

# APN Science Bulletin

Asia-Pacific Network for Global Change Research

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**Past Trends and Future Projections of Climate and Hydrology over Asia including 18 Demonstration Basins in Asian Water Cycle Initiative (AWCI) Countries**

**Strategic Rice Cultivation for Sustainable Low Carbon Society Development in Southeast Asia**

**Coastal Marine Biodiversity of Viet Nam: State and Current Problems**

**Reconstruction of Sea Level Change in Southeast Asia Waters Using Combined Coastal Sea Level Data and Satellite Altimetry Data**

**Socio-Economic Vulnerability of the Mangrove Ecosystems to Climate Change in South Asia: A Case Study of the Indus and Ganges Deltas**

**Capacity Building Assessment for Integrated Marine Biogeochemistry and Ecosystem Research in the Asia-Pacific Region**

**Building Capacity on Access and Benefit-Sharing in Southeast Asia**

**Marine Invasive Species in the Northwest Pacific Region of China**

**Conservation Farming Village (CFV) Programme for Protecting Uplands and Building Resilient Communities**

Global Environmental Change





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# PREFACE

The present publication is the 4th 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 4 (2014) 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 and supported by the APN, the bulletin focuses on issues of underpinning science that are policy-relevant. The 2014 Science Bulletin aims to satisfy readers in both the science and non-science communities who have a keen interest in Global Environmental Change in the Asia-Pacific region.

The 2014 APN Science Bulletin highlights APN projects either funded and/or completed in the year of publication (the present year runs from April 2013 – March 2014). 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. In addition, the present bulletin provides summaries of work undertaken in the APN's area of focused activities under its Low Carbon Initiatives Framework (LCI).

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 past trends and future projections of climate and hydrology over Asia to protecting uplands and building climate-resilient communities. Other issues focus on low carbon society development in Southeast Asia, coastal marine biodiversity of Viet Nam, socio-economic vulnerability of mangrove ecosystems to climate change, and building capacity on access and benefit sharing.

The core regional research programme is supporting twenty-seven regional-based research activities this year, 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 the bulletin summarises fifteen capacity development activities and their impacts in the region. Activities extend from supporting young and early-career scientists to attend major global change programme events such as SCOR and MAIRS, to providing regional climate modelling training programmes (CORDEX) and looking at the impacts of global environmental change on a number of important sectors.

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 fourth issue of the APN Science Bulletin both interesting and useful in your work.

Linda Anne Stevenson (Head, APN Communication & Scientific Affairs)

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# FEATURED ARTICLES

I

ARCP2011-05CMY-BAE

# Past Trends and Future Projections of Climate and Hydrology over Asia including 18 Demonstration Basins in Asian Water Cycle Initiative (AWCI) Countries

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**ABSTRACT:** The present study analysed historical climate and hydrology trends of future climate change impacts over 18 demonstration basins in Asian Water Cycle Initiative (AWCI) countries. The Mann-Kendall test was employed for past trend analyses. The analysis showed an increasing trend for average temperature and a decreasing trend for average precipitation and runoff over Asia in the past 30 years (1977–2006). To analyse future climate change impacts, three Global Circulation Models (GCMs), i.e., CGCM3\_T47, CGCM2\_3\_2 and CM4 were selected using criteria based on probabilistic uncertainty analysis, correlation coefficient and RMSE. The analysis projected increases in average temperature, precipitation and runoff over Asia in 2020s, 2050s and 2080s. By 2080s, the average temperature, precipitation and runoff over Asia were projected to increase by 3.7°C, 10.7% and 11.1%, respectively.

**KEYWORDS:** *climate change, trends analysis, Mann-Kendall, GCM*

## Introduction

Climate change impact assessments are necessary to mitigate and prepare for climate change-induced disasters in the future. The Asian monsoon region is highly susceptible to natural hazards and the monsoon plays an important role in global water circulation, providing substantial precipitation and water resources to the people living within the region. While the Asia

monsoon can provide substantial benefits, such as for power generation and foodgrain production, etc., it can also contribute to flood and drought problems.

Many factors contribute to water-related problems, but climate change complicates the issues in Asia, thus rendering difficult-to-manage scenarios during the monsoon period. Presently, policy decisions in the water sector are often made with uncertain information regarding the future state of climate and available water

resources. Thus, prediction of future climate trends could be a key factor that affects further development of the Asian region. The main objectives of the present study are to analyse historical trends of climate and hydrology over Asia as a whole and in eighteen individual basins, one selected from each of the countries that participate in the Asian Water Cycle Initiative (AWCI), using the Mann-Kendall test, and to project future change in climate and hydrology using suitable GCMs.

### Study Area and Data

The present study analysed both historical trends and future projections of climate and hydrology in the Asian monsoon region. The study area covered all eighteen countries involved in the AWCI, i.e., Bangladesh, Cambodia, India, Indonesia, Japan, Laos, Malaysia, Mongolia, Nepal, Pakistan, Philippines, South Korea, Sri Lanka, Thailand, Uzbekistan, Bhutan, Myanmar and Viet Nam as shown in Figure 1. The analysis first addressed climate and hydrology trends in Asia overall and then in eighteen specific hydrologic basin (one in each country). The basins were selected based on their importance from the viewpoint of socio-economic benefits and availability of hydrological data including precipitation, maximum and minimum temperature, streamflow and wind speed data. Table 1 identifies basins that were selected.

Precipitation and temperature data at 0.5 degree horizontal grid resolution was obtained from the APHRODITE data set (Asian Precipitation-Highly-Resolved Observational Data Integration Towards Evaluation of Water Resources). This data set is based primarily on data obtained from a rain-gauge-observation network (Yasutomi et al., 2011 and Yatagai et al., 2012) that covers all eighteen countries. To run the Variable Infiltration Capacity (VIC) macroscale hydrologic model, the Digital Elevation Model (DEM), Soil and Land use datasets were obtained from U.S. Geological Survey (USGS, 1996) (<http://eros.usgs.gov>), Food Agriculture Organization (FAO, 1998) and University of Maryland (Hansen et al. 1998), respectively at different available resolutions and converted to 0.5 degree grid resolution to comply with resolution of other datasets used in the study. In addition, we used 0.5 degree gridded meteorological forcing dataset (Adam & Lettenmaier, 2003; Adam et al. 2006) as input for VIC model. For analysis of historical trends, we used temperature, precipitation and runoff data for 30-year period from 1977 to 2006.

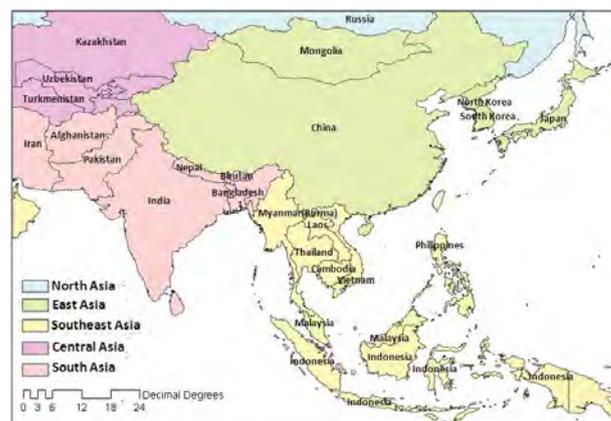
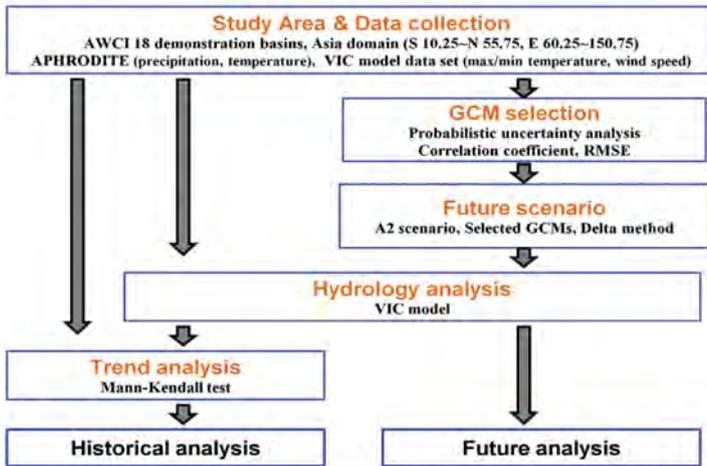


Figure 1. The study area.

No.	Country	Basin name	Area (Km <sup>2</sup> )	Climate regime
1	Bangladesh	Meghna	61,021	Humid
2	Bhutan	Punatsangchhu	13,263	Temperate
3	Cambodia	Sangker	2,961	Very Humid
4	India	Seonath	30,760	Humid
5	Indonesia	Mamberamo	78,992	Humid
6	Japan	Tone	3,300	Humid
7	Korea	Upper Chungju-dam	6,662	Temperate
8	Lao PDR	Sebangfai	8,560	Very Humid
9	Malaysia	Langat	2,350	Very Humid
10	Mongolia	Selbe	303	Semi-arid
11	Myanmar	Shwegyin	1,747	Very Humid
12	Nepal	Bagmati	3,700	Humid
13	Pakistan	Gilgit	12,800	Humid
14	Philippines	Pampanga	10,540	Humid
15	Sri Lanka	Kalu Ganga	2,720	Very Humid
16	Thailand	Mae Wang	600	Humid
17	Uzbekistan	Chirchik-Okhangaran	20,160	Humid
18	Viet Nam	Huong	2,830	Very Humid

Table 1. General description of 18 demonstration basins.



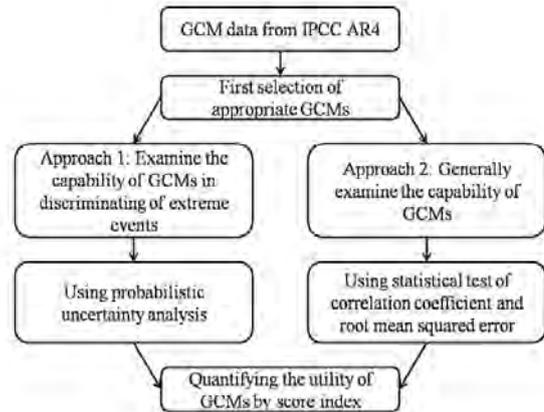
**Figure 2.** Methodology.

