations, breakout sessions were held and recorded during which groups were charged to address the following three questions: (1) What are the big science questions? (2) What expertise is necessary for meaningful results? and (3) What are the data gaps? Selected answers to these questions included:

- Uncertainties regarding utilization of natural resources at the coast.
- Importance of soil resources and the threat of soil and shoreline erosion.
- Lack of current soil, hydrological and meteorological data.
- Need for data at multiple scales from satellite products to agrometeorological stations.
- Need to quantify losses, mitigation strategies, political actions, for

**PROJECT SUMMARY**

Settlements in coastal lowlands are vulnerable to risks associated with climate change and extreme weather events. Sea-level rise and higher intensity storm events increase the risk of shoreline erosion, lowland flooding and ecological disruption. The quantities and characteristics of affected populations have the potential to threaten economic and political stabilities of host countries. This research therefore engaged in a scoping workshop and related activities to support the design of a spatially explicit model that models human responses to coastal risks. Workshop participants identified key science question, data gaps, and the need for both natural and social science collaborative approaches. Relationships with key science agencies and two universities were established. Village interviews identified riverbank erosion and coastal inundation due to storm surge as key research themes that future initiatives plan to investigate.

| | |
|---|---|
| **Flood Inundation and Hydrological Modelling** | Dr. Ashok Mishra, Indian Institute of Technology — Karagpur, India |
| **Issues in Flood Mitigation and Adaptation** | Dr. Anuradha Mukherji, East Carolina University, USA |
| **Bangladesh & Eastern North Carolina: Sea-Level Rise and Surges** | Dr. Tom Allen, East Carolina University, USA |
| **Satellite Precipitation Data** | Drs. Scott Curtis & Ahmed Salahuddin, East Carolina University, USA |
| **Climate Data Availability and Catastrophic Monsoon Events** | Mr. Kehellala Premalal, Dept. of Meteorology, Sri Lanka |
| **Decision Support System of Riverbank Erosion of Bangladesh** | Drs. Roshidul Hasan & Rafiqul Islam, Bangabandhu Sheikh Mujibur Rahman Agricultural University, Bangladesh |
| **Monsoon and Regional Development Issues in South Asia** | Dr. Ahsan Ahmed, Center for Global Change, Bangladesh |
| **Environment and Migration: A Recursive Conceptual Model** | Dr. Don Bradley, East Carolina University, USA |
| **People and Pixels: Spatially Explicit Human-Environment Interactions** | Dr. Tom Crawford, East Carolina University, USA |

**Table 1.** Expert workshop presentations

adopting technological innovations and migration decisions.
- Problem of unevenness in adaptive capacity especially in regards to gender.
- Need for data measuring farmer perceptions of land-use changes and governmental responses.
- Adequacy of warning systems for natural hazards/disasters.
- Need for multidisciplinary team(s) including biophysical scientists, economists, geographers, and sociologists/anthropologists.

On 19 September, the research team met with personnel from two Bangladesh science agencies: (1) Bangladesh Disaster Management Bureau (DMB), and (2) Institute of Water Modelling (IWM). DMB staff presented an overview of disasters relevant to Ganges-Brahmaputra-Meghna basin with special emphasis on Bangladesh management issues. IWM staff provided information regarding their mission and relevant geospatial data sources. Both agencies agreed in principle to support future research initiatives of the research team via potential data sharing and collaboration. We also met with a representative of the Bangladesh Bureau of Statistics (BBS) during the workshop and discussed potential for future collaboration. Additionally, the team met on separate occasions with vice chancellors and faculty from two universities including presentations of research capacities: Bangabandhu Sheikh Mujibur Rahman Agricultural University and Noakhali Science and Technology University. These meetings established relationships with strong potential to result in future international collaborative research.

A team of eight researchers travelled to Char Algi, a village located in Lakshmipur District, to meet with village residents and discuss challenges related to coastal hazards. After a group-wide meeting with the village Chairman and other leaders attended by 60–70 people, team members were separated into three group interview sessions with village residents representing fishermen, farmers, and other occupations. Each group consisted of approximately 25 people. These sessions took place near the banks of the Meghna River, and audio was recorded using digital recorders. Listed below are selected interview responses representing local perceptions of challenges facing the village:

- River bank erosion is major problem in the area. They are losing their jobs due to river bank erosion. During the prior six months, the river washed away about 2 km.
- Fishermen were affluent 30 years ago and now they are despaired.
- Flooding caused by storm surges is one of the severe hazards they face every year.
- Flooding has worsened in recent

**Figure 1.** Expert workshop at Hotel Eastern Residence, Dhaka, Bangladesh
**Figure 2.** Meeting with Vice Chancellor and leaders of Bangabandhu Sheikh Mujibur Rahman Agricultural University
**Figure 3.** Meeting with village leaders, Char Algi, Bangladesh
**Figure 4.** Village group interviews, Char Algi, Bangladesh
**Figure 5.** River bank erosion on the Meghna River, Char Algi, Bangladesh

years and has become more unpredictable.
- The onset of monsoon has been changed.
- Frequent saline water intrusion during high tide (storm surge) destroys crops.
- Coastal inundation during storm surge is more frequent now compared to the last 30 years.
- After the river takes away their land, villagers take shelter with nearby relatives and friends for a short period and look for a better place where they can live permanently.
- River bank protection (embankment) can protect the village and will help to sustain it.
- About 60–70 shelters were eroded away by the river.
- People living in the village are getting poorer due to river bank erosion.

## Acknowledgements

We appreciate the contributions of Ms. Lisa Dozier, Ms. Jolene Evans, Mr. Bill Pace, and East Carolina University's Center for Geographic Information Science.

**ARCP2012-23NSG-CRAWFORD**

### PROJECT TITLE

**Scoping Workshop: Human Responses to Catastrophic Monsoon Events in South Asia — Designing a Spatially Explicit Model in Low-Lying Coastal Areas**

### COUNTRIES INVOLVED

Bangladesh, India, USA

### PROJECT DURATION

1 year

### APN FUNDING

US$ 15,000

### PROJECT LEADER

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The 5"APN Southeast Asia Sub-Regional
Meeting
Climate Adaptation Seminar

# CAPaBLE PROJECTS 3

*Scientific Capacity Development Projects funded under*

# the CAPaBLE Programme

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CBA2012-01CMY-ABAWI

# Identifying Key Climate Drivers in Southeast Asia to Improve Climate Forecasting and Risk Management Decision-Making

Yahya Abawi and Simon White

## Introduction

The overall aim of the project is to build scientific capacity in the use of seasonal climate forecasting (SCF) in risk management decisions across climate sensitive industries in Southeast Asia. The specific objectives are to:

- conduct training works to build local capacity in the theory and operational use of SCF;
- conduct a validation study to identify the relationship between ENSO-based drivers and seasonal rainfall, including extreme rainfall events such as drought, flood and the onset of monsoon;
- assess the spatial and temporal characteristics of statistical forecasting skill in the region for different ENSO based predictive systems and identify key climate drivers, potential lead times and times of the year at which forecasts can be made;
- identify practical adaptation strategies for climate variability and climate change particularly in agriculture and water sectors through future pilot projects; and
- raise awareness of climate variability and climate change impacts among policy makers, researchers, government agencies and the farming communities in Southeast Asia.

This project aligns with all three of APN's core strategies and is specifically designed to transfer existing knowledge and information systems developed as part of previous investments in the Asia-Pacific region by international funding agencies (AusAID and ACIAR) to other countries in the region. This transfer of knowledge will

**PROJECT SUMMARY**

Climate variability and climate change have a wide range of impacts in the Asian region including threats to food and water security, extreme events and impacts on human health. The problem in the region is further exacerbated by a lack of national capacity for climate monitoring and forecasting; low levels of awareness among decision makers to the impact of climate variability and change; and lack of effective policy responses. This project addresses some of these limitations through targeted training workshops in seasonal climate forecasting (SCF) for leading scientists within meteorological organizations and professionals in the agriculture and water sectors in the participating countries of Indonesia, Philippines and Bangladesh. Nine scientists were trained in the use of climate forecasting software SCOPIC during a regional training workshop in January 2012 in Kuala Lumpur. A validation study was conducted to identify key climate drivers specific to each country. Preliminary results show that ENSO impact on rainfall appears strong in the Philippines and Indonesia, but weak in Bangladesh. ENSO has a strong influence on monsoon onset and duration, particularly in Indonesia. Final results from the validation study will be published after the second regional workshop in 2013 and will provide a first reference point for developing operational SCF and adaptive capacity in climate sensitive industries in the region.

**Figure 1.** During a visit to the Philippines, Professor Yahya Abawi discusses the purpose of the APN project with Attorney Edgar M. Chatto, the Governor of Bohol Province (left) and Ms. Jovencia Ganub of the Bohol Environment Management office

> Obtaining a good output using the historical rainfall data of Tagbilaran City was so inspiring. Moreover, I have learned the importance of religiously collecting rainfall data and during the workshop, I have made initial talks with Ms. Edna Juanillo of PAGASA for a partnership with the Provincial Government to ensure that rainfall data is regularly collected and rainfall observers capacitated. I still have a lot to learn and I appreciate very much the dedication of Prof. Yahya Abawi and Dr. Simon White in guiding and coaching us all throughout the workshop. The SCOPIC software is well-developed and it provides guidance to the users on its applications with the HELP option to us participants. Thank you APN for this opportunity from the Province of Bohol.
>
> *— Ms. Jovencia Ganub, Philippines*

not only promote and encourage activities that will develop scientific capacity and improve the level of awareness on global change issues specific to the region, but also identify present and future needs and emerging challenges for the region. The project will create a lasting network among partner countries and strengthen interactions among scientists and policy makers, providing scientific input to policy decision-making and transferring scientific knowledge to the public.

The project was initially contracted to the Australian Bureau of Meteorology as the lead agency. However, a change in lead agency midway through the project has caused some delays. Despite this the project has progressed well with in-country visits and the first regional training workshop held from 10–13 January 2012 in Kuala Lumpur, Malaysia. Nine collaborators from the Philippines, Indonesia, Bangladesh and Australia attended the workshop. Training was provided in climate science; data homogeneity testing; validation techniques; forecast skill assessment and hands-on training in SCOPIC. An outline of the climate validation process with examples from a recently completed study in the Pacific was given and participants were asked to use the methodology to conduct the validation study for their country using their own data. Given the complexity of the study undertaken, the enthusiasm, dedication and contribution of participants during the workshop were outstanding.

A comment (above) from Ms. Jovencia Ganub of the Philippines reflects the general feedback received.

Some preliminary findings presented during the final day of the workshop include:

- Impact of ENSO appears to be strong in the Philippines with moderate to high forecasting skill particularly for climate type IV. Niño 3.4 has the

**Figure 1.** The first regional training workshop

strongest relationship with rainfall variability across the whole region.

- Impact of ENSO on Indonesian rainfall is also very strong with moderate to high forecasting skill particularly in eastern Indonesia. Over western Indonesia and Java, the Indian Ocean Dipole may have a significant influence on rainfall variability and will be further investigated and reported on at the second regional workshop.
- Results from Indonesia showed that on average the onset of monsoon tends to be delayed by up to 1 month and have a shorter duration in El Niño years as compared to La Niña years.
- There appears to be little influence of ENSO on the climate of Bangladesh in terms of the predictability of rainfall quantity. However, there is some influence of ENSO on the onset and duration of the monsoon season.