### Methodology

The methodology adopted to analyse the historical and future trends is illustrated in Figure 2. Primarily, the past climatology (precipitation, max/min/mean temperature, wind speed) data was collected from APHRODITE and VIC model dataset. The selection of appropriate GCM is an important step for projection of future climate and hydrology. In this study, nine GCMs (as shown in Table 2) available for use in Asia were compared and evaluated. The optimum GCMs were selected based on methods of probabilistic uncertainty analysis, correlation coefficient, and root mean square error (RMSE) as shown in Figure 3. The overall ranking of each GCM was computed based on the scores of all three statistical tests and the three highest-ranked GCMs, i.e., CGCM3\_T47, CGCM2\_3\_2 and CM4 were selected in this study. For further details on GCMs selection procedure the reader may refer (Le & Bae, 2013). The future scenarios (A2) of three selected GCMs were disaggregated to daily time scale using delta method.

The VIC model was employed for analysis of hydrology data. A regionalisation method was used for parameter estimation of the VIC model at ungauged basins using runoff data from the Global Runoff Data Centre (GRDC). The regionalisation method employed was based on climate zones obtained from Köppen climate classification for Asia (Nijessen et al. 2001).

The Mann-Kendall test was used to analyse past trends. It is a non-parametric test for detecting trends in time series data which has the ability to cope with missing values and values below a specified detection limit. The test is widely used for analysing trends in environmental data (Kahya & Partal, 2007; Liu & Zheng, 2004).



**Figure 3.** Procedure for evaluating the utility of IPCC AR4 GCMs.

### Results and Discussion

#### Past Trends of Climate and Hydrology over Asia

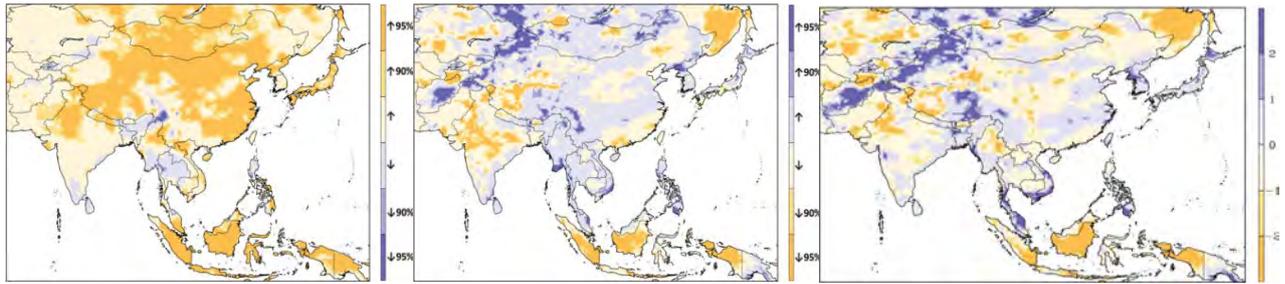
The Mann-Kendall test was applied to 30-years (1977–2006) of temperature, precipitation and runoff data in Asia as a whole and at selected basins. The Mann-Kendall test statistics were computed for each grid point and the spatial distribution of trends was obtained as shown in Figure 4. The results show increasing and decreasing trends with 90% and 95% significance levels. The arrows (↑) and (↓) denote the increase and decrease trends, respectively. Results

#### HIGHLIGHTS

- » Decreasing trends in precipitation and runoff, and increasing trends in temperature over most regions in Asia over the past 30 years.
- » Temperature is projected to increase in all areas in Asia.
- » Precipitation is projected to significantly increase over southwestern parts of South Asia and decrease over bordering regions of South Asia and East Asia.

indicate that over the past 30 years, the average temperature over Asia increased approximately by  $0.27^{\circ}\text{C}/\text{decade}$ . This estimated increase is substantially high compared to global temperature increase of  $0.13^{\circ}\text{C}/\text{decade}$  by 4th assessment report of the Intergovernmental Panel on Climate Change (IPCC, 2007).

Most regions show increasing temperature trends except Bangladesh, Thailand and Sri Lanka. Especially distinct increasing trends (95% confidence level) are observed over Indonesia, Malaysia, Tibetan Plateau,



**Figure 4.** Mann-Kendall test results of annual historical temperature, precipitation and runoff over Asia region.

northwest India, Mongolia, China, Korea and Japan. Some other regions also show increasing trends, although with less significant confidence levels.

The average annual precipitation was observed to decrease by 86.5 mm over Asia as a whole over the 30-year period. Especially significant decreasing trends of precipitation (with a 95% confidence level) appeared over the Tibetan Plateau, Indonesia, inland

India and southern Far East Russia, while increasing trends were observed over northwest China, north Pakistan, eastern Afghanistan and Korea. The average annual runoff over Asia overall decreased by approximately 41.8mm over the same time period. The spatial distribution of runoff trends was similar to that of precipitation trends.

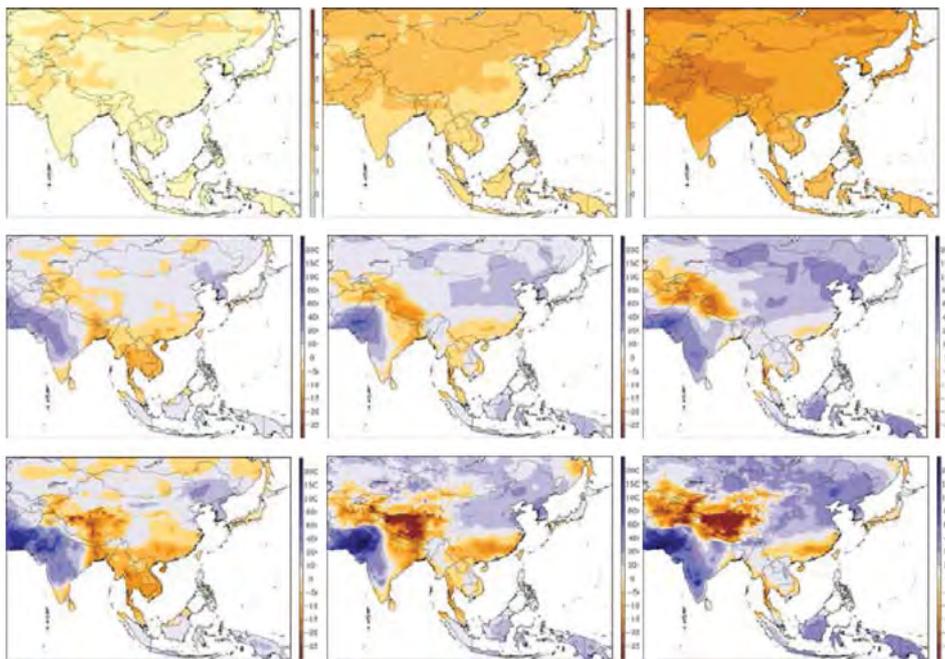
The basin-scale trend analysis was also conducted for eighteen selected basins applying the Mann-Kendall test for the 30 years. The results for annual temperature, precipitation and runoff for these basins are shown in Table 3. All eighteen basins demonstrated an increasing trend in annual temperature. The trend in temperature increase at ten basins was statistically significant at 95% confidence level.

The Mann-Kendall test revealed a decreasing trend for annual precipitation at Mamberamo basin, and increasing trends at Langat, Gilgit, and Huong basins with statistical significance at 95% confidence level. All remaining basins showed increasing trends for annual precipitation at a lower confidence level except Sangker, Seonath, Sebangfai and Selbe basins. The trend analysis of runoff showed decrease in the annual runoff at Mamberamo basin and increase at Chungju-dam, Langat and Gilgit basins with statistical significance at 95% confidence level. All remaining basins showed increasing trends for annual runoff except Punatsangchuu, Sangker, Seonath, Sebangfai and Selbe basins at a lower confidence level.

The results of basin-scale analysis should be used with care to deduce the general trend over a particular region as these results may sometimes be misleading due to uncertainty in data for a single grid point or a single station. For instance, the basin-scale analysis at Kalu Ganga basin in Sri Lanka showed an increasing trend in temperature even though Sri Lanka has an overall decreasing temperature trend over the past 30 years, as shown in Figure 4.

No.	Country	Basin	Trend analysis		
			TMP	PPT	RNF
1	Bangladesh	Meghna	△	△	△
2	Bhutan	Punatsangchhu	△	△	▽
3	Cambodia	Sangker	▲	▽	▽
4	India	Seonath	△	▽	▽
5	Indonesia	Mamberamo	▲	▼	▼
6	Japan	Tone	▲	△	△
7	Korea	Chungju-dam	△	△	▲
8	Lao PDR	Sebangfai	▲	▽	▽
9	Malaysia	Langat	▲	▲	▲
10	Mongolia	Selbe	▲	▽	▽
11	Myanmar	Shwegylin	△	△	△
12	Nepal	Bagmati	▲	△	△
13	Pakistan	Gilgit	▲	▲	▲
14	Philippines	Pampanga	△	△	△
15	Sri Lanka	Kalu Ganga	△	△	△
16	Thailand	Mae Wang	△	△	△
17	Uzbekistan	Chirchik-Okhangaran	▲	△	△
18	Viet Nam	Huong	▲	▲	▲

**Table 2.** Trend analysis of temperature (TMP), precipitation (PPT) and runoff (RNF) using the Mann-Kendall test at 18 demonstration basins. The filled triangle indicate statistically significant trend at 95% confidence level.



**Figure 5.** Relative change of temperature (top), precipitation (middle) and runoff (bottom) by 2020s (left), 2050s (centre), 2080s (right).

#### *Future Projections of Climate and Hydrology over Asia using CGCM3\_T47, CGCM2\_3\_2 and CM4*

In this study nine GCMs were compared and evaluated for Asia region and three best GCMs i.e. CGCM3\_T47, CGCM2\_3\_2 and CM4 were selected. For future climate and hydrology impact, the ensemble mean values of selected GCMs were used. To assess the uncertainty of selected GCMs for future projections, we analysed the results of each GCM. The results showed increased uncertainty toward future periods. By the end of 21st century, the projections results of temperature showed the uncertainty of about 1.1°C with average annual temperature increase of 3.0°C, 3.6°C and 4.1°C over Asia as a whole by CGCM2\_3\_2, CGCM3\_T47 and CM4, respectively. The projection results for average annual precipitation over Asia as a whole showed comparatively low uncertainty with difference of about 3.3%. The increase of 14.5%, 14.3% and 11.2% average annual precipitation was projected by CGCM2\_3\_2, CGCM3\_T47 and CM4, respectively.

Figure 5 shows the changes projected in temperature, precipitation, and runoff at future periods (2020s:2011-2040, 2050s:2041-2070, 2080s:2071-2100) relative to the reference period (1977-2006). The projections showed increase of average temperature over Asia during all future periods. The average temperature over Asia was expected to increase by 0.9°C, 2.1°C and 3.7°C in 2020s, 2050s and 2080s, respectively. The projection results showed 1.8%, 4.6%

and 10.7% increase in annual mean precipitation over Asia by 2020s, 2050s and 2080s, respectively. The precipitation was projected to significantly increase over the southwest region of South Asia and decrease over the bordering regions of South Asia and East Asia. The projection results showed 1.5%, 3.9% and 11.1% increase in annual mean runoff over Asia by 2020s, 2050s and 2080s, respectively. The projected spatial distribution of future runoff change was similar to that of precipitation over Asia.

The results of future change in the eighteen specific basins are summarised in Table 4 showing change rates of temperature, precipitation and runoff in the 2020s and 2080s. Temperature was projected to increase at all the basins in both future periods. The highest increase of 5°C was projected in the Gilgit basin and lowest increase of 2.6°C was projected in the Pampanga basin by 2080s. For precipitation, nine basins showed decreasing trends by the 2020s and subsequently increasing trends by the 2080s.

Precipitation was projected to increase in all of the remaining basins for both future periods of the 2020s and the 2080s except Chirchik Okhangaran basin which showed an increasing trend by the 2020s followed by a decreasing trend by the 2080s. By 2080s the highest increase of 21.1% and highest decrease of 16.4% precipitation was projected at Mamberamo and Giglit basins, respectively. The projected features of runoff at most selected basins were similar to that of precipitation for future periods. By 2080s the highest increase of 28% and highest decrease of 19.9% runoff

	Demonstration basins	Temperature		Precipitation		Runoff	
		2080s	2020s	2080s	2020s	2080s	2020s
1	Meghna	1.3	4.0	-6.4	6.6	-9.7	6.1
2	Punatsangchhu	0.7	4.0	-7.1	4.8	-11.0	3.8
3	Sanker	0.6	3.0	-8.7	0.4	-12.8	-0.6
4	Seonath	0.8	4.0	11.8	14.9	18.8	19.5
5	Mamberamo	0.6	2.8	6.8	21.1	9.2	28.0
6	Tone	0.6	3.3	1.0	4.1	0.5	1.2
7	Chungju-Dam	0.9	3.8	11.6	17.7	15.4	21.2
8	Sebanfai	0.8	3.1	-8.2	7.2	-11.3	8.8
9	Langat	0.6	2.8	-0.9	5.7	-1.2	6.2
10	Selbe	1.2	4.4	1.9	17.6	-0.1	16.7
11	Shwegyin	1.0	3.5	-5.4	1.6	-7.1	0.4
12	Bagmati	0.4	3.8	-1.9	7.9	-0.8	10.8
13	Gilgit	1.1	5.0	-3.0	-16.4	-3.5	-19.9
14	Pampanga	0.6	2.6	0.6	6.2	0.6	6.5
15	Kalu Ganga	0.7	2.7	0.1	9.3	0.0	10.3
16	Mae Wang	0.8	3.5	-7.6	3.6	-11.7	4.3
17	Chirchik Okhangaran	0.7	4.0	2.7	-1.5	3.1	-3.9
18	Huong	0.7	2.9	-8.3	-1.3	-10.9	-2.7
	Max.	1.3	5.0	11.8	21.1	18.8	28.0
	Min.	0.4	2.6	-8.7	-16.4	-12.8	-19.9
	Ave.	0.8	3.5	-1.2	6.1	-1.8	6.5

**Table 3.** Change rates of annual temperature, precipitation and runoff at 18 demonstration basins.

was projected at Mamberamo and Gilgit basins, respectively.

### Conclusions

In the present study, the past and future trends of climate and hydrology were analysed for the Asia monsoon region and for eighteen specific basins in AWCI countries. The average temperature was observed to increase by 0.27°./decade over Asia during past 30 years (1977-2006). The trend analysis showed increase in temperature over whole Asia except some regions i.e. Bangladesh, Thailand and Sri Lanka. The basin-scale analysis showed increasing temperature trend for all the basins. The trend over Asia during the past thirty years revealed decrease of 86.5 mm and 41.8 mm in average precipitation and runoff, respectively. Trend analysis of precipitation in specific basins showed a statistically significant decreasing trend in Mamberamo basin, and an increasing trend in the Langat, Gilgit and Huong basins.

To analyse future climate change impact, three optimum GCMs (CGCM3\_T47, CGCM2\_3\_2, and CM4) were selected using probabilistic uncertainty analysis, correlation coefficient and RMSE methods. The uncertainty analysis of the selected GCMs showed increased uncertainty toward future periods which was higher for temperature compared to precipitation. Significant increase of average temperature (0.9°C, 2.1°C, 3.7°C), precipitation (1.8%, 4.6%, 10.7%) and runoff (1.5%, 3.9%, 11.1%) was projected for Asia overall for three future periods (2020s, 2050s, 2080s). Temperature was projected to increase in all regions. The precipitation was projected to significantly increase over southwest parts of South Asia and decrease over the bordering regions of South Asia and East Asia. Basin-scale analysis revealed significant increase of precipitation at Memberano basin and decrease at Gilgit basin by 2080s. The temperature was projected to increase for all the basins.

The results demonstrated in this study showed change with high spatial variation such as increase

in precipitation and runoff over some regions/basins and decrease over others regions/basins of Asia. Further research needs to be carried out to identify the deriving factors of these variations. Moreover, the projected change may result in positive or negative impacts over different regions that urges the need of detailed regional impact assessment and adaptation studies over vulnerable areas to alleviate future climate-induced disasters.

## Acknowledgement

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## ARCP2011-05CMY-BAE

### PROJECT TITLE

**Climate Change Impact Assessment on the Asia-Pacific Water Resources under AWCI/GEOSS**

### COUNTRIES INVOLVED

All APN member countries

### PROJECT DURATION

Two-year project

### APN FUNDING

US\$ 84,000

### PROJECT LEADER

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ARCP2011-09CMY-TOWPRAYOON

# Strategic Rice Cultivation for Sustainable Low Carbon Society Development in Southeast Asia

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**ABSTRACT:** This research work focused on the assessment and identification of strategic rice cultivation practices, i.e. rotation with energy crops, to enable Southeast Asia (SEA) to develop towards a self-sufficient low carbon society, thereby contributing to global warming mitigation and climate change adaptation. The results indicate that to rotate the cultivation of rice with the cultivation of selected energy crops is a good strategy to reduce greenhouse gas (GHG) emissions and would contribute to increased soil carbon storage in the long term. The expansion of this strategy to all of SEA would not only contribute to enhancing biomass resources utilisation for biofuel and bioenergy, but would also alleviate the competition faced for planting food and fuel crops while minimising land-use change. Moreover, such strategic practices would help increase the carbon sink potential of the agricultural sector and enhance the welfare of rural communities. However, the existence of a market for energy crops is a prerequisite for the successful implementation of such a practice in the region. It is, therefore, imperative to formulate and implement clear policies on renewable energy and biomass utilisation, which should be strongly promoted both at the country and SEA regional levels.

**KEYWORDS:** *rice, energy crops, climate change, low carbon agriculture, soil carbon stock, GHG emission*

## Introduction

Southeast Asia (SEA) covers an area of 410 million hectares and agricultural land represents about 20% of the total area. Over the past decades, agricultural land has been expanding in SEA, some into previously forested areas. Such land-use changes reflect the development of intensive agriculture, which is a major economic activity in SEA. According to the Food and Agriculture Organization (2012), rice plantation covers an area representing about 12.5% of global crop plantation area (see FAOSTAT data available at <http://faostat.fao.org/>). This translates into rice production amounting to 659 million tonnes in 2012, contributing US\$ 164 billion to the world economy.

SEA represents the largest area of rice plantation coverage representing 30% of the world plantation. Maximising rice yield in this region is, therefore, essential to increasing global food stock. Nevertheless, the current climate and energy crisis strongly influence the regional potential of rice production. Temporary or permanent conversion of rice plantation into plantation of oil palm or other energy crops has already taken place in many

## HIGHLIGHTS

- » Cultivation of energy crops in rotation with rice is a good strategy to reduce GHG emissions in rice fields.
- » Strategic rice cultivation practices can enable SEA to move towards development of a sustainable low carbon society.
- » Sustainable low carbon agriculture can help address the competition between food and fuel crop cultivation while enhancing carbon sink potential and increasing welfare of farmers in SEA.

SEA countries, notably Thailand and Indonesia.