A second regional workshop is planned in 2013 to conduct further validation which will provide a first reference point for risk management decisions and developing adaptive capacity in climate sensitive industries in the region.

## Acknowledgments

The assistance and support provided by collaborating institutions during in-country visits and contribution to the validation study is acknowledged. In particular the contributions from Ms. Jovencia Ganub, Edna L. Juanillo, Ferdie Billones (Philippines), Adi Ripaldi and Ir. Surana (Indonesia), M. Abdul Matin, Giashuddin Miah, and Abdul Mannan (Bangladesh) are very much appreciated.

**CBA2012-01CMY-ABAWI**

**PROJECT TITLE**

**Building Scientific Capacity in Seasonal Climate Forecasting (SCF) for Improved Risk Management Decisions in a Changing Climate**

**COUNTRIES INVOLVED**

Australia, Bangladesh, Indonesia, Philippines
Bangladesh, India, USA

**PROJECT DURATION**

2 years

**APN FUNDING**

US$ 70,000

**PROJECT LEADER**

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CBA2012-03NMY-RASUL

# Impact of Climate Change on Glacier Melting and Water Cycle Variability in Asian River Basins

G. Rasul, T. Koike, B. Ahmad and I. Kaihotsu

## Introduction

The project was launched to study the impact of climate change on the glacier melting process and water cycle variability in Asian river basins. The project kicked off at the 9th Meeting of the GEOSS Asian Water Cycle Initiative-International Coordination Group (AWCI/ICG) and the 2nd AWCI Climate Change Assessment and Adaptation (CCAA) Study Workshop held in Tokyo from 29 September to 2 October 2012. This was the first meeting of the project leader, co-leaders and collaborators to discuss the framework and future plan of activities to be undertaken during the first year in the light of set goals. Prominent scientists of the region from Bhutan, India, Mangolia, Nepal and Uzbekistan are collaborating to address the climate change issue in the cryosphere for assessing water availability in large Asian river basins. The University of Tokyo will be providing technical support on downscaling techniques, scenario development, climate impact assessment and use of hydrological models.

## Project Objectives

The project aims to achieve the following objectives:

- Improving climate change assessment and downscaling techniques;
- Building the capacity of member countries for the finest temporal and spatial resolution climate projections;
- Training of professionals for application of WEB-DHM-S (Hydrological Model);
- Assessment of glacier melt and hydrological regime shift in the light of climate change scenario;
- Assessment of water cycle variability and development of a drought early warning system.

**PROJECT SUMMARY**

Climate change has dramatically increased the variability of the flows of major Asian rivers, and peaks of meltwater occur much earlier than normal. Changing weather patterns have increased the vulnerability to hydrological extremes, drought and floods hence hampering food production. For sustainable development, an integral approach covering entire components of the water cycle is adopted to address the related issues. Comparison of past and present satellite imageries shows the mixed response of the Hindukush-Karakoram-Hymalayan part of the cryosphere to global warming. A rapid recession at the terminus of low elevation glaciers is quite visible while some terminal surging/advancing behaviour in the Karakoram Glaciers is also seen. More details will become available after further analyses of satellite imageries and climate data.

There are 18 Asian countries collaborating at a common platform of GEOSS/AWCI to address water cycle issues ranging from climate change to impact assessments targeting drought, flood and water quality. A continuous flow of data from member countries for demonstration basins is maintained and managed by the University of Tokyo under the Data Integration and Assimilation System (DIAS). Members have free access to the DIAS database through formal request. With the continued support of APN through several CAPaBLE and ARCP projects funded in the past, the GEOSS/AWCI has been developing an integrated system employing data sets from satellite, *in situ* and numerical model outputs that is supported by DIAS (http://www.editoria.u-tokyo.ac.jp/dias/link/portal/english_index.html). Based on the needs recognized in the project proposal, the project will exploit the database and expand AWCI activities focusing

on water cycle variability with an emphasis on drought in glacier and snow-fed basins.

## Data Analysis and Results

Ground-based meteorological data on temperature and precipitation was acquired from DIAS and meteorological archives of NMHS/WMO for the assessment of temporal change in the precipitation and thermal regimes. A significant warming trend, in general, has been seen over the Hindu Kush-Himalayan (HKH) region and associated basins. However, precipitation neither shows increasing trend nor any well-marked decreases. The inter-annual, inter-seasonal and intra-seasonal variability of precipitation has increased over the time especially during the last two decades.

Cloud-free satellite imageries of selected glaciers have been analysed relating the past with the present by using different software tools. The focus was initially on the changes in the terminus of the glaciers, therefore recession and surge was mapped on different time intervals. Interestingly, a mixed back-and-forth type was seen in the terminal extent of some glaciers. The recession rate in low elevation glacier termini is higher than that at higher elevation. In some Karakoram Glaciers, surging/advancing signs were also visible. Further analysis will reveal facts about the glacier dynamics under the prevailing thermal regime.

Work on downscaling of global climate models (GCMs) by regional climate models (RCMs) has also started to develop future climate projections. Initially, the data of ECHAM5 is being incorporated by using RegCM4 and PRECIS for downscaling temperature and precipitation baseline and future projections. At the first stage the Indus Basin is covered, later this activity will be extended to other basins too.

## Publications

An activity report or working paper on climate projections, water cycle variability and drought early warning system in Asia is our publication plan. It may be one of the series for GEOSS/AWCI publications. Also a publication resulting from the research work is intended for publication in a peer-reviewed journal.

## Acknowledgements

The project team greatly acknowledge the moral and financial support of APN to undertake the capacity building activities mentioned in the project.

**CBA2012-03NMY-RASUL**

**PROJECT TITLE**

**Impact of Climate Change on Glacier Melting and Water Cycle Variability in Asian River Basins**

**COUNTRIES INVOLVED**

Bhutan, Japan, Mongolia, Nepal, Pakistan, Uzbekistan

**PROJECT DURATION**

2 years

**APN FUNDING**

US$ 80,000

**PROJECT LEADER**

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CBA2012-04NSY-KANIE

# Exploring Effective Architecture for Emerging Agencies in International Sustainable Development Governance

Erin Kennedy and Norichika Kanie

## Project Objectives

The purpose of this project was to facilitate young and developing country participation from Asia-Pacific countries (APCs) in the Earth System Governance Tokyo (ESG) conference in January 2013 (hosted by UNU-IHDP Earth System Governance project) and thereby increase interactions between them and leading scholars and policy makers in the field.

The conference focused on sustainable development governance (SDG), and brought together scientists and policy makers from the north and south. APCs play a significant role in the realization of sustainable development. Providing young and developing country participants the opportunity to interact with policy makers and scientists created the opportunity for long-term relationships to develop for future cooperation in the area of effective governance from local to global levels.

This project, through the Earth System Governance Tokyo conference, sought to identify and converge the latest views and perspectives on Institutional Framework for Sustainable Development (IFSD) and International Environmental Governance (IEG) in the face of diverse, sometimes opposing, interests. As it stands, western scholars dominate this research field, with only a handful of scholars from APCs able to participate in discussions. As the first Earth System Governance conference held outside of Europe and the US, an important objective of the Earth System Governance Tokyo conference was to strengthen the ESG network among APC members and to provide opportunities for long-term regional collaborations among scientists and policy makers. By providing a grant opportunity to selected participants, early-career scholars from developing countries were able to participate in the conference and cooperate with other global change practitioners.

**PROJECT SUMMARY**

This project, through the Earth System Governance Tokyo conference, sought to identify and converge the latest views and perspectives on Institutional Framework for Sustainable Development (IFSD) and International Environmental Governance (IEG). The objective of this project was to provide a supportive environment for early-career researchers coming from within the APN region to participate in an international conference that would facilitate networking and collaboration opportunities between scientists and policy makers, let alone developing scientific understandings. The outcome of this project was the active participation of early-career researchers from developing countries, providing the opportunity to participate in discussions on IFDS and IEG as well as creating long-term collaborative and inter-disciplinary projects with scientists and policy makers within the international Earth System Governance community.

## Project Outcomes

At the onset of this project one of the main goals was to strengthen networks of groups that have an intellectual interest in IEG — particularly in Japan and the APCs, and further establish the network and interaction with counterparts in the United States and Europe. Participants from APCs were asked to provide feedback on the outcomes of the Earth System Governance Tokyo

conference in reference to the goal of strengthening networks. The following are statements from APN recipients:

> "I personally feel that China has been underrepresented in the ESG community, both in terms of research (on China) and in terms of people (researchers from China), even though people are very interested in China and everyone seems to talk about the role of China. But there is an importance between "talking about" and actually hearing from people who have studied aspects of the ESG research agenda in China. I hope my presence and my outreach at the ESG Tokyo Conference will help in "putting China on the map," or at least drawing attention to the need for more ESG oriented research on and in China.
>
> *— Sander Chan, China*

> "The ESG conference is a great platform that gave a chance to network with senior researchers, peers, civil society groups from different parts of the world. This networking has created a chance for me to further understand the need for working with other researchers with similar research interests.
>
> *— Aliyu Salisu Barau, Malaysia*

The Earth System Governance Tokyo conference proceedings and papers will be internally published and distributed to co-hosts, sponsors and be available for use within the Earth System Governance Programme. Additional materials from the conference include a series of graphic recordings from the plenaries and semi-plenaries. These recording will be made available on the conference website as well as the Earth System Governance Programme website.

## Acknowledgments

On behalf of the Earth System Governance community we would like to thank APN for providing us with monetary support to fund 17 early-career researchers from within the Asia-Pacific region to attend the Earth System Governance Tokyo conference. We would also like to thank Dr. Akio Takemoto for speaking at the welcome reception of the Earth System Governance Tokyo conference. It is due to APN's financial support and dedicated staff that this project could successfully build lasting networks and collaborations between scientists and policy makers that have an intellectual interest in IEG. Of particular importance is the involvement of participants from the APN region and the established networks between the APCs and other countries that have developed from the Earth System Governance Tokyo conference.

**CBA2012-04NSY-KANIE**

**PROJECT TITLE**

**Exploring Effective Architecture for Emerging Agencies in International Sustainable Development Governance**

**COUNTRIES INVOLVED**

Cambodia, Lao PDR, Thailand, Viet Nam

**PROJECT DURATION**

1 year

**APN FUNDING**

US$ 50,000

**PROJECT LEADER**

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CBA2012-06NSY-ZHANG

# Enhancing Capacity for Integrated Marine Biogeochemistry and Ecosystem Research in the Asia-Pacific Region

Jing Zhang

## Background

Oceanographic research requires expensive infrastructure, particularly seagoing facilities, which many developing countries are unable to afford. Scientists from such countries often encounter a lack of access to equipment, research funding and infrastructure, as well as recent literature and state-of-the-art techniques. They are consequently often somewhat isolated from the global scientific community. In order to enhance Integrated Marine Biogeochemistry and Ecosystem Research (IMBER) in the Asia-Pacific region, an international workshop to assess capacity development for IMBER research was proposed. The objective of this project was to evaluate the current efforts within IMBER and other ocean science projects in the Asia-Pacific region, identify the gaps where additional capacity development is required, and to provide recommendations on future capacity building actions. This workshop aimed to assist Asia-Pacific countries to make appropriate contributions to regional and international IMBER research.