The present study aimed at identifying strategic rice cultivation practices that would help tackle both climate and energy security issues, by rotating rice with energy crops in order to fully utilise the rice plantation fallow period, hence optimising rice and energy feedstock production. The proposed cultivation practices aim at reducing GHG emissions while increasing potential

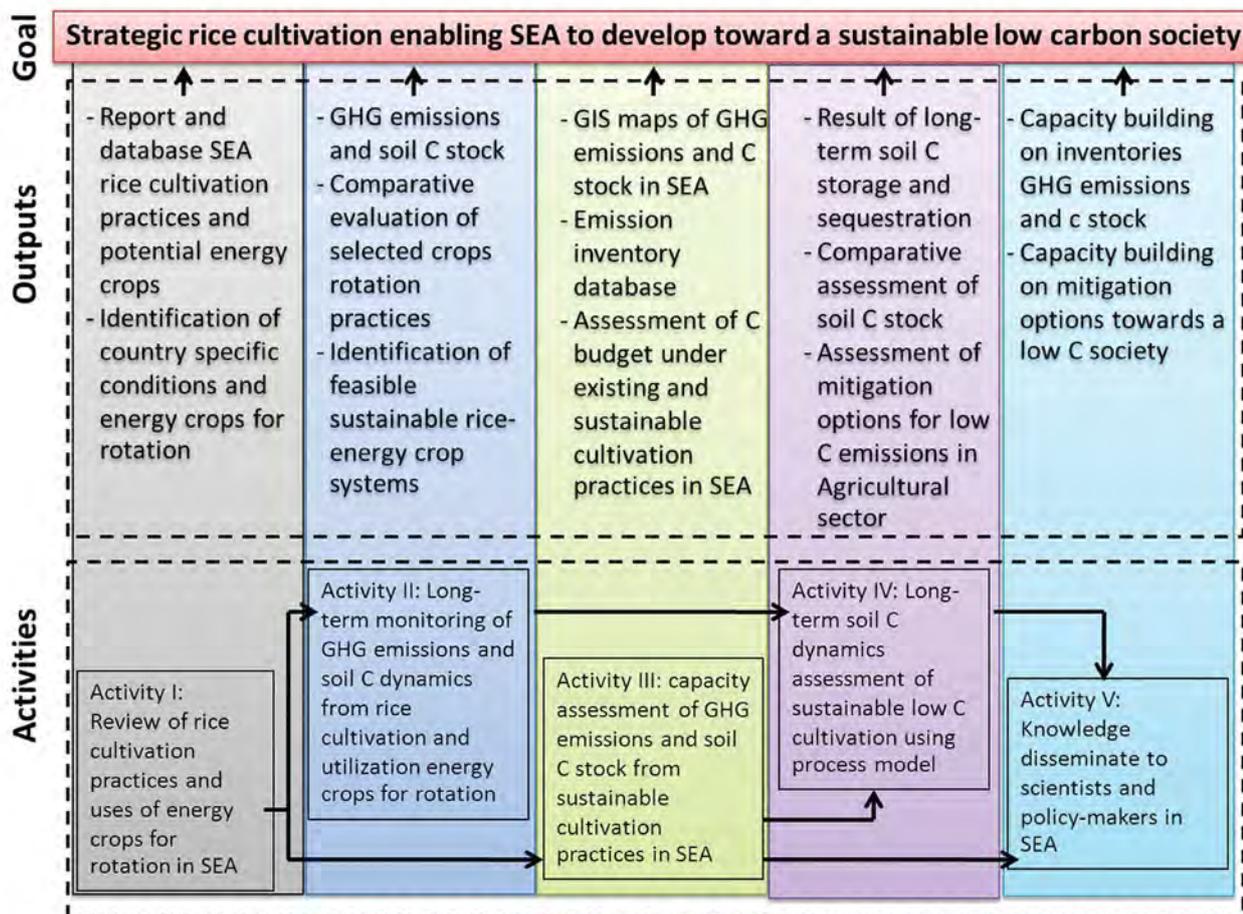
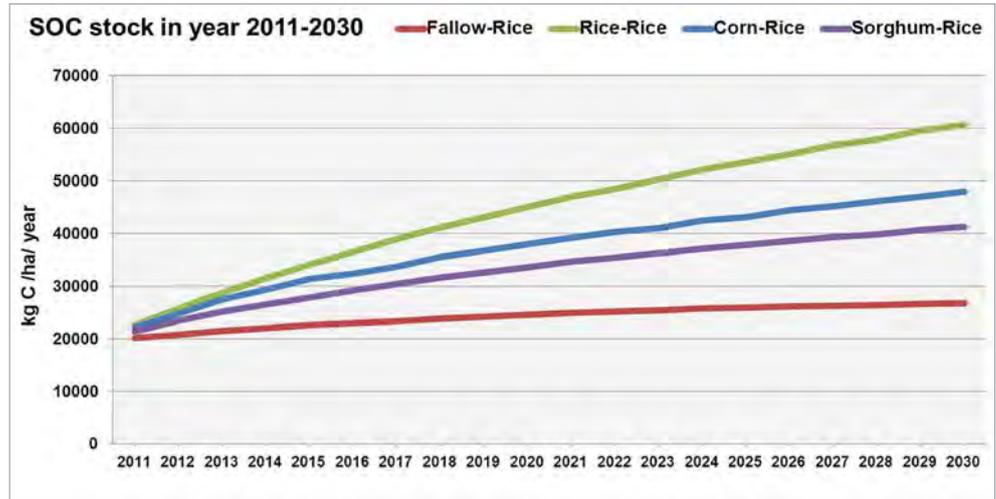


Figure 1. Research framework.



**Figure 2.** Simulation of annual SOC dynamics over 20 years.

long-term soil carbon stock by optimising land-use change and cultivation practices. Sustainable development is considered in terms of enhancing economic and social benefits while developing a low carbon society to bring down net GHG emissions and increase soil carbon stock.

**Methodology**

Several activities were undertaken in order to evaluate strategic rice cultivation practices, starting with an assessment of the current status of rice cultivation practices in SEA and of potential crops that can be used in rotation with rice. Such information was collected via a literature survey, a meeting of experts, and a questionnaire survey that was conducted in Thailand and Indonesia. Following this initial assessment, we evaluated the long-term GHG emissions and soil carbon dynamics of various rice cultivation systems, including rotation with selected energy crops (corn and sorghum), at an experimental site in Thailand.

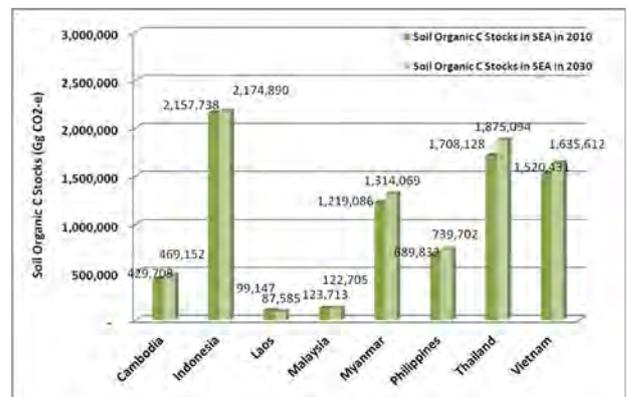
Socio-economic considerations associated with such practices were then taken into account to come up with possible options for strategic rice cultivation in rotation with energy crops. The data generated from this assessment served as input to the Agriculture and Land Use (ALU) software<sup>1</sup> and the DeNitrification-DeComposition simulations (DNDC) model<sup>2</sup> to investigate GHG emissions, carbon stock and soil

carbon dynamics for various scenarios of rice cultivation systems.

While the simulations were performed first only for the case of Thailand, where experimental data on GHG emissions had been generated and soil carbon measurements had been performed – it is possible to expand the simulations to other SEA countries, including Cambodia, Indonesia, Lao PDR, Malaysia, Myanmar, Philippines, and Viet Nam. The overall research framework of this study is illustrated in Figure 1.

**Results and Discussion**

Project investigations found that in ASEAN countries, rain-fed rice fields occupy an area of 19.8 million hectares. Such coverage represents almost half of the total area of rice cultivated in the region. These fields are used for only 4 to 5 months per year with single cultivation, while for the rest of the year the land is



**Figure 3.** SOC stocks in SEA in 2010 and 2030 with implementation of rotating cultivation of energy crop and rice.

1 The ALU software is publicly available at <http://www.nrel.colostate.edu/projects/ALUsoftware/>

2 The DNDC biogeochemistry model is available online at <http://www.dndc.sr.unh.edu/>

left to lie as fallow.

The project investigations revealed that sustainable low carbon agriculture through improved practices of rice cultivation, particularly, through rotation with energy crops during fallow period, is a sustainable and strategic rice cultivation option to follow. There are three main reasons supporting this finding as detailed below.

In terms of environmental performance, rotation with energy crops in rain-fed areas can reduce annual GHG emissions and increase soil organic carbon (SOC) storage over the long term. As seen in Figure 2, DNDC simulations indicate that significant changes in SOC could be achieved over 20 years.

Similar trends were observed across various crop rotation systems that were investigated. SOC contents for the crop rotations rice-rice, corn-rice and sorghum-rice were observed to increase over the simulated period 2010–2030. The highest rate of increase in SOC was observed for double cropping of rice, which is due to, as demonstrated in our experiment, the incorporation of crop residue into the soil. The results show that SOC storage for rice-rice, corn-rice and sorghum-rice systems are 42%, 33% and 25% higher, respectively, than the baseline (fallow-rice crop system).

For the eight SEA countries investigated in the present project, the SOC stock change of rice cultivation was also estimated using ALU for the period 2010–2030 based on rotated cultivation of rice and energy crops. The results are reported in Figure 3. They indicate that Thailand is the country with the highest gain, followed by Viet Nam and Myanmar.

The results obtained from both the DNDC model and ALU software showed that long-term

implementation of energy crop rotation using corn and sorghum can contribute to enhancing SOC as compared to having either rain-fed rice cultivation with fallow land instead in that period. Results from ALU also show that, for most countries in SEA (except Lao PDR and Malaysia), rice fields can act as a carbon sink.

It was also found that farmers would benefit from gaining additional income as a result of producing several crops, instead of just rice as in the monoculture system. Thus, for instance, rice rotation with either corn or sorghum brings 1.5 and 1.7-fold increases in income, respectively, over a single rice rain-fed cultivation with fallow land instead in that period. to farmers than opting for only rice rain-fed cultivation. In terms of land-use change and competition with food crops, introducing a crop rotation system can help avoid this as the same area of land is used to cultivate two kinds of crops.

### Conclusions

The results of this study are in line with reports from IPCC which indicate that the agricultural sector offers a promising carbon sink potential, particularly in Asia. Indeed, the results of this research work indicate that rice fields could provide an interesting carbon sink potential if appropriate cultivation practices were to be implemented, i.e. rotation with energy crops.

In SEA, the types of energy crops that can be cultivated in rotation with rice in rain-fed ecosystems can differ between countries depending on physical and ecological characteristics. Corn and sorghum were selected as suitable rotation crops because of

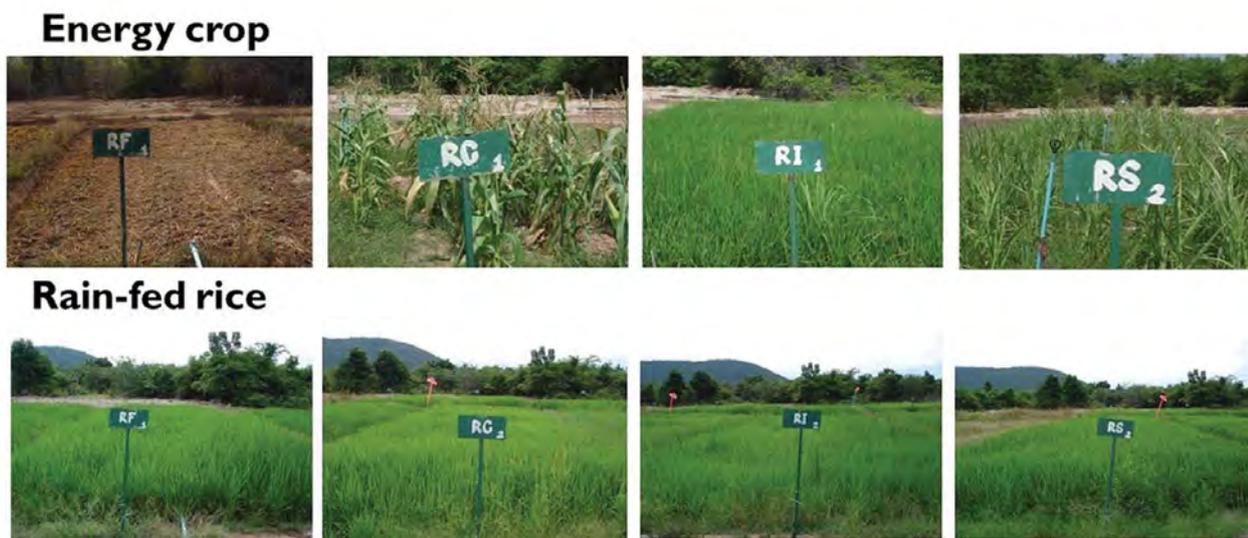


Figure 4. Photos of energy crop and rain-fed rice.

their short life, low water requirement and their potential for conversion to bioenergy, including biofuel.

However, to successfully implement such rotation systems depends on the existence of a market for energy crops. The formulation and implementation of clear policies on renewable energy and biomass utilisation are therefore necessary and should be promoted.

The knowledge generated from this project was disseminated to ASEAN countries through expert meetings of experts and training events. Country reports on rice cultivation including potential of energy crops for rotation during fallow period were exchanged and discussed. This project also built the capacity building of scientists and policy makers in the region in assessing the influence of alternative cultivation practices on soil carbon stock and GHG emissions were performed. The events organised over the course of this research work aimed at providing an opportunity for multilateral communications and

exchange of experiences and knowledge among ASEAN participants and experts on rice cultivation practices. Through these activities, a network of ASEAN countries was established, involving particularly, Cambodia, Myanmar, Indonesia, Japan, Viet Nam and Thailand, enabling potential further collaboration in the future on strategic rice cultivation in the region.

### Acknowledgements

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## ARCP2011-09CMY-TOWPRAYOON

### PROJECT TITLE

**Strategic Rice Cultivation for Sustainable Low Carbon Society Development in Southeast Asia**

### COUNTRIES INVOLVED

Indonesia, Japan, Thailand

### PROJECT DURATION

Two-year project

### APN FUNDING

US\$ 80,000

### PROJECT LEADER

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ARCP2011-10CMY-LUTAENKO

# Coastal Marine Biodiversity of Viet Nam: State and Current Problems

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**ABSTRACT:** The present project was intended to study marine biological diversity in coastal zones of Viet Nam, its modern status, threats, and recent and modifications due to global change and human impact. A synthesis of data and original research were conducted on coral reef modifications, biota of the intertidal zone, meiobenthic communities, species richness of rare groups of animals and economically important molluscs and the results of this synthesis and research are presented. There are numerous threats to marine biodiversity in the coastal zones of Viet Nam: habitat degradation, fragmentation and loss; global climate change including sea level rise, storm events, rainfall pattern change, warming of the coastal ocean; effects of fishing and other forms of overexploitation; pollution and marine litter; species introduction/invasion; physical alterations of coasts; and tourism. The data of Vietnamese and Russian researchers on biodiversity and coastal zone management was consolidated and used to interpret ecosystem changes and develop recommendations for local/national decision makers. The project's outcomes are not only relevant to coastal zones of Viet Nam, but may also contribute to current understanding of the entire ecosystem of the South China Sea.

**KEYWORDS:** *Viet Nam, marine biodiversity, coral reefs, coastal zone, threats*

## Introduction

The main objectives of the project were to collect information about species diversity and to compile species lists of some taxonomic groups of biota in Viet Nam coastal zones as a basis for monitoring expected changes; to develop approaches for monitoring biodiversity

changes in the South China Sea; to document species diversity in island ecosystems along the Viet Nam coast as a baseline study for conserving coastal and marine biodiversity; to conduct inter-comparisons of coastal biodiversity status in the South China Sea and adjacent regions; to hold joint workshops on biodiversity of the coastal zones of Viet Nam involving scientists from Viet

Nam, Russia, and Korea; to the results of the project; and, also through this project, prepare and publish the monograph "Biodiversity and Bioresources of the Viet Nam Coastal Waters" as a final outcome of the project; and, through the project activity, to enhance regional cooperation in global change research on biodiversity, to increase the number of joint publications, and to involve as many young scientists as possible in regional biodiversity research.

## Methodology

The project collected and analysed relevant data on biodiversity through literature study and through original biodiversity/ecological research on some groups of animals (nemertean, sipunculids, gastropod and bivalve molluscs), meiobenthic organisms, and macrobenthos of intertidal communities. Some data collected during past decades and archived in Russian institutions, were summarised for the first time.

Specific methods used in the field studies are described in the Final Activity Report of the project (available on <http://www.apn-gcr.org/resources/items/show/1591>).

## Results and Discussion

The richness and productivity of the coastal coral reefs of the South China Sea are seriously threatened by the high rate of population growth, pollution, excessive harvesting and habitat modification, resulting in a

rapid loss of habitat and impairment of the regenerative capacities of living systems. Viet Nam has been considered as rich in marine biodiversity both in terms of coral diversity and typical tropical marine ecosystems. Marine resources are significant in terms of livelihoods of coastal communities and development of the country. Located in the tropical monsoon area of Southeast Asia (SEA), marine waters of central Viet Nam are characterised by high biodiversity of coral fauna and high abundance of coral reefs. However, coral biodiversity and the state of coral reefs in Viet Nam are threatened by human activities and natural impacts induced by global climate change that tend to reduce species diversity and put more species on the verge of extinction.

Based on various literature data, the survey of coral reefs in Viet Nam during the last 15 years shows that the area of coral reefs has been reduced by 15-20%, mainly in coastal waters of the central part of Viet Nam from Da Nang to Binh Thuan province. Coal dust has caused the death to large areas of corals in the Ha Long and Bai Tu Long bays (Quang Ninh Province). Along with the decline in coral reef coverage, the number of species has also been reduced. For example, the coverage of coral reefs in Bai Tien area (Nha Trang) was 30% in 1984 with 60 species, has been reduced to 1% by 1998 with 30 species. Other living organisms were also reduced in number significantly.

At present, many other countries surrounding the South China Sea have degraded reefs, for example reefs around Hainan Island have been degraded by

### HIGHLIGHTS

- » Literature review shows that during the last 15 years, the area of coral reefs in Viet Nam have been reduced by 15-20%, mainly in coastal waters of the central part from Da Nang to Binh Thuan Province. Coal dust has caused death to large areas of corals in the Ha Long and Bai Tu Long bays (Quang Ninh Province). The number of species of corals (species richness) also declined — in some areas from 60 species to 30.
- » Studies on the biota of intertidal zone of some Vietnamese islands show that diversity of macrobenthos on hard substrates is richest in qualitative and quantitative compositions whereas the diversity of benthic organisms in the silty-stony intertidal zone and sandy beaches is poor. Macrophytic algae in the upper horizon and the major part of the middle horizon of surf-open sandy beaches are not found. These data may serve as a basis for future long-term monitoring of biodiversity changes.
- » The distribution and density of meiobenthos were studied in bottom sediments of Ha Long and Nha Trang estuaries, both in northern Viet Nam, for the first time. These organisms are good indicators of environmental pollution.
- » The biodiversity of rare and little-known groups of invertebrates in coastal zones of Viet Nam was studied for the first time. Twenty species in eleven genera and five families of Sipunculida were recognised in South Viet Nam.
- » Threats to marine biodiversity in Viet Nam include habitat degradation, fragmentation and loss; global climate change including sea level rise, storm events, rainfall pattern change, warming of the coastal ocean; effects of fishing and other forms of overexploitation; pollution and marine litter; species introduction/invasions; physical alterations of coasts; and tourism.



**Figure 1-2 (L-R).**  
The settlements  
of branched stony  
corals *Acropora* and  
*Pocillopora* in Viet  
Nam (courtesy of  
Tatyana Dautova);  
A sipunculid species  
*Siphonosoma*  
*australe* from Viet  
Nam (courtesy of  
Anastasya Mayorova).

95%. Sustainable use and protection of the SEA coastal reefs are now a focus of the international agendas (see reviews in: Dautova & Lutaenko, 2010, in Project Publications).

The biota of the intertidal zone of the Vietnamese islands from Namzu Islands (9°40' N, 104°22' E) in the Gulf of Thailand to Daochao Island (20°50' N, 107°20' E) in the Gulf of Tonkin were studied based on previously taken collections. Belt-forming communities of macrobenthos were investigated in five bionomical types of the intertidal zone. These data may serve as a basis for future long-term monitoring of biodiversity changes.