The marine ecosystem in the Asia-Pacific region is particularly vulnerable to human-induced climate changes and may have considerable socioeconomic implications. Marine research capacity in this region is different from country to country. The proposed workshop on needs assessment for capacity building for IMBER research aimed to analyse the needs and mechanisms for capacity building within the integrated marine biogeochemistry and ecosystem research community in the Asia-Pacific region. This could help countries in this region to identify their specific needs, share existing capacity building recourses, and explore potential collaboration.

**PROJECT SUMMARY**

In order to enhance the research capacity for marine science in the Asia-Pacific region, an international workshop on needs assessment for capacity development for Integrated Marine Biogeochemistry and Ecosystem Research (IMBER) was held from 31 July to 4 August 2012 at the East China Normal University (ECNU), Shanghai, China. Participants shared the capacity building experiences and identified critical issues of capacity building, within the integrated ocean science programmes in the Asia-Pacific region where capacity development needs for marine science are predominantly driven by social and economic priorities. Three marine research topics were identified as priorities for capacity building in the region: climate change impacts, ecosystem health, and food security. Challenges faced by these issues include sustained funding support for research infrastructure and sea-going facilities, technical capability for data acquisition and analysis, the need to develop models, and attracting postgraduate students and early-career scientists into marine science-related careers and providing opportunities for the development of young professionals. The need for more collaboration to share facilities and expertise for research, and for joint efforts between natural and social scientists to address the issues were noted.

## Work Undertaken

The main activity of this project was an international workshop involving participants from counties in the region with interests in oceanic research, together with representatives of IMBER and international agencies with expertise and experience in capacity building for

marine research. The workshop was held from 31 July to 4 August 2012 at the East China Normal University (ECNU) in Shanghai, China. The workshop brought together about 20 marine researchers and capacity building experts from 14 countries to discuss capacity building experiences, assess regional capacity building needs, and consider recommendations to improve regional capacity building, which would be of interest to other groups and other geographical regions. Prior to this workshop, participants were involved in planning the agenda and meeting format through a questionnaire and collected information relevant to the capacity building of marine research in their nation or region. The survey of ongoing regional and national capacity building activities shows that types of capacity building activities common in this region include postgraduate education, summer schools, training courses, training through research, training on ships, and grants to support travel and short-term training, while visiting professorship, internship, and infrastructure and technical support were also offered in some countries, for example, China and Republic of Korea. Three marine research topics were identified during the workshop as priorities for capacity building efforts in this region: climate change impacts, ecosystem health and food security. It is suggested that building a capacity building platform with the involvement of relevant international/regional organizations, promoting globalization of capacity building activities, and sustaining capacity building network will help to enhance regional marine research capacity (Hu et al., 2013).

A small group meeting will be held in March 2013 in China to finalize the workshop report and explore follow-up action on the future capacity building in the Asia-Pacific region.

## Publications

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IMBER RPO, IMBER CBTT. (2012). Needs assessment for capacity development for integrated marine biogeochemistry and ecosystem research in the Asia-Pacific region. *APN Newsletter, 18* (4), 28–30.

## Acknowledgments

The workshop was initiated by the IMBER Capacity Building Task Team, and financially supported by IMBER, APN, and ECNU.

**CBA2012-06NSY-ZHANG**

**PROJECT TITLE**

**International Workshop: Needs Assessment for Capacity Development for Integrated Marine Biogeochemistry and Ecosystem Research in the Asia-Pacific Region**

**COUNTRIES INVOLVED**

Australia, Chile, China, India, Korea, Pakistan, Philippines, South Africa, Thailand, Turkey, USA

**PROJECT DURATION**

1 year

**APN FUNDING**

US$ 50,000

**PROJECT LEADER**

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CBA2012-07NSY-ARIDA

# ASEAN Training Workshop on Building Capacity on Access and Benefit Sharing (ABS)

Ana Maria E. Tolentino, Anthony C. T. M. Foronda and Clarissa C. Arida

The fair and equitable sharing of benefits arising from the utilization of genetic resources is one of the core objectives of the Convention on Biological Diversity (CBD). To move forward with the achievement of the third objective on access and benefit sharing (ABS), the Nagoya Protocol was adopted at the Tenth Meeting of the Conference of the Parties of the CBD in October 2010, in Nagoya, Japan.

Effective implementation of the Nagoya Protocol requires building capacities in developing regulatory frameworks and mechanisms. It also requires understanding the legal, institutional, administrative, scientific and technological aspects of ABS. Moreover, indigenous and local communities need support to prepare them in national ABS processes. More than 80% of the population in developing countries still depend on traditional medicine for their daily needs; therefore traditional knowledge is a crucial part of the scientific knowledge base.

To address these tasks, the ASEAN Centre for Biodiversity (ACB) has been implementing regional capacity development initiatives in the region. The partnership with APN through the CAPaBLE Programme focused on an ASEAN training workshop on building capacity that involved ABS National Focal Points, academia, scientists, researchers, lawyers, policy makers and representatives from industry, indigenous and local communities groups (ILCs) and NGOs. The workshop helped raise understanding of the procedural aspects of Prior Informed Consent (PIC), Mutually Agreed Terms (MAT), and issues such as ownership of genetic resources and traditional knowledge.

The project enabled these stakeholders to raise their critical understanding of the legal, institutional, scientific and technological capabilities in terms of extensive discussions on ABS topics including bioprospecting, biotechnology, and biopiracy. This aptly addressed the APN goals and research agenda as ABS requires the search of biodiversity for valuable genetic and chemical information found in plants, animals, and microorganisms, thus enriching biological inventories and taxonomy. Through this project, the need for ASEAN capacity building took on special significance as capacity-related issues are at the root of most developing countries' inabilities to conserve their genetic resources which

## PROJECT SUMMARY

A capacity building activity for Southeast Asian key stakeholders was conducted to enhance their understanding of the policy, mechanisms and implementation of the third objective of the CBD on access to genetic resources and the fair and equitable sharing of benefits arising from their utilization (ABS) and in preparation for the enforcement of the Nagoya Protocol (NP). About 56 participants representing academic and scientific communities, lawyers, policy makers, NGOs, indigenous and local communities, industry, and ABS national focal points participated in the 3rd Regional Workshop on ABS held in Kuala Lumpur, Malaysia in December 2012. The four-day workshop, comprised of lectures and a field visit to a research institute, critically discussed the status and key elements of the NP, relevance of the draft ASEAN Framework Agreement on ABS, and procedures for sharing of benefits and country experiences in implementing ABS policies. The field visit demonstrated the experience of FRIM in documenting selected traditional knowledge associated with genetic resources and its interface with science and policy development. The activity provided an analysis of the international and regional guidelines on ABS, procedures of benefit sharing, ABS implementation in different countries, and prepared participants in developing national roadmaps towards ABS legal frameworks.

prevented them from ensuring a more equitable benefit-sharing from the use of their resources.

Representing the providers or owners, regulators and users of genetic resources were 56 participants from the nine ASEAN Member States (except Indonesia) and Timor-Leste. Distinguished resource speakers with a wealth of knowledge on ABS were from the Centre for Biodiversity Law-Malaysia, United Nations University-Institute for Advanced Studies, Environment Division-ASEAN Secretariat, Forest Research Institute Malaysia (FRIM), Sarawak Biodiversity Centre, Third World Network (Malaysia), and Japan Bioindustry Association. The workshop, hosted by the Ministry of Natural Resources and Environment of Malaysia was held at Hotel Novotel, Kuala Lumpur, 10–13 December 2012.

Participants were exposed to an analysis of the Nagoya Protocol (NP) including the draft ASEAN Framework Agreement on ABS. An interactive sharing of the procedures and mechanisms on benefit-sharing and country experiences on ABS in Malaysia, Viet Nam and the Philippines provided added practical experiences to the participants as well as the experiences from a Bioindustry from Japan. Equally important was the step-by-step guidance provided to the participants on how to prepare a roadmap towards national ABS legal frameworks.

Another highlight of the workshop was the interaction with ILCs — *Orang Asli* in Peninsular Malaysia. Facilitated through a field visit at the Forest Research Institute of Malaysia (FRIM) in Kepong, the participants witnessed working linkages among science, traditional knowledge and policy development. Researchers of FRIM presented a project documenting traditional knowledge associated with genetic resources. The researchers highlighted the methodology in obtaining PIC, MAT, documenting traditional knowledge, testing of pharmaceutically-important biochemicals, and conserving traditional knowledge vis-à-vis biological resources.

The field visit at FRIM, likewise, provided participants further application of the ABS mechanism. A field trip held in August 2012 in Thailand at Ban Santitham Centre for Agroforestry and Community Development during the 2nd Regional ABS Training Workshop showcased the

community's long-term management approach in conserving botanical resources including traditional knowledge associated to these resources. Emphasized was PIC from the community is required and sharing back to the community 1% of the revenue from sales of botanical resources and plant-based products such as facial treatment masks, shampoo, balm oil and mouthwash.

The success of the FRIM project can be attributed to the empowerment, involvement and attainment of PIC from the community and in the inclusion of the MAT process as negotiated between the researchers and community leaders. It provides an example of how to create a harmonious relationship between researchers and ILCs, built on mutual trust. This kind of relationship between science and policy enhances the contribution of biodiversity to sustainable development and human well-being.

The project also supported the improvement of the ABS web page in the ACB portal. This would enable a wider dissemination of project results and other ACB-related initiatives through knowledge management and information sharing on the web.

## Acknowledgments

The ASEAN Centre for Biodiversity would like to thank the APN for this meaningful partnership to raise capacities in biodiversity conservation and for providing financial support for the participation of key stakeholders in the *Third Regional Workshop on ABS: Developing a national roadmap towards ABS legal frameworks*. These key stakeholders supported by APN represented academia, scientists, researchers, NGO and indigenous and local community groups, policy makers, lawyers and key government officials representing the following countries in Southeast Asia: Cambodia, Lao PDR, Malaysia, Philippines, Thailand and Viet Nam, as well as resource speakers from United Nations University-Institute of Advanced Studies, Sarawak Biodiversity Centre, and the Japan Bioindustry Association.

## References

ASEAN Centre for Biodiversity. (2012). *Report of the 2nd Southeast Asia Training-Workshop on Building Institutional and Stakeholder Capacities on ABS*. Bangkok, Thailand. 20–23 August 2012, Bangkok, Thailand (Unpublished).

ASEAN Centre for Biodiversity. (2012). *Report of the 3rd Regional Workshop on ABS: Developing national roadmap towards ABS legal frameworks*. Kuala Lumpur, Malaysia. 10–13 December 2012 (Unpublished).

**CBA2012-07NSY-ARIDA**

**PROJECT TITLE**

**ASEAN Training Workshop on Building Capacity on Access and Benefit Sharing (ABS)**

**COUNTRIES INVOLVED**

Cambodia, Indonesia, Lao PDR, Malaysia, Myanmar, Philippines, Thailand, Timor Leste, Viet Nam

**PROJECT DURATION**

1 year

**APN FUNDING**

US$ 40,000

**PROJECT LEADER**

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CBA2012-08NSY-HONGBO

# International Workshop on Marine Invasive Species (MIS) problems in Northwest Pacific

Hongbo Shang

The problem of marine invasive species (MIS) is one of the major threats to marine biological diversity, which plays a critical role in overall sustainable development and poverty eradication, and is essential to our planet, human well-being and to the livelihood and cultural integrity of people. According to the Regional Overview on Marine Invasive Species in the NOWPAP Region, there is insufficient information about MIS at both national and international levels. Additionally, there is a strong need to strengthen data exchange and communication among relevant countries to share available information and to discuss future activities in this field.