In the intertidal zone of studied areas, 101 plant and 268 animal species were found. Biota of the intertidal zone is typical for tropical region of the Pacific Ocean. Tropical and tropical-subtropical species prevail (for the south Viet Nam coast – 54 species, or 34%, for the Central Viet Nam coast – 61, or 33%, and for the North Viet Nam coast – 50, or 39%); faunal elements with wide distribution (from notal to boreal sea waters) are represented as well, but in low proportions.

Macrobenthos on hard substrates (the rocky and rocky-blocky-bouldery intertidal zone) is the richest in qualitative and quantitative compositions, whereas species composition on crumbly substrates (the silty-stony intertidal zone and sandy beaches) is the poorest. Macrophytic algae are not found in the upper horizon and in the major part of the middle horizon of surf-open sandy beaches. The intertidal zone of dead coral reef has no analogues in temperate waters (see: Lutaenko, 2011 in Project Publications).

For the first time, the distribution of taxonomical composition and density of meiobenthos depending on some factors of environment were studied in bottom sediments of the northern estuary of Ha Long Bay – a total of 66 species belonging to 17 families and 52 genera were identified. The estuary of the Ha Long

Bay is exposed constantly to anthropogenic impact of seaport activities (e.g., bottom dredging works), and to freshwater drainage from the mainland which results in significant seasonal changes of salinity.

In general, differences in composition and distribution of meiobenthic communities in Ha Long Bay appeared to be connected with changes in granulometric composition of bottom sediments. The silted sediments are characterised by the low species diversity and higher density of the animals than the slightly silted sands. The meiobenthos density at Nha Trang Bay reefs also shows an uneven distribution and depends on the sediment type. The correlation analysis revealed the dependence of the median diameter of sediment particles on the density of meiobenthos.

However, taxonomic diversity of meiobenthos in Nha Trang Bay (26 groups) was greater than in other areas. Nematodes dominated in bottom sediments both in Nha Trang Bay itself and on its reefs. In total, representatives of 4 orders, 28 families and 97 genera were found in Nha Trang Bay. Nematodes made up to more than 90% of the total population density of meiobenthos at stations with high number of silt particles in sediments. Probably, oxygen deficiency is a limiting factor for the penetration of animals into the depth of sediments in the central part of Nha Trang Bay.

The biodiversity of rare and little-known groups of invertebrates (nemertean, sipunculids and opisthobranch molluscs) of Viet Nam was studied for the first time. Twenty species in eleven genera and five families of Sipunculida are recognised from the total 371 individuals collected in southern Viet Nam. An analysis of the literature on Sipunculida shows that 5 of these species are new for Nha Trang Bay. 157 species of opisthobranch molluscs are recorded in southern Viet Nam, about half of them for the first time. About 80 nemertean species belonging to 5

orders: Archinemertea (4 species), Tubulaniformes (2 species), Heteronemertea (32 species), Polystilifera (6 species), and Monostilifera (36 species) were collected in Viet Nam, a majority for the first time.

An extensive literature review was also undertaken with regard to molluscan biodiversity in the South China Sea. Based on data obtained from this review, it appears that the richest faunas of bivalve molluscs are found in Viet Nam (more than 800 species) and in the Philippines-Indonesian region (more than 1200 species). The diversity of bivalves appears to show an increase from north (Taiwan and Guangdong Province, 401–463 species) to south, (as latitudinal gradient of biodiversity is widely known in biogeography). The impoverished character of the bivalve faunas of the Tonkin Gulf and the Gulf of Thailand can be explained by significant river discharge which decreases salinity.

## Results and Conclusions

As noted at the beginning of this paper, the many threats to marine biodiversity in Viet Nam include habitat degradation, fragmentation and loss (especially important are mangrove forest destruction, loss of coral reefs, change in landscape mosaic of wetland, estuary, sand and mud flats); global climate change including sea level rise, storm events, rainfall pattern change, warming of the coastal ocean; effects of fishing and other forms of overexploitation; pollution and marine litter; species introduction/invasion;

physical alterations of coasts; and tourism.

This project sought to fill knowledge gaps for biodiversity in the coastal zone of Viet Nam, taking into account the impact of the threats identified above. The project collected and analysed relevant data on biodiversity through literature study and through original biodiversity/ecological research on some groups of animals (nemerteans, sipunculids, gastropod and bivalve molluscs), meiobenthic organisms, and macrobenthos of intertidal communities.

The literature study was based in large part on data collected since the 1980s and archived in Russian institutions which were summarised for the first time. Current original researches were conducted. As a result of the literature study and of the researches, overviews of the present state of knowledge on corals and bivalve molluscs, two ecologically and economically important groups, were prepared; a number of papers were published (especially a monograph on “Biodiversity and Bioresources of Viet Nam Coastal Waters”); and a book is in preparation.

Two workshops were held, one in the Institute of Oceanography, Viet Nam Academy of Science and Technology (VAST) and one in the Research Institute of Aquaculture No. 3 in Nha Trang, to enhance regional and international cooperation in biodiversity research and to involve young scientists.

From this study, it appears that the tropical marine biodiversity of Viet Nam and South China Sea – even in developed countries like Singapore is



**Figure 3.** Participants of the biodiversity meeting.

still insufficiently studied and would benefit from additional research in the long term. However, such research faces some serious problems. Research on molluscan biodiversity in the South China Sea is hampered by a lack of taxonomic expertise in many countries in this region, by a lack of professional malacologists trained in taxonomy, and by the fact that there are few well-curated research collections/museums with voucher specimens in the region. Education and training of additional experts in these areas would be very helpful, as would the establishment of additional research collections/museums.

## Acknowledgements

We are grateful to the following contributors to the project and this paper: Dr. Tatyana N. Dautova (A.V. Zhirmunsky Institute of Marine Biology FEB RAS, Vladivostok, Russia; hereafter IMB), Dr. Alexey V. Chernyshev (IMB), Dr. Elena E. Kostina (IMB), Prof. Eduard A. Titlyanov (IMB), Dr. Anastasya S. Mayorova (IMB), Dr. Olga N. Pavlyuk (IMB), Mrs. Tatyana V. Lavrova (IMB), Dr. Alexander V. Martynov (Zoological Museum, Moscow University, Moscow, Russia), Dr. T.A. Korshunova (Institute of Higher Nervous Activity and Neurophysiology RAS, Moscow, Russia), Dr. Yuri I. Kantor (Institute of Problems of Ecology and Evolution RAS, Moscow, Russia), Mrs. Do Minh Thu (Institute of Oceanography, Viet Nam Academy of Science and Technology, Nha Trang, Viet Nam; IO). The financial support for this project was additionally provided by three institutions – IMB; IO; Institute of Biology and Soil Science, Far East Branch of the Russian Academy of Sciences, Vladivostok,

Russia; and Research Institute for Aquaculture No. 3, Nha Trang, Viet Nam.

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## ARCP2011-10CMY-LUTAENKO

### PROJECT TITLE

**Coastal Marine Biodiversity of Viet Nam: Regional and Local Challenges and Coastal Zone Management for Sustainable Development**

### COUNTRIES INVOLVED

Republic of Korea, Russian Federation, Viet Nam

### PROJECT DURATION

Two-year project

### APN FUNDING

US\$ 80,000

### PROJECT LEADER

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ARCP2011-21NSY-MANURUNG

# Reconstruction of Sea Level Change in Southeast Asia Waters Using Combined Coastal Sea Level Data and Satellite Altimetry Data

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**ABSTRACT:** Low-lying and densely populated coastal areas with thousands of small islands spreading across Southeast Asia are highly prone to sea level rise caused by global warming. Accurate sea level change maps in Southeast Asia are of great importance to scientists and decision makers in the region interested in past and present sea level change. Improving near-coast satellite altimetry data processing will extend the coastal sea level record back in time and allow accurate mapping of sea level change in the region as well as supporting various potential applications of sea level data in the coastal zone. Our initial comparisons of sea level trends show good agreement between global sea level reconstructions in areas and times of larger signal to noise associated with strong decadal sea level variability forced by low frequency wind forcing.

**KEYWORDS:** *sea level change, tide gauge, coastal altimetry, reconstruction, re-tracking, Cyclostationary Empirical Orthogonal Function (CSEOF)*

## Introduction

Since 1993 satellite altimetry has provided accurate measurements of sea surface height (SSH) with near-global coverage. These measurements have led to the first definitive estimates of Global Mean Sea Level (GMSL) rise and have improved our understanding of how sea level is changing regionally at decadal timescales. The relatively short satellite record, however, does little to

answer the question of how the current state of the ocean compares to previous states. Tide gauges, on the other hand, have measured sea level over the last 200 years, with some records extending back to 1807. While providing long records, the spatial resolution of tide gauges is poor, making studies of GMSL and the large-scale patterns of low-frequency ocean variability difficult. Reconstruction of sea level overcomes these respective shortcomings of tide gauge and satellite altimetry records by combining the shorter but essentially complete global

coverage offered by satellite altimetry with the longer but sparsely distributed tide gauge data set. The work presented here focuses on sea level trends in the Southeast Asian Seas (SEAS) region as quantified by the satellite altimetry and sea level reconstructions.

The SEAS region spans the largest archipelago in the global ocean and is comprised of a total of 20 seas according to the Limits of the Ocean and Seas published by the International Hydrographic Organization (IHO) in 1953 (IHO, 1953). Figure 1 shows the regional seas, straits, and gulfs as defined by the IHO and delineated by a high-resolution coastline data set. The region has many low-lying and densely populated coastal areas, including large urban and rural river deltas and thousands of small-inhabited islands. The Indonesian archipelago alone consists of 17,508 islands (6,000 inhabited) and encompasses the only tropical interoceanic throughflow in the global ocean, providing a complex oceanic pathway connecting the Pacific and Indian Oceans. The Indonesian throughflow, and thus sea level, is driven primarily by free equatorial Kelvin and Rossby waves (Figure 2) originating along the Indian and Pacific equatorial waveguides (Wijffels & Meyers, 2004). The SEAS region is also one of the most biodiverse oceanographic regions on the planet. Southeast Asia's coral reefs have the highest degree of biodiversity of all of the world's coral reefs and it is

estimated that only 10 percent of the marine species associated with coral reefs have been identified and described (Reaka-Kudia, 1997). As a result, this region is increasingly impacted by sea level rise and a warming climate.