With financial support from APN, and technical support from Regional Coordination Unit (RCU) of NOWPAP, A.V. Zhirmunsky Institute of Marine Biology of the Far-East Branch of Russian Academy of Science, Japan Agency for Marine-Earth Science and Technology, and East Sea Fisheries Research Institute of Korea National Fisheries Research & Development Institute, the Data and Information Network Regional Activity Center (DINRAC) held the Regional Workshop on MIS Problems in Northwest Pacific Region in Qingdao, China during 23–24 October 2012. About 20 prominent experts were invited from 17 organizations, such as Division of Marine Environment of the Department of Pollution Prevention and Control of the Ministry of Environmental Protection of China, Division of Biological Safety of the Department of Nature and Ecology Conservation of the Ministry of Environmental Protection of China, NOWPAP RCU, Shandong Maritime Safety Administration of China, and more than 20 local researchers in Qingdao City.

## PROJECT SUMMARY

The problem of marine invasive species (MIS) is one of the major threats to marine biological diversity at present, while there is still insufficient information about MIS at both national and international levels. With the aim of exchanging of information on MIS problems, and exchanging of experiences on the prevention and control of MIS, the Regional Workshop on marine invasive species (MIS) Problems in Northwest Pacific Region was held in Qingdao, China during 23–24 October 2012. During the workshop, participants discussed this issue and made recommendations on several areas, which includes regional cooperation, reliable research and study, prevention measures and so on.

This regional workshop aimed to promote exchange of information on MIS problems among officials and experts from NOWPAP member states, exchange of experiences on the prevention and control of MIS among officials and experts, analysis of the needs for policies and measures on MIS and recommendations for NOWPAP member states. The workshop included three major session: (1) Current situation of MIS problems in NOWPAP member states, and (2) Impacts of the MIS on Ecosystems and Environment in NOWPAP Member Countries, and Session 3: Current policies and measures on preventing and controlling MIS problems in the NOWPAP member states and future needs for policies, measures and regional cooperation.

The workshop made the following conclusions:

- The problem of MIS is one of the major threats to marine ecosystems including the Northwest Pacific area, and this workshop is necessary for the Northwest Pacific region to bring together relevant officials and experts to exchange information and experiences on the prevention and control of MIS.
- In the Northwest Pacific region, there are already a lot of research and information on the current situation of MIS, such as the origins, pathways, categories, distribution and impacts of MIS, but they are still inadequate for policy-making

and management. There is insufficient reliable research and statistics of the origins, pathways, categories, distribution and impacts of MIS.

- Countries in the Northwest Pacific region have made many efforts to prevent and control MIS, including legislations, empowerment of governmental organizations, implementation of international rules and guidelines and development of technologies, etc. However, due to limited knowledge and understanding of MIS, and also due to the extreme difficulty to fully investigate and control this problem, the measures are still inadequate in terms of legislation, management system and concrete actions. Through this workshop, participants shared information, experiences and knowledge on MIS in the Northwest Pacific region and their understanding of the issue of MIS was improved.
- More research on MIS are needed, and countries in the Northwest Pacific region need to provide resources to strengthen the investigation and research on this issue, and to develop regional cooperation on data-sharing in the framework of NOWPAP.
- Since it is very difficult to eliminate MIS after their invasion, prevention measures are very important and indispensable, including strict inspection and environmental impact assessment.
- A rapid entry into force of the IMO Ballast Water Convention is essential to prevent the further spread of MIS. There is a need to strengthen regional cooperation through participation in international organizations, including FAO, UNEP and PICES, etc.
- Current national legislation and management systems for MIS need to be improved to further prevent and control MIS, which may include control of pathways that lead to the introduction and spread of MIS, routine monitoring for early detection and response, and long-term response to mitigate the impacts of MIS.

## CBA2012-08NSY-HONGBO

### PROJECT TITLE

**International Workshop on Marine Invasive Species (MIS) problems in Northwest Pacific**

### COUNTRIES INVOLVED

China, Japan, Korea, Russia

### PROJECT DURATION

1 year

### APN FUNDING

US$ 32,250

### PROJECT LEADER

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CBA2012-09NMY-HASHIM

# Global Environmental Change and Human Health

Jamal Hisham Hashim and Christopher D. Metcalfe

## Introduction

The objectives of the project are (1) to foster intra-/inter-regional cooperation networks of research/practitioners with expertise on the impact of extreme events and urbanization on human health; (2) to boost global health and environmental research aimed at the development of adaptation and mitigation strategies; (3) to develop new capacities on the health/environment nexus; (4) to enable science-policy interface; and (5) to raise awareness within the non-science communities.

The activity encompasses APN's main goals, as it is intended to enhance the scientific capacity of young scientists from the Asia-Pacific region, especially those from the developing countries and to improve their decision-making and public-awareness capability within the context of sustainable development by (1) establishing a regional cooperation network of experts (researchers/practitioners) engaged in research and policy analysis related to the impact of extreme events and urbanization on human health; (2) promoting inter-regional cooperation within the framework of the global environmental change and human health; (3) training young scientists on interdisciplinary/transdisciplinary research on global change and human health; (4) strengthening science-policy dialogues; and (5) raising public awareness on the impact of extreme events on health and on related mitigation/adaptation actions/policies. Given the multi-disciplinary nature of the project, it relates to several cross-cutting concerns, for example, global change impact and sustainable development; global change and water and health management; and global change implications for urbanization.

## Work Undertaken

A Symposium and Workshop on Global Environmental Change and Human Health was held in Kuala Lumpur from 14–18 January 2013. The main organizers were the International Institute for Global Health (UNU-IIGH) and the Institute for Water, Environment and Health (UNU-INWEH) of the United Nations University, as well as the Global Environmental Change and Human (GECHH) Project. It involved a two-day symposium, followed by a day of field visits, and culminating in a two-day workshop. The theme of the symposium and workshop was extreme events and urbanization. Under APN's sponsorship, 24 young scientists from Malaysia, Indonesia, Thailand, Cambodia, Lao PDR, Viet Nam, Philippines, China and Australia participated in the events.

The symposium was attended by about 50 participants. It was highlighted by presentations from eight international speakers on topics related to forecasting and preparedness, emergency response, and mitigation and adaptation, in relation to extreme events and urbanization. A breakout session was organized around the three topics and each of the three breakout groups made a presentation on their deliberations.

A field visit was organized to the City Hall of Kuala Lumpur where participants were briefed on urban planning of the city including a demonstration of the city's traffic control system. Next, they visited the National Hydraulic Research Institute of Malaysia (NAHRIM) where participants were briefed on the role and function of NAHRIM in climate change research and prediction, followed by a visit to their Hydraulic Research Laboratory.

## PROJECT SUMMARY

The project is intended to enhance the scientific capacity of young scientists from the Asia-Pacific region, especially those from the developing countries, and to improve their decision-making and public-awareness-raising capability within the context of sustainable development. A Symposium and Workshop on Global Environmental Change and Human Health was held in Kuala Lumpur from 14–18 January 2013. The main organizers were the International Institute for Global Health (UNU-IIGH) and the Institute for Water, Environment and Health (UNU-INWEH) of the United Nations University, as well as the Global Environmental Change and Human Health (GECHH) Project. It involved a two-day symposium, followed by a day of field visits, and culminating in a two-day workshop. The theme of the symposium and workshop was extreme events and urbanization. Under APN's sponsorship, 24 young scientists from Malaysia, Indonesia, Thailand, Cambodia, Lao PDR, Viet Nam, Philippines, China and Australia participated in the two events. Eight international speakers gave presentations at the two events. The young scientists presented their country reports. They also worked on and presented three research proposals which were evaluated and commented by the international experts.


A two-day workshop was organized for the 24 young scientists. Five international speakers presented on various topics related to climate change, extreme events and urbanization. Participants presented country reports. They were then divided into 3 groups to work on research proposals based on the themes of extreme events due to climate change, environmental impacts of urbanization and environmental change and human health. Each group then presented their research proposal which was evaluated and commented on by the international experts.


## Acknowledgments

The authors acknowledge contributions from the main organizers, UNU-IIGH, UNU-INWEH and the GECHH Project, as well as APN as the main sponsor. We would also like to thank all international experts and speakers who participated in the symposium and workshop and, last but not least, all staff and students of UNU-IIGH who acted as the Secretariat for both events.


**CBA2012-09NMY-HASHIM**

**PROJECT TITLE**

**Global Environmental Change and Human Health: Extreme Events and Urbanization in the APN Region (UNU-GECHH-APN-EEU)**

**COUNTRIES INVOLVED**

Autralia, China, Malaysia, India

**PROJECT DURATION**

2 years

**APN FUNDING**

US$ 53,573

**PROJECT LEADER**


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CBA2012-10NSY-ZONDERVAN

# Uncertainty and Governance of Transboundary River Basins

Louis Lebel and Ruben Zondervan

The governance of transboundary river basins is marked by persistent uncertainty regarding the causes of climate change, its impacts, the interlinkage of various causes and response options, and the effects of possible response options. These uncertainties can be classified in many ways, for example, with respect to magnitude, source and system, and are multi-level and interdependent. The perception and subsequent role in governance of these uncertainties depends on interests but also cultural settings. In the basins in Asia, complex power relations and imbalances demand explicit consideration of normative uncertainty in addition to the conventional focus on analytical uncertainty. Normative uncertainty refers to uncertainty with respect to goals and perceptions of acceptable risk.

A capacity building workshop to address the policy and research challenges of uncertainty among early-career researchers in the region has been held under this project in Chiang Mai, Thailand, 21–23 January 2013. The workshop was organized by the Earth System Governance Project and the Unit for Social and Environmental Research of Chiang Mai University, and endorsed by the Global Water System Project.

The participatns, including 15 trainees, 5 trainers, 2 co-chairs, and 4 observers came from Australia (3), Bangladesh (2), Bhutan (1), Canada (1), China (1), India (3), Nepal (1), Pakistan (2), Russia (2), Philippines (1), Sweden (1), Thailand (7), and USA (1). While all participants had academic backgrounds in a range of relevant disciplines including political science, meteorology, civil engineering and law, a number of them currently have positions in NGOs, diplomacy or business. This was important because uncertain risks have already become the normal context in which regional water governance takes place. The diverse composition of the group was very beneficial for an active and constructive discussion and learning not only through lectures but also through peer-to-peer interactions.

Case studies were presented on transboundary river basins, which were discussed by early-career researchers

## PROJECT SUMMARY

A capacity building workshop was held in Chiang Mai, 21–23 January 2013 to help increase understanding of the implications of analytical and normative uncertainties associated with climate change and other large-scale drivers for the governance of trans-boundary river basins. The mix of participants in terms of countries, expertise and disciplines allowed for a critical perspective on issues in several key transboundary river basins including the Indus, Ganges, Brahmaputra and Mekong. The deliberations underlined that in Asia, complex power relations demand explicit consideration of normative uncertainty in addition to the conventional focus on analytical uncertainty. Power imbalances, for instance, were noted as an important barrier to the flow of information and sharing of data, which increases uncertainty. It was recognized that it is often easier and more appropriate for negotiations to focus on sharing the benefits of water than just on the allocation of physical water flows. Participants and trainers jointly developed a set of propositions on uncertainty and the governance of transboundary river basins under a changing climate and committed to completing a co-authored synthesis article around some of these.

from upstream and downstream countries sharing the river basins. This, in particular, provided a rich and balanced perspective to a situation in which a lot of the politics around river basins in the region have little to do with water, but influence positions, cooperation and negotiations about water and river governance. As one participant put it, these rivers have "shared blood, borders, and water." Conversely, cooperation on water may help reduce conflicts in other areas. Such cooperation can and should include scientific collaboration and joint capacity.

It this sense, the workshop already contributed to reducing uncertainty by creating trust, exchanging views and information, and establishing relationships and social learning between the participants. The workshop thus directly addressed APN's goal to support regional cooperation in global change research on issues relevant to the region and through developing capacity of individual early-career researchers. Stakeholders at the workshop also contributed to improving the scientific capabilities of nations in the region. As the Earth System Governance Project is designed as the central nodal point within the global change research programmes to guide, organize and evaluate various activities on governance (see www.earth-systemgovernance.org), the event also was an important networking opportunity and platform to initiate and combine momentum for new research on governance of transboundary rivers under uncertainty in Asia within the global research community.

Participants and trainers developed a set of propositions on uncertainty in governance of transboundary river basins under climate change during the workshop and there is strong commitment and a process in place to synthesize these into a scientific article co-authored by all trainers and participants. This article will use the empirical case studies on many river basins in Asia prepared before and presented at the workshop by the participants.

## CBA2012-10NSY-ZONDERVAN

### PROJECT TITLE

**Governing Critical Uncertainties: Climate Change and Decision-Making in Transboundary River Basins**

### COUNTRIES INVOLVED

All APN countries

### PROJECT DURATION

1 year

### APN FUNDING

US$ 40,000

### PROJECT LEADER

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CBA2012-12NSY-CRUZ

# Training Courses on Farming Village Conservation with LGUs in the Philippines

Rex Victor O. Cruz, Wilfredo M. Carandang, Genevieve A. Galapia, Vida Q. Carandang and Catherine C. de Luna

The Conservation Farming Village (CFV) approach adopts a community-based participatory approach to technology development, promotion and utilization; and is a multi-level technology promotion mechanism that will capacitate local extension/change agents. With the passage of the Philippine Republic Act 7160 in 1991, local executives were given the autonomy to chart their path towards sustainable access and development of their resources, including adaptation strategies for climate change and food security. Such strategies would ensure sustainability of efforts in promoting upland farming technologies and approaches, and would strengthen the "multiplier effect" of existing technology diffusion processes at the local level.

CFV is a modality for transforming traditional upland farming systems into sustainable upland production systems, stimulating upland community development resilient to climate changes. This project will help build the capacities of local government unit (LGU) executives and their technical personnel to undertake CFV. In turn, LGU personnel will help upland farmers improve their economic conditions by strengthening their capacities to manage their natural resources, thereby protecting their communities against environmental degradation while sustaining their sources of livelihood.

CFV has been implemented across the Philippines in five areas from 2009 to 2011, representing five different biogeophysical and social-economic-cultural environment. From the 16 villages initially adopting CFV, 15 more villages in 15 provinces are targeted in this project.

The project on "Enhancing the LGU Capacity for Implementing Conservation Farming Village as a Strategy for Climate Change Adaptation and Upland Development" includes the empowerment of farmers to become the vanguards of sloping land resources by providing them with skills and knowledge in food, wood and fibre production and resource management; tapping active leadership and participation of the LGUs in carrying out programme activities down to the barangay level such as extension work, community organizing, and facilitating market linkages and other support services; and provision of technical expertise and guidance of a state university/college in the province or near the site.

The project aims to build the capacities of LGUs to undertake sustainable development-related programmes and strategies and facilitate adoption and implementation of science and technology-based sloping land management and agroforestry systems to promote sustainable upland development and adapt to climate change.

This capacity building project works at the grassroots level, where it is the farmers and LGUs that chart their path to sustainable development and decide on climate change adaptation strategies that are appropriate and environment-friendly. The academic research institution provides the technical expertise and research component, while the LGU provides for ground extension activities. The farmers take on the dual role of both researcher and decision maker.

Upland development cannot prosper unless the local government embraces unconditionally the responsibility of being the facilitator of mobilizing resources that are needed. While farmers' ability and commitment to upland

development cannot be understated, the sheer immensity of the resources required to veer the management of uplands from the path of degradation to sustainable development will be overwhelming for farmers alone to shoulder. Local governments must believe that there is a way to better pursue upland development than leaving it in the hands of farmers with arms that are long in aspirations but short in resources.

## Project Management Team Formation

The College of Forestry and Natural Resources, University of the Philippines Los Baños in partnership with Bicol University College of Agriculture and Forestry (BUCAF), Ifugao State University (IFSU), Silliman University (SU), University of Southeastern Philippines (USeP) implement the project in 15 provinces in the Philippines. Five clusters of provinces were identified and each cluster was assigned with a project leader to facilitate project operations.

On 31 July 2012, a project leader's Meeting was held at the UPLB to plan for the implementation of the project. The five identified project leaders were:

- Dr. Antonio P. Payonga, project leader from the Bicol University College of Agriculture and Forestry;
- Dr. Wilfredo M. Carandang, project leader from UPLB;
- Prof. Santiago Utzurrum, Jr., project leader from Siliman University;
- Prof. Loinaz Dulawan (representing Prof. Nathaniel Dimog, project leader) of Ifugao State University;
- Prof. Teresita Modesto (representing Dr. Danilo Pacoy, project leader) of University of Southeastern Philippines (USeP).

Each project leader will constitute their own Project Management Team who will be responsible for the implementation of the capacity building activities on site, including conduct of pre-training activities and model farm development.

## Criteria for Selecting the Provinces to Receive Capacity building Programme

The Project Management Team agreed to use the following criteria for selecting the provinces to receive the capacity building programme:

- Proximity to existing CFV sites
- Majority of the municipalities within the province are upland areas

With the above criteria, the following provinces were chosen as recipients:

| Existing CFV sites | Adjacent provinces |
|---|---|
| General Nakar, Quezon | Laguna, Batangas, Rizal, Quezon |
| Ligao City, Albay | Albay, Camarines Sur, Sorsogon |
| Alfonso Lista, Ifugao | Ifugao, Mountain Province, Kalinga |
| La Liberttad, Negros Oriental | Cebu, Negros Occidental, Siquijor, Negros Oriental |
| Panabo City, Davao del Norte | Compostela Valley, Davao del Sur, Davao del Norte |

**Table 1.** Seleted recipient provinces

## Training Needs Assessment Implementation

Tools were developed for assessing the training needs of LGU personnel and farmers. These focused on organizing and implementing CFV, agroforestry and other sloping land management technologies. As the circumstance permitted, the questionnaires were administered to the respondents through email, fax, or personal interview.

### *Socio-Demographic Profile of Respondents*

The respondents were mostly male, college graduates in their thirties or fifties and majority of the respondents have attended training courses related to upland development (see Figure 1).

### *Training Needs Results: LGU Personnel*

Partial results of the training needs conducted are shown in the table below. Based on the weighted score for each

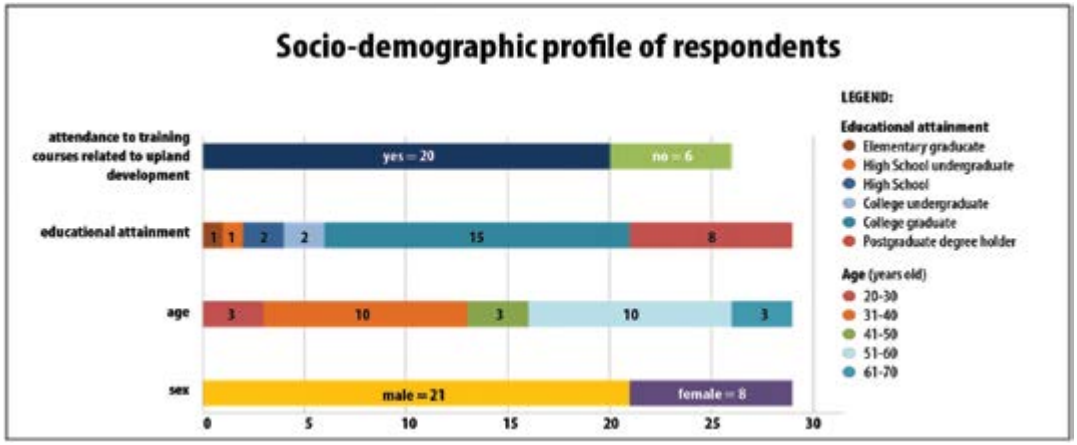


**Figure 1.** Socio-demographic profile of respondents

suggested topic, ranking shows that climate change and upland development is number 1, cropping combinations appropriate for sloping areas ranked second and soil erosion and its control ranked third (Table 2).

### *Training Needs Results: Farmers*

The training needs of farmers are shown in Table 3. Farmers ranked local policy/ordinance formulation as first, climate change and upland development as second and community organizing as third.

**Table 2.** Training needs results: LGU personnel

| Rank | Suggested Topics | Weighted Score |
|---|---|---|
| 1 | Climate change and upland development | 287 |
| 2 | Cropping combinations appropriate for sloping areas | 276 |
| 3 | Soil erosion and its control | 264 |
| 4 | Community organizing | 234 |
| 5 | Local policy/ordinance formulation | 225 |
| 6 | Soil fertility management | 221 |
| 7 | Basic concepts of watershed management | 215 |
| 8 | Multi-stakeholder community development planning | 196 |
| 9 | Farm and farmer profiling | 189 |
| 10 | Livelihood support mechanism | 182 |
| 11 | Barangay development planning | 174 |
| 12 | Alley cropping | 144 |
| 13 | Financial management | 132 |
| 14 | Community sustainability indicators | 122 |
| 15 | Marketing strategies | 118 |

The weighted scores were computed based on topics given first priority rated with 15 points, those given second priority, 14 points and so on, until topics ranked 15th were given a score of 1 (ftp://ftp.cgiar.org/isnar/papers/tna-radio.pdf)

## Training Implementation

Based on the results of the TNA, four training courses have been developed specifically for each provincial cluster to meet the needs identified by the prospective participants both from the LGU and the farmers perspectives, especially on upland development and climate change.

The four training courses were participated by 197 participants. The number fell short from the 216 targeted participants (54 participants per training course). Typhoon Pablo that visited the Mindanao area in November 2012 prevented the LGU personnel from Davao del Norte from participating in the training course.