## Methodology

**Satellite Altimetry:** The satellite altimeter data set used in this study was produced and distributed by the Archiving, Validation, and Interpretation of Satellite Oceanographic (AVISO; <http://www.aviso.oceanobs.com/>) as part of the SSALTO ground-processing segment. The data set has a quarter-degree resolution and was created from measurements spanning 1992 through 2009 using the following satellites: TOPEX/Poseidon, ERS-1&2, Geosat Follow-On, Envisat, Jason-1, and OSTM. These sea level measurements were updated and reprocessed by applying homogeneous corrections and inter-calibrations and referenced to a consistent mean. Then, the along-track data were gridded through a global space-time objective mapping technique. These data are used as a baseline for comparison as well as in four of the five sea level reconstructions used in this study.

Attempts had been made to improve satellite altimetry data sets in low-lying coastal areas where the accuracy of satellite altimeter data is highly degraded because the altimeter measurement system was primarily designed to accurately measure sea surface height measurements in the open ocean, not near the coast. It should be recalled that coastal altimetry products in the archipelagic area such as Indonesia are still experimental and undergoing further refinement. Much has been learned on how to handle data and interpret outputs. A series of MATLAB scripts were made available to assess the improvement gained from the adoption of specialised retracers and corrections in the coastal zone.

**Tide Gauge Data:** Each reconstruction uses tide gauge data from the Permanent Service for Mean Sea Level (PSMSL; <http://www.psmsl.org>). PSMSL supplies a wide range of tide gauge data, but availability depends highly on the region and timeframe in question. Each reconstruction uses different tide gauge editing and selection criteria depending on time-series length, data gaps, area weighting, etc. These will not be discussed in this report but can be found in the respective references for each of the reconstructions.

**Sea Level Reconstruction Methods:** Sea level reconstructions are created by decomposing the

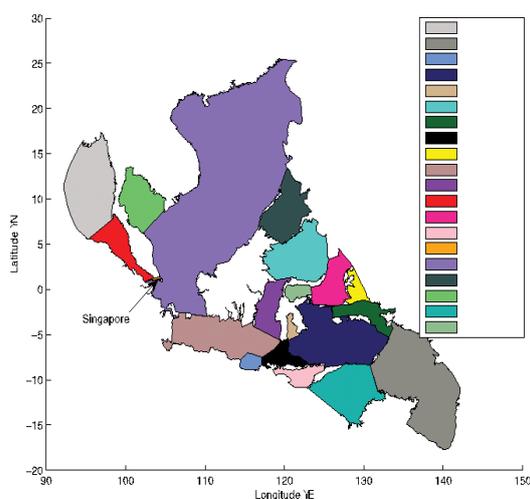
### HIGHLIGHTS

- » Maps of global sea level change affected by global warming are reconstructed using CSEOFs by fitting the satellite-derived sea level variability to coastal tide gauge observations. This method is an improved reconstruction technique, in comparison to methods based on fitting EOFs to global coastal tide gauge data. Regional distribution of sea level trends over the last 60 years has been estimated.
- » The CSEOF reconstruction method, applied to an improved satellite altimeter-data archive calibrated using coastal gauge stations in the region and incorporating the spatial data, can potentially improve mapping of sea level change in the Southeast Asia region.
- » Coastal Altimetry is a developed method to utilise a relatively mature open ocean altimetry technology in coastal areas. However, a proper processing including re-tracking and/or new/improved corrections can improve the accuracy of satellite in coastal area and shallow waters.

training data into basis functions to explain the original variance, in this case satellite data and/or ocean model data. These basis functions are then interpolated back in time using in situ measurements. Sea level measurements from tide gauges were used for the four univariate reconstructions. For the bivariate reconstruction, both sea level measurements from tide gauges and shipboard measurements of sea surface temperature were used.

The reconstructions compared here use two basis function decomposition methods: empirical orthogonal functions (EOFs) and cyclostationary empirical orthogonal functions (CSEOFs). Both methods decompose the training data set into loading vectors (LVs) and principal component time series (PCTS) for each individual mode. CSEOFs differ from EOFs, however, in that they include a time dependence in the LVs, allowing extraction of non-stationary cyclostationary signals. See Kim et al. (1996) or Kim & Wu (1999) for more details. A number of modes are selected, which explain a subset of variance in the original training data set, and are interpolated back in time to determine the PCTS to create the reconstructed sea level data set. The five different sea level reconstructions used in this analysis vary based on the training data and reconstruction method used. A summary of basic information concerning each reconstruction is given in Table 1. More details on some of the reconstruction are given in the following sections. If more information is desired about any reconstruction, please refer to the corresponding references.

Hamlington et al. (2012) Bivariate Reconstruction



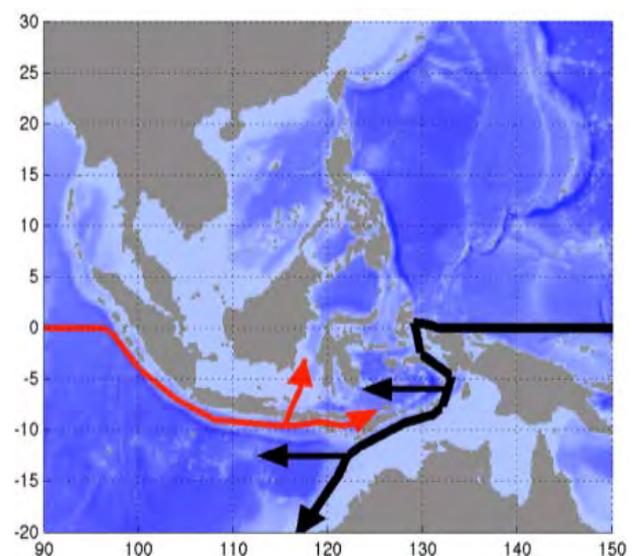
**Figure 1.** The 20 bodies of water (seas, straits, and gulfs) defined in the Limits of the Ocean and Seas (IHO,1953) for the SEAS region.

(HLK/BV): In addition to AVISO and PSMSL data, HLK/BV uses sea surface temperature (SST) to create a bivariate reconstruction. The SST training data are Optimal Interpolation SST (OISST; <http://www.esrl.noaa.gov/psd/data/>) data from NOAA, which are a combination of in situ and satellite measurements, as well as simulated SST values near sea ice. The historical in situ SST data come from the International Comprehensive Ocean-Atmosphere Data Set (ICOADS; <http://icoads.noaa.gov/>), averaged to a  $2^\circ \times 2^\circ$  grid and known as superobservations (Smith et al., 1996).

To utilise SST measurements for an SSH reconstruction, basis functions of the SST training data are computed using CSEOFs. These basis functions are then transformed to have the same principal component time series as the SSH basis functions. The transformed SST basis functions and the SSH basis functions are then interpolated with the respective in situ measurements to form a bivariate reconstruction. See Hamlington et al. (2012) for more details.

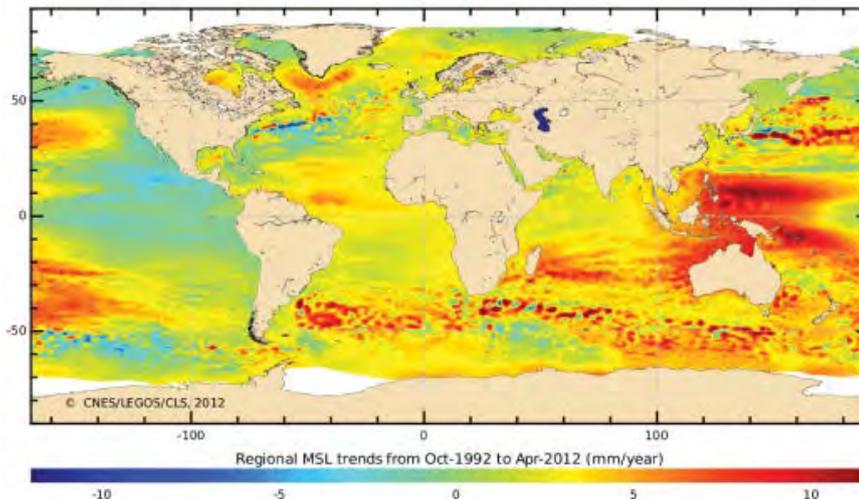
Church and White (2011) Reconstruction (CW): CW utilises a custom satellite altimetry training data set, merging and filtering data from 3 different satellites, as described in Church et al. (2004).

Meyssignac et al. (2011) Mean Reconstruction (M/Mean): Meyssignac et al. (2011) created a mean sea level reconstruction data set by averaged a satellite altimetry reconstruction with two model data reconstructions made using the SODA 2.0 (Carton & Giese, 2008) and the Drakkar/NEMO (Dussin et al., 2009) ocean models.



**Figure 2.** Schematic of remotely forced wave pathways into the Indonesian throughflow region (after Wijffels & Meyers, 2004).