## Farm Development

One of the outputs during the training cources was to formulate a "farm development plan" to include the following:

- Location
- Owner of the Area/Farmer
- Area
- Technologies to be implemented
- Materials needed
- Timeframe for development
- Budget

The farm development activities are ongoing and the provincial members of the

| Rank | Suggested Topics | Weighted Score |
|---|---|---|
| 1 | Local policy/ordinance formulation | 55 |
| 2 | Climate change and upland development | 35 |
| 3 | Community organizing | 24 |
| 4 | Soil erosion and its control | 17 |
| 5 | Barangay development planning | 15 |
| 6 | Financial management | 14 |
| 7 | Community sustainability indicators | 13 |
| 7 | Cropping combinations appropriate for sloping areas | 13 |
| 8 | Basic concepts of watershed management | 11 |
| 8 | Farm and farmer profiling | 11 |
| 9 | Multistakeholder community development planning | 9 |
| 10 | Livelihood support mechanism | 8 |
| 11 | Soil fertility management | 4 |
| 12 | Marketing strategies | 3 |
| 13 | Alley cropping | 2 |

**Table 3.** Training needs results: farmers

The weighted scores were computed based on topics given first priority rated with 15 points, those given second priority, 14 points and so on, until topics ranked 15th were given a score of 1 (ftp://ftp.cgiar.org/isnar/papers/tna-radio.pdf)

Project Management Team are implementing this component in their respective cluster of provinces.

- Laguna, Rizal, Quezon,and Batangas
- Sorsogon, Albay and Camarines Sur
- Ifugao, Mountain Province and Kalinga
- Davao del Norte, Davao del Sur and Compostela Valley

## Acknowledgments

The project team acknowledges the following provincial and municipal LGUs for their contributions to the project:

**CBA2012-12NSY-CRUZ**

**PROJECT TITLE**

**Enhancing the Local Government Units Capacity for Implementing Conservation Farming Village as a Strategy for Climate Change Adaptation and Upland Development in the Philippines**

**COUNTRIES INVOLVED**

Philippines

**PROJECT DURATION**

1 year

**APN FUNDING**

US$ 45,000

**PROJECT LEADER**

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CBA-2012-13NSG-BORA

# Scoping Workshop to Develop an APN Proposal on "Capacity Building in Climate Change Mitigation through Precision Agriculture"

Ganesh C. Bora, Manzul Hazarika, Deben Baruah and M. Alam

## Project Objectives

The project was undertaken to organize a scoping workshop to prepare a proposal for enhancing the capacity of developing countries to adapt to precision agriculture in order to mitigate climate change, especially reducing GHG emissions by variable rates, while reducing application of fertilizer, chemicals and water in crop field. The project was intended to involve beneficiaries from Bangladesh, India, Thailand and Viet Nam. Officials from these countries joined the workshop in Bangkok, Thailand to discuss and gather thoughts to prepare the full proposal to be submitted to APN.

The proposed project will develop capacity building in Southeast and South Asia to mitigate climate change and reduce GHG emissions using the concept of precision agriculture (PA). PA is a system concept that involves the development and adoption of knowledge-based technical management systems with the goal of optimizing input resources to reduce fertilizer, chemical, seed and water application in order to reduce production costs and have positive environmental impacts. To meet the growing demand for food in a changing climate that reduces yields, adoption of PA is a practical solution to optimize input and maximize benefits reducing GHG emissions. The project plans to transfer knowledge and technology, adapted in developed countries for customized PA systems for scientists and policy makers.

### *Work Undertaken and Results*

A scoping workshop was organized at the Asian Institute of Technology, Bangkok, Thailand from 17–19 September, 2012. The workshop was attended by **Dr. Ganesh C. Bora** from North Dakota State University, Fargo, ND, USA; **Dr. Manzul Hazarika,** Associate Director of Geoinformatics Center (GIC); **Dr. Ganesh P. Shivakoti**, Professor of Resource Economics and **Dr. Peeyush Soni**, Assistant Professor of Precision

**PROJECT SUMMARY**

Policy makers along with scientists and academicians in developing countries like Bangladesh, India, Thailand and Viet Nam have substantial influence on development of modern agricultural methodologies. Precision agriculture (PA) in the USA has greatly contributed to reducing the use of chemicals and fertilizers, bringing positive economic impacts without affecting productivity. This has resulted in the reduction of greenhouse gas (GHG) emissions and aided in mitigating climate change impacts. Similar technology with adaptive modifications/customization can be used in developing countries and policy makers and professionals could be trained to influence the use of PA systems among farmers. A scoping workshop was conducted with experts and officials from Bangladesh, India, Thailand and Viet Nam to prepare a proposal to develop training activities in the use of PA to mitigate climate change.

Agriculture in Asian Institute of Technology, Bangkok, Thailand; **Dr. Deben Baruah,** Professor of Energy, Tezpur University; **Mr. Rajib Kr. Kalita** Scientist, Rain Forest Research Institute, Jorhat, India; **Dr. Le Thi Chau Ha,** Vice director of Centre of Geomatics, Water Resources University; **Ms. Le Yen Dung,** Deputy Director General of Department of Social and Natural Sciences, Ministry of Science and Technology, Hanoi, Viet Nam; and **Dr. Md. Monjurul Alam,** Professor of Farm Power and Machinery, Bangladesh Agricultural University, Mymensingh, Bangladesh.

Representatives from four countries presented the status of precision agriculture and the impacts of climatic factors and resource inputs in crop production. Precision agriculture is in the nascent stages in all these countries. It was fascinating to note that the technology is available and some of the large farmers have started to use it for economic benefits.

A common crop such as rice may be selected for this project. An economic analysis on the importance of Q certification, carbon balance, livelihood adjustment due to changes in climate should be studied. Studies can incorporate changes in methane gas emissions by changing crop rotation from rice-rice-rice to rice-X-rice and the results should be documented. Economic analysis should be done in terms of gross marginal analysis, partial budgeting, and


incremental benefits of using precision agricultural techniques in available forms. The impact of climate change can be assessed by reducing agricultural inputs and its effects on GHG emissions.

The full proposal on "Capacity Building in Climate Change Mitigation through Precision Agriculture" is being developed and will be submitted to APN in 2013 under the call for proposals for the CAPaBLE programme.

## Acknowledgments

The project team acknowledges the help and time provided by the staff of Geoinformatics Center of Asian Institute of Technology, Bangkok, Thailand in hosting the workshop.

**CBA-2012-13NSG-BORA**

**PROJECT TITLE**

**Scoping workshop to Develop an APN Proposal on "Capacity Building in Climate Change Mitigation through Precision Agriculture"**

**COUNTRIES INVOLVED**

India, Thailand, USA

**PROJECT DURATION**

1 year

**APN FUNDING**

US$ 15,000

**PROJECT LEADER**

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CBA2012-14NSG-ADININGSIH

# Climate Change Adaptation on Urban Planning in Southeast Asia

Erna Sri Adiningsih, Subramaniam Moten, Kim Chi Ngo, Jariya Boonjawat, Marcial Amaro Jr., Sem Sundara and Roland Fuchs

## Project Activities

The project consists of a scoping workshop to develop an APN proposal on climate change adaptation in urban planning. The discussions are a continuation of a series of discussions among the members of the APN Southeast Asia Sub-Regional Cooperation (SEA-SRC) Meetings in the past two years. The workshop will be held in Bandung, a city in West Java about 130 km from Jakarta. The city has been growing fast in the last three decades. Although it is located in a mountainous area, floods are a major disaster in Bandung due to dense settlement along river banks and increasing rainfall. Urban planning has, therefore, become an interest among climatologists and planners, as well as local government officials. The workshop is expected to be attended by 22 participants from APN member countries in SEA, i.e., from Indonesia, Malaysia, Thailand, Viet Nam, Philippines, Lao PDR, and Cambodia. Potential topics to be discussed are: (1) Reassessment of the original proposal and combined proposal based on reviewers' feedback; (2) Compilation and analysis of previous work and national systems related to urban planning school development; (3) Identification of key issues in urban planning related to climate change adaptation; (5) Identification of resource persons to be involved in the future work and the roles of APN SPG members and nFPs; and (6) Formulation of specific topics, scope of activities, and mode of operation in the proposal development and the way forward to strengthen and qualify a proposal from the APN SEA-SRC.

The project objectives are:

- To identify real problems and needs in climate change adaptation on urban planning in SEA;
- To identify existing gaps in human resources and technical skills necessary for climate change adaptation in the region among planners, government officials and universities;
- To discuss and formulate related previous works to enhance the proposal, including APN past projects, IPCC works, national and regional works, etc.;
- To formulate activities needed in capacity building of climate

**PROJECT SUMMARY**

The urgency for climate change risk management and reduction to become "part and parcel" of urban planning in the region has been recognized in recent reports by the UN and other organizations whose work is related to climate change. Climate change adaptation has become a major issue in SEA. The APN Southeast Asia Sub-Regional Cooperation meetings concluded that climate change impacts in urban areas are of common concern. A previous APN project, addressing megacities at risk, revealed common problems in urban areas in SEA. Appropriate urban planning as an adaptation action to climate change was then identified as a common interest. Unfortunately, planning schools in SEA do not include this as part of their curricula. A workshop will be conducted with the objective to develop curricula of planning schools in the SEA to incorporate climate change adaptation in urban areas.The outcomes of the workshop are to increase the capacity of SEA cities to deal with climate impacts, risk and vulnerability assessments; to increase the capacity of locally-led policy-relevant research on vulnerability of ASEAN coastal cities; and to develop an ASEAN knowledge network of researchers with international partners, and to share findings, experiences, and practices on adaptation to climate change.

change adaptation on urban planning and the mode of operation;
- To identify related resources and resource persons in respective countries;
- To develop a solid and qualified proposal to be submitted under APN 2013 Calls for Proposals.

The project is very relevant to APN's science agenda, particularly under the theme of climate change and climate variability. Adaptation has become a major tool for combating the impacts of climate change. The IPCC has also raised the issue of sea-level rise and flooding risks exacerbated by climate change. Recent research suggested that sea-level rise is occurring much faster than earlier anticipated and may reach 1–2 m by the end of the century, with serious consequences for flooding of coastal regions in Asia. Moreover, increasing rainfall in certain regions will exacerbate flood risks. Therefore, urban adaptation measures in Asian cities take on an even greater urgency than anticipated in earlier IPCC reports. Furthermore, all APN member countries in Southeast Asia, in its sub-regional cooperation meeting, revealed the importance of climate change as a priority problem to address. As APN's science and policy agendas focus on enhancing regional collaboration and linking science and policy in the region, this project is very relevant in terms of engaging scientists and policy makers in related areas to join the workshop.

## Work Undertaken

At the APN SEA-SRC meeting held in Siem Reap in October 2012, the project leader presented a concept paper and project details on an urban planning summer school in the SEA. The workshop was initially to be undertaken in December 2012 in Indonesia, but the project team agreed to postpone the date to avoid overlap with other APN and country activities. All APN SEA-SRC members have agreed to hold the workshop in the first or second quarter of 2013.

## Acknowledgments

The project team acknowledges APN for funding and the APN Secretariat for their technical and administrative support.

**CBA2012-14NSG-ADININGSIH**

**PROJECT TITLE**

**Scoping Workshop to Develop an APN Proposal on Climate Change Adaptation for Urban Planning in the Southeast Asia**

**COUNTRIES INVOLVED**

Southeast Asia

**PROJECT DURATION**

1 year

**APN FUNDING**

US$ 15,000

**PROJECT LEADER**

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CBA2012-15NSY-HIWASAKI

# Capacity Building to Strengthen Resilience of Coastal and Small Island Communities against Impacts of Hydro-Meteorological Hazards and Climate Change

Lisa Hiwasaki, Faisal Djalal, Emmanuel Luna, Jessica Mercer and Rajib Shaw

## Introduction

The Asia-Pacific region is increasingly threatened by extreme weather events and natural disasters that are becoming more frequent and catastrophic. With climate change, hydro-meteorological hazards — such as floods, droughts, storms, hurricanes and cyclones — are predicted to increase in frequency and will have more serious consequences (IPCC, 2007).

Efforts to mitigate the impact of natural hazards tend to focus on infrastructure development, or on high-tech solutions such as sophisticated early warning systems based on scientific data and modelling. While these technical solutions save lives when hazards strike, in recent years, the benefits of local and indigenous knowledge (LINK) in reducing disaster risk are increasingly being acknowledged. LINK refers to the understandings, skills and philosophies developed by societies with long histories of interaction with their natural surroundings. Such knowledge has helped many local communities live through, and survive, disasters and climatic changes in the past. Such knowledge will help increase our understanding of hydro-meteorological hazards and climate change. We can integrate this knowledge and know-how to better mitigate the hazard's impacts, to increase the preparedness, to have effective early warning methods, and to enable proper community responses in case of disasters.

It is against such background that a three-year project that aims to build the resilience of communities living in coastal zones and small islands against hydro-meteorological hazards and climate change impacts in Indonesia, the Philippines, and Timor Leste was launched in late 2010 by the UNESCO Office, Jakarta. The project "Strengthening Resilience of Coastal and Small Island Communities towards Hydro-Meteorological Hazards and Climate Change Impacts (StResCom)" is supported

**PROJECT SUMMARY**

Asia and the Pacific is a region particularly vulnerable to natural hazards, which, in combination with climate change, environmental degradation and social factors, increase the vulnerability of communities. The Hyogo Framework for Action (UNISDR 2005) emphasizes the need to understand the linkages between disaster risk reduction and climate change adaptation and, at the same time, highlights the importance of indigenous knowledge for disaster risk reduction. The objective of the project is to increase the resilience of coastal and small island communities in Indonesia, the Philippines and Timor Leste against hydro-meteorological hazards and climate change impacts by building the capacities of scientists and non-scientists to integrate different knowledges. The first activity implemented under the project was a workshop, "Integrating Local and Indigenous Knowledge with Scientific Knowledge for Knowledge-based Risk Reduction," held in Jakarta, Indonesia from 6–8 August 2012. Between October 2012 and April 2013, researchers are conducting action research to validate local and indigenous knowledge related to climate change and hydro-meteorological hazards, and to develop self-assessment tools and educational and awareness-raising materials that integrate local and indigenous knowledge with science. This will be followed by another regional workshop to launch the materials developed and share lessons learned.


financially by the Ministry of Education, Culture, Sports, Science and Technology of Japan through Japan Funds-in-Trust. Implemented in the second year of the StResCom project, the APN-funded activity is an integral part of the larger project and will substantially enrich the project outcomes, strengthen the expected results, and will play a crucial role in leading the StResCom project to its third year.

## Objectives

The objectives are to build the capacities of scientists and non-scientists to integrate scientific, local and indigenous knowledges, and to develop disaster risk reduction and climate change adaptation educational and awareness-raising materials.

The project is relevant to the APN's goals and Science Agenda as stated in its Third Strategic Plan (2010–2015) due to its focus on hydro-meteorological hazards, which are closely interlinked with climate change. Although activities related to natural disasters in the Asia-Pacific region have so far focused on earthquakes and tsunamis, in light of climate change it is in fact hydro-meteorological hazards that pose threats to people and their livelihoods, especially to those living in coastal zones and small islands. The activity's focus on hydro-meteorological hazards and climate change also contributes to the core strategies of the APN, in that it improves the level of awareness on global change issues that are specific to the region. Hydro-meteorological hazards are having devastating impacts on Asia's coastal areas. Such problems will be compounded by the effects of climate change, most notably sea-level rise.

## Work Undertaken

The workshop "Integrating Local and Indigenous Knowledge with Scientific Knowledge for Knowledge-based Risk Reduction" held in Jakarta, Indonesia from 6–8 August 2012, involved 22 participants from five countries representing experts, local and national organizations of targeted countries, government agencies, and the the UNESCO Office, Jakarta. During the workshop, participants discussed: (a) models, self-assessment tools, and methodologies for integrating local & indigenous knowledge with scientific and other knowledge for disaster risk reduction, and climate change adaptation; and (b) educational and awareness-raising materials for disaster risk reduction and climate change adaptation. The Center for Disaster Preparedness (CDP) in the Philippines, Tsunami and Disaster Mitigation Research Center (TDMRC) in Indonesia, and Universidade

Nacional Timor Leste (UNTL) in Timor Leste are currently conducting action research to develop self-assessment tools for communities to integrate LINK with scientific knowledge, as well as awareness-raising and educational materials that integrate knowledges for disaster risk reduction and climate change adaptation. The materials will be published in local language of each of the three countries. The project is being implemented as planned in the project timeline. The UNESCO Office, Jakarta is currently working closely with the partnering organizations to deliver the expected results of the project.

Educational & awareness-raising materials will be published by April 2013 and a synthesis report and a policy brief targeting archipelago countries in Asia and the Pacific will be developed in June 2013.

## Acknowledgments

The authors would like to thank the Asia-Pacific Network for Global Change Research (APN) for providing financial assistance to enable the development of the knowledge integration models, self-assessment tools, and educational & awareness-raising materials. The Japanese Ministry of Education, Culture, Sports, Science and Technology is gratefully acknowledged for providing funding for the three-year "StResCom" project, through UNESCO/Japan Funds-in-Trust.

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UNISDR. (2005). Hyogo Framework for Action 2005–2015: Building the Resilience of Nations and Communities to Disasters.

**CBA2012-15NSY-HIWASAKI**

**PROJECT TITLE**

**Capacity Building to Strengthen Resilience of Coastal and Small Island Communities against Impacts of Hydro-Meteorological Hazards and Climate Change**

**COUNTRIES INVOLVED**

Indonesia, Japan, Philippines

**PROJECT DURATION**

1 year

**APN FUNDING**

US$ 49,000

**PROJECT LEADER**

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CBA2012-16NSY-GORDOV

# Capacity Building to Study and Address Climate Change-Induced Extremes in Northern Asia

Evgeny Gordov

## Introduction

The activity is aimed mainly at involving the regional research community, especially young scientists, in professional activities in the area of climate change in Northern Asia with special emphasis on their interrelations with observed and projected extremes and anthropogenic load. Another objective of the activity is to provide regional decision makers with updated information on these important issues for regional well-being, thus paving the way to addressing their concerns with development of adaptation measures.

## Work Undertaken

Firstly, an international workshop was organized with enlarged participation of young scientists from the targeted region devoted to different aspects of climate change-induced extremes in Northern Asia and their impact on the regional environment. It was embedded into the biannual **International Conference and Early-career Scientists School on Environmental Observations, Modelling and Information Systems ENVIROMIS-2012** and took place in Irkutsk from 27 June–2 July 2012. The APN Workshop comprised five sessions: environmental and socioeconomical consequences of climate change and related extremes; organizational, observational and ICT infrastructures of regional scale environmental Studies in Northern Eurasia; meteorological extremes and climate change in Northern Eurasia; drought and flood extremes; and geosphere-biosphere interactions and related extremes. A round table was organized that provided first outcomes and visions for regional decision makers. Also, young scientists' education and training activities were discussed.

During the workshop leading experts in the area delivered three lectures and 24 invited talks, providing participants with cutting-edge knowledge in meteorological information on climatic extremes and their interrelations with anthropogenic load and climate

**PROJECT SUMMARY**

The activity includes workshop organization with enlarged young scientists' participation from the targeted region devoted to the study of climate change-induced extremes in Northern Asia. The Workshop was embedded into the international ENVIROMIS Conference, which enlarged the number of young scientists and regional decision makers involved. Also a dedicated website will be launched in support of young scientists' education/training in this domain thus involving regional research community into professional activity as well as attracting attention of population and decision/policy makers to these issues. Generation and transfer of new findings about climate change-induced extremes with special emphasis on their manifestations in Northern Asia and their potential role in sustainable development in the region Assistance in the career development of promising young scientists in the region and their involvement with APN and the community of global change scientists represented at the ENVIROMIS Conference. The dedicated website containing educational and basic thematic information on climate change-induced extremes and their manifestations in Northern Asia will form a powerful instrument for young scientists' training and a platform for dissemination of important environmental information on global change issues and relevant risks to sustainable development in the region.



**Figures:** (1) Prof. Jianlong Li (Nanjing University, China) and Dr. P. Groisman (NOAA, USA) are establishing new links between MAIRS and NEESPI. (2) The Workshops Co-Chairs Evgeny Gordov (SCERT, Russia) and Pavel Groisman ((NOAA, USA) are discussing a technical problem. (3) Poster Session gave Dr. Renchin Tsolmon and young scientist Amar Tungalag (NMU, Mongolia) opportunity to get new information on dry and wet spells from Dr. P. Groisman (NOAA, USA)

change in Northern Asia. Young scientists presented 25 reports. The workshop promoted the generation and transfer of new findings and methodologies in climate change; and assisted in the career development of promising young scientists in the region and their involvement with APN and the community of global change scientists represented at the ENVIROMIS event. The young scientists become a part of an overall network of NEESPI scientists interested in different aspects of global change in Northern Asia.

In the second stage a set of educational materials that are important for understanding the impacts of the regional climate change-induced extremes was prepared by the key APN workshop participants based on the thematic presentations. The set included 15 thematic papers, which are extended versions of the materials presented.

During the third stage these materials will be opened to access via a dedicated website, which will be developed and launched as an open information system aimed at supporting education/training in the domain of climatic and environmental change in Northern Asia, with a special emphasis on climate change-related extremes.

## Project Publications

Proceedings MAIRS/NEESPI/SIRS APN Workshop "Climate change-induced extremes in Northern Asia," Tomsk, Russia, 27 June – 2 July 2012, CNTI Publishing House, Tomsk, Russia, 2012.

## Acknowledgments

Additional support of the ENVIROMIS Conference and APN workshop by RFBR and START is acknowledged.