**Figure 3.** Regional sea level trends computed from October 1992 to April 2012 using AVISO SSH data.



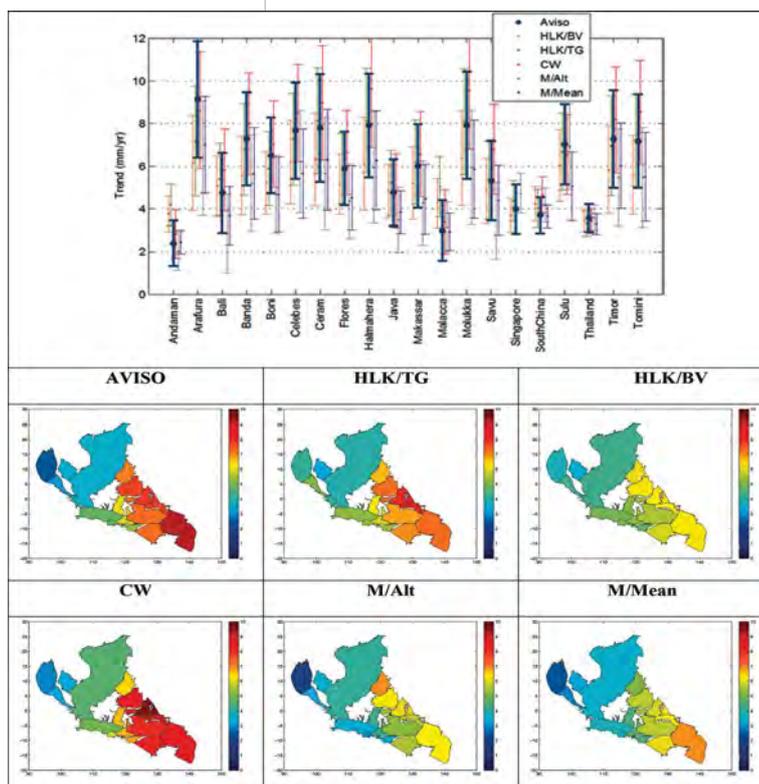
**Figure 4.** SEAS average sea level trends over the 17-year satellite altimeter record from 1993–2009 shown plotted as trend values with standard (upper plot) and as colour maps (bottom panels) for AVISO and each of the reconstructions.

Estimating Sea Level Trends: Prior to any comparison, each reconstruction was annually averaged for consistency. Linear trends were computed over a variety of time spans and the uncertainty of each trend was found using standard error estimates for the trend term determined from the least squares linear regression.

SEAS Region Definition and Analysis: For the SEAS regional analyses, the region was subdivided into 20 separate bodies of water defined according to the

Limits of the Oceans and Seas (1953). For each data set, all points within a given boundary were averaged to determine an areal averaged mean time series for each body of water. If no points were present in a data set, the nearest point was used. Linear trends were found after the calculation of subregion averages.

Transfer of Knowledge: Two workshops, two training sessions, and continuous technical and scientific support were conducted during the project duration. An important effort was dedicated to information transfer, namely software to read, process and visualise altimeter data and sea level reconstructions. The retracking methodology was also seen as another key aspect to be focused upon. The Workshops were aimed at (1) transferring knowledge in terms of data and methods, and (2) assisting the local community in building autonomous capacity of developing and processing satellite and in situ measurements of sea level.



### Results and Discussion

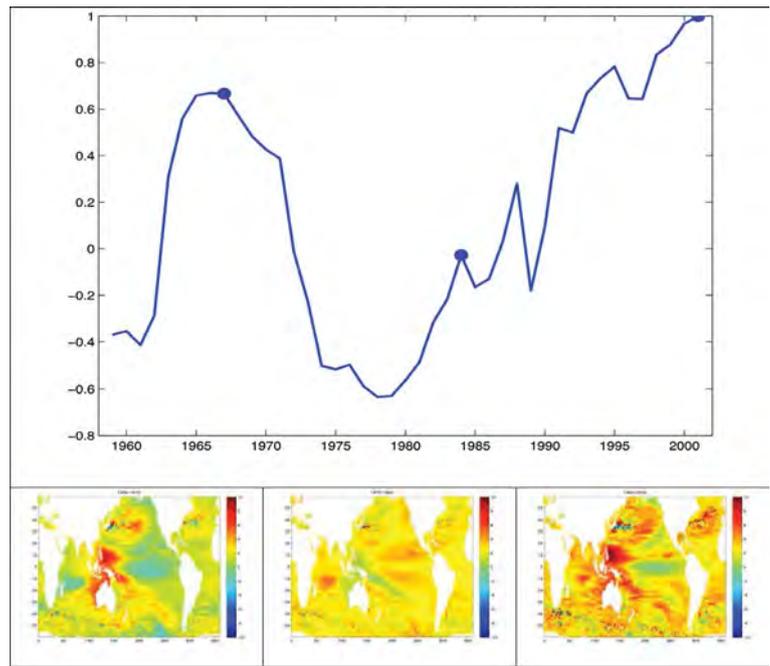
Sea level changes in the SEAS region are among the largest observed in modern satellite altimeter record (Figure 3). Regional sea level trends over the 17-year satellite altimeter record (1993 through 2009) are shown in Figure 4 for the AVISO data set and each of the sea

level reconstructions during the training data set time period. Reconstructed sea level average trends in the SEAS agree with the AVISO values to within the estimated error.

To highlight the trend variability at the time scales observed over the current altimetric record we performed the following analysis:

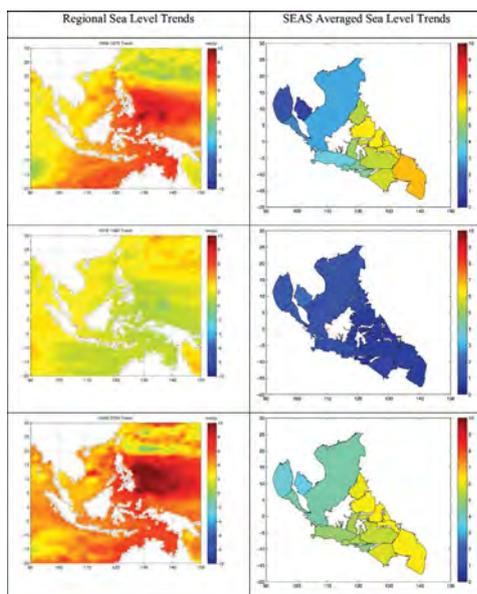
- Averaged all reconstructed data sets to form annual averages over the 1950 through 2009 record.
- Calculated 17-year linear trends from the annual averaged data sets to produce 44 17-year trend maps from 1958 through 2001.
- Performed a lagged correlation analysis (present versus past) of the 17-year trend time series for each data set.

A sample of the lagged correlation analysis is shown for the HLK/BV reconstruction in Figure 6. There are roughly three extrema in the 17-year trend variability of the global sea level reconstructions associated with independent 17-year time periods in the 60-year record: 1959–1975 (centred on 1967); 1976–1992 (centred on 1984); and 1993–2009 (centred on

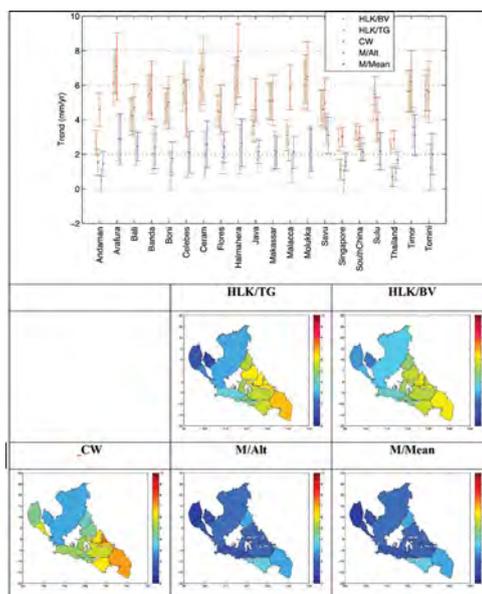


2001). The 1959–1975 time period was correlated with the 1993–2009 record, showing strong regional sea level trends in the western Pacific similar to those observed during the satellite record. On the other hand, anti-correlation is found between the 1976–1992 and 1993–2009 17-year trends, with the former time period exhibiting much smaller sea level

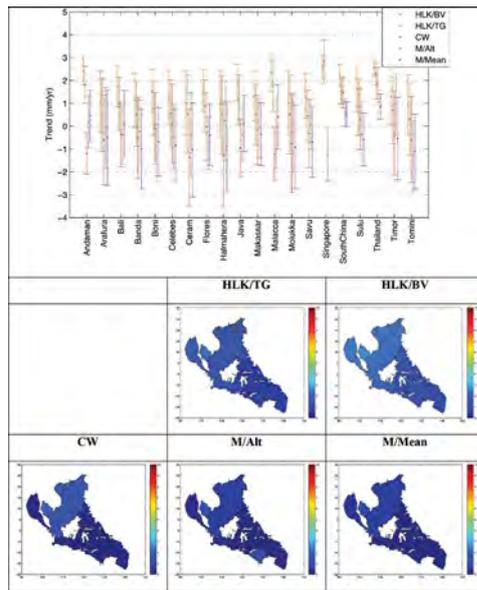
**Figure 5.** Lagged correlation coefficient (shown as the blue line in the upper plot) of the historical 17-year regional linear trend maps with the linear trend map from the satellite altimeter time period 1992–2009 centred on 2001 (leftmost blue dot). The bottom plots show the 17-year sea level trend maps in mm/year for the 1959–1976 (left), 1977–1992 (centre), and 1992–2009 (right) time periods. The blue dots shown on the upper plot are the centre points of the three 17-year windows.



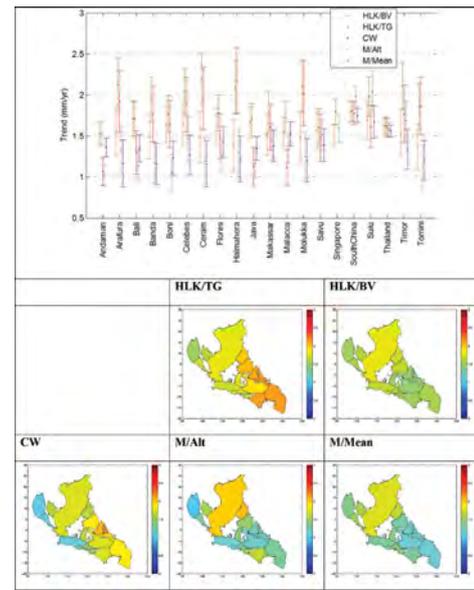
**Figure 6.** SEAS regional and averaged sea level trends for the (a) 1959–1975, (b) 1976–1992, and (c) 1993–2009 time periods from the bivariate sea level reconstruction (Hamlington et al., 2012).



**Figure 7.** SEAS average sea level trends over the 17-year time period from 1959 through 1975 shown plotted as trend values with standard error (upper plot) and as color maps (bottom panels) for each of the reconstructions.



**Figure 8.** SEAS average sea level trends over the 17-year time period from 1976 through 1992 shown plotted as trend values with standard error (upper plot) and as color maps (bottom panels) for each of the reconstructions.



**Figure