**CBA2012-16NSY-GORDOV**

**PROJECT TITLE**

**Capacity Building to Study and Address Climate Change-Induced Extremes in Northern Asia**

**COUNTRIES INVOLVED**

China, Russia, USA

**PROJECT DURATION**

1 year

**APN FUNDING**

US$ 40,000

**PROJECT LEADER**

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CBA2012-17NSY-PRADHANANGA

# Empowering Asia-Pacific Youth on Green Economy

Dhiraj Pradhananga, Jeeban Panthi, Roshana Maharjan, Gregory Pierce, Tek Jung Mahat and Utsav Maden

## Background

Small Earth Nepal (SEN) in collaboration with the Consortium for Capacity Building (CCB) and the International Centre for Integrated Mountain Development (ICIMOD), with major funding support provided by the APN under its CAPaBLE programme, organized the Asia-Pacific Graduate's Youth Forum on Green Economy in Kathmandu, Nepal, 25–29 September 2012. The Forum was supported by over a dozen organizations including the Asia-Pacific Mountain Network (APMN), the Swiss Agency for Development and Cooperation (SDC), the University of Colorado at Boulder, the United States Agency for International Development/ Office of Foreign Disaster Assistance (USAID/OFDA), the Asian Institute of Technology (AIT), the Centre for Hydrology at the University of Saskatchewan and many others. The youth forum brought together 40 motivated young people between the ages of 18–30 from 14 countries across the Asia-Pacific region, which includes the sub-regions of Greater South Asia, the Hindu Kush-Himalayas, East Asia, Central Asia, Pacific Rim nations and others, to deliberate on and better understand the promise of a green economy. The goal of the forum was to build the capacity of the young participants on issues relating to green economy and climate change adaptation in countries and regions from high mountains to coastal lowlands, that is, from the highlands to the oceans (H2O), especially in anticipation of the UNFCCC-COP process and COP18 events that followed in Doha, Qatar. The main objectives of the youth forum were as follows:

- Developing the capacity of selected Asia-Pacific youth on green economy, environmental

**PROJECT SUMMARY**

Green economy is a framework that is hoped will ensure genuine, long-term sustainability, survivability, well-being and happiness for all people everywhere, always within the limits of nature. It is an inclusive approach, promoting fairness, equity, participation, freedom and democracy, with social and environmental justice at its core. The five-day workshop "Asia-Pacific Graduate Youth Forum on Green Economy" organized in Kathmandu in September of 2012 focused on building the capacity of 40 youth leaders from across the Asia-Pacific region, thereby facilitating knowledge exchange, enhancing collaboration and strengthening capacity on issues related to green economy and climate change adaptation. A declaration produced by the youth participants was drafted at the end of the forum as an outcome that was hoped would balance their previous understanding of the issues discussed, the knowledge they gained during the event and the space for specific future action that they produced in coming together at the forum. The declaration covers six key areas: green entrepreneurship, sustainable energy, low carbon economy, climate change adaptation, collaboration, policy implementation and monitoring, and youth empowerment and inclusiveness. The voice of youth should be recognized when policy is made because such policy will affect the future, which is embodied in the youth of all nations.


governance and climate change adaptation;

- Facilitating information and knowledge sharing, networking and advocacy in the Asia-Pacific region through the establishment of virtual and physical networks of dedicated youth; and
- Improving participation of regional youth in the globally-important meeting of UNFCCC COP18.

The project was conducted in accordance with the APN's science and policy agendas, fostering increased science-policy interactions by embracing the interdisciplinary approach of a green economy. The project gave participating youth from APN member countries the opportunity of interacting in different ways with scientists and policy makers throughout the workshop. The workshop also included the formulation of a declaration that strongly requests policy makers and other powerful stakeholders to listen to the voices of the young generation when debating policy agendas that must include measures to ensure sustainable development.

Specifically, the programme focused on the capacity building and knowledge sharing sessions, leadership workouts and excursions to neighbouring environmental project areas.

## Asia-Pacific Graduate Youth Forum on Green Economy

The workshop facilitated youth involvement through knowledge sharing in diverse aspects of green economy through various expert presenters with whom participants were given many opportunities to interact. The workshop communicated the challenges and opportunities of green economy, REDD+, GIS applications, low carbon growth, social media, and quantification of energy, renewable energy technology, green entrepreneurship, and ICT and climate change. A day-long visit to a nearby green entrepreneurship site motivated the participants by showing them how working in green sectors is often undertaken by motivated individuals like themselves.

## Declaration

The participants concluded the scientific discussion of the forum with the formulation of a declaration: *Adaptation and Mitigation Strategies for Climate Change through Green Economy Initiatives*. The declaration is aimed at government officials and decision makers, asking them to take immediate steps towards implementing the six key areas chosen as crucial by the young participants. Those key areas are green entrepreneurship,

sustainable energy, low carbon economy, climate change adaptation, collaboration, policy implementation and monitoring, and youth empowerment and inclusiveness.

## Participation at UNFCCC COP18

Four delegates among the workshop participants were selected to participate at UNFCCC COP18 as Asia-Pacific representatives. They had the chance to participate in various events like the World Climate Summit, the revival of the Asian Youth Climate Network, Momentum for Change, etc. They utilized the opportunity by disseminating the workshop declaration to national and international stakeholders as well as to climate negotiators. Their participation also motivated them to become active role models within their communities, and especially for young people, and to further develop their genuine concern for the global environment.

## Acknowledgments

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**CBA2012-17NSY-PRADHANANGA**

**PROJECT TITLE**

**Preparation of Next Generation Leadership in Sustainability: An Approach in the Asia-Pacific Region**

**COUNTRIES INVOLVED**

South Asia with leadership from Nepal and USA

**PROJECT DURATION**

1 year

**APN FUNDING**

US$ 44,994

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CBA2012-18NSY-PAGES

# PAGES Young Scientists Meeting 2013 in India — Building Capacity for Asia-Pacific Scientists

Thorsten Kiefer and Saadia Iqbal

Past Global Changes, or PAGES (www.pages-igbp.org), a core project of the International-Geosphere-Biosphere Programme, held its 2nd Young Scientists Meeting (YSM) and 4th Open Science Meeting (OSM) in Goa, India, from 11–16 February 2013. These two coupled meetings are PAGES premier scientific events, held once every four years and geared toward helping the best young and established scientists advance their scientific skills and build international networks with peers and programme representatives. With generous co-sponsorship, APN is enabling early-career researchers from the Asia-Pacific region to participate in the YSM and afterwards mingle with their more established colleagues at the OSM.

The event's predecessor, the last YSM/OSM held in 2009 in the USA, was already extremely successful, particularly in raising a group of excellent early-career scientists. However, the meeting's location made it less favourable for Asian participants. Therefore, India was chosen as this year's location, with the overarching objectives of strengthening the international involvement of Asian scientists and of nurturing leadership capacity among them. The YSM is reserved for 83 competitively selected early-career scientists from all over the world. Of these, 37 come from APN member countries, mostly from Asia.

The main objectives of the PAGES YSM/OSM are:

- To support the career development of early-stage scientists and raise a group of future leaders who are accustomed to working in international networks.
- To discuss global change research and coordination strategies at the highest level.
- To launch publication and working group activities that will extend collaboration beyond the meetings.
- To facilitate networking between scientists from different countries, disciplines, career stages, and programmes.
- To foster scientific exchange about past global change research and encourage international collaborations.

Moreover, the specific aims of the 2013 YSM/OSM are:

- To advance science and promoting regional cooperation on Asia-relevant topics such as monsoon, sea-level rise and the coastal zone, regional climate variability, river systems and estuaries, land-cover change, biodiversity, ecosystem processes, and ocean circulation.
- To facilitate science-policy-public interaction in Asia. Government representatives and senior scientists advising governments attended to

**PROJECT SUMMARY**

Past Global Changes, or PAGES, a core project of the IGBP, will hold its 2nd Young Scientists Meeting (YSM) in February 2013 in Goa, India, as a prelude to the subsequent 4th Open Science Meeting (OSM). The meetings aim is to build capacity for young and established scientists in the Asia-Pacific region and foster scientific exchange and collaboration internationally. Event highlights include scientific sessions that address burning scientific issues; strategic debates on future research requirements and discussions about research implementation; dissemination and outreach through scientific publications and reports, videos, and downloadable materials; networking via extensive poster sessions, breakout discussions, social events, and post-meeting opportunities; and knowledge transfer through scientific sessions, professional skill development sessions, and presentation feedback.

> Overall, the six days were remarkably informative and inspirational. In particular, the presentations demonstrated a consistently high degree of integration, both between different proxies and between the data and modelling communities. This sets a standard towards which we should all aspire.
>
> *—Steven J. Phipps, Joelle Gergis and Lynda Petherick about the 1st YSM in 2009*

ensure policy input. Rajendra Pachauri, Chair of the IPCC, delivered a public lecture, which is expected to contribute to public awareness of global change and its impacts on South Asia.

- To encourage Asian scientists to be involved in the international global change community and assume leadership roles.
- To broadly involve the APN community in the PAGES debate about future research requirements and directions.

To cooperate with global change networks and organizations, including defining the future role of past global change science, particularly in the context of "Future Earth."

The above goals demonstrate the close links between the meetings' aims and APN's science and policy agendas. It is anticipated that the meetings will help acquaint scientists in the Asia-Pacific region with APN and its mission to support global change research.

## Next Steps

Just like the meetings themselves, the follow-up activities have a strong capacity building component. In particular, YSM aims to equip young scientists to take on future leadership in sustainability science and associated programmes with the idea that these up and coming leaders will seed future scientific communities. The decision to hold the YSM/OSM in India was specifically motivated by the large intellectual and economic potential for this form of capacity building in the region.

Below are some of the expected outcomes for the 2013 YSM/OSM:

- Publication of research results presented by the young scientists in an open access journal, with involvement of young scientists as guest editors;
- Meeting reports for publication in various organizations' magazines (for example, APN, PAGES, IGBP, AGU-Eos) written predominantly by young scientists;
- A concept paper on the future role of international past global change science and its coordination;
- Web-videos (and DVDs) of the plenary talks at the OSM; and
- An online exhibition of the talks and posters on the YSM/OSM website.

## Publications

The last PAGES YSM in Corvallis in 2009, the first of its kind, resulted in several publications:

Basse, E. M. (2010). PAGES 1st Young Scientists Meeting (YSM) — "Retrospective views on our planet's future". *IOP Conference Series: Earth and Environmental Science, 9*(1). Retrieved from http://

> The YSM successfully bridged the gap between summer schools and conferences by providing a relaxing environment to learn from colleagues from other fields. Simultaneously, it facilitated networking between emerging young scientists and introduced them to organizational aspects of science, such as funding, publishing, and communication of results. The concept behind this meeting worked efficiently to support the young scientists on their initial steps toward advancing the field of paleoclimatology.
>
> *—Pedro Dinezio, Caroline Cleroux, Patrick Applegate and Pamela Collins about the 1st YSM in 2009*

iopscience.iop.org/1755-1315/9/1/011001

Phipps, S. J., Gergis, J., & Petherick, L. (2009). Pages 1st Young Scientists Meeting and 3rd Open Science Meeting. *Quaternary Australasia, 26*(2), 8. Retrieved from http://search.informit.com.au/documentSummary;dn=976225297498108;res=IELHSS

Reyes, A., & Gagen, M. (2009). Young Paleoclimate Scientists Meet to Broaden Knowledge and Build Ties: PAGES 1st Young Scientists Meeting: Retrospective Views on Our Planet's Future; Corvallis, Oregon, 6–7 July 2009. *Eos, Transactions American Geophysical Union, 90*(39), 344–344. Retrieved from http://onlinelibrary.wiley.com/doi/10.1029/2009EO390005/abstract

DiNezio, P., Cleroux, C., Applegate P., & Collins. P. (2009). Young scientists meet to exchange science, network and learn about PAGES, PAGES news 17 (3): 131–133. Retrieved from http://pages-142.unibe.ch/products/newsletters/2009-3/workshop%20reports/DiNezio_etal_2009-3(131-133).pdf

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**CBA2012-18NSY-PAGES**

**PROJECT TITLE**

**The Past: A Compass for Future Earth — PAGES 2nd Young Scientists Meeting and 4th Open Science Meeting**

**PROJECT DURATION**

1 year

**APN FUNDING**

US$ 30,000

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The SPG Members recommend a scientific programme including proposals for priority of funding and allocation of current available funding for consideration by the Inter-Governmental Meeting (IGM); works with the Steering Committee and the Secretariat in arranging scientific programme activities; and interacts on the APN's behalf with other international research programmes on global change. SPG Members also interact with the national Focal Point of their respective countries, the Secretariat, and the national and global change communities.

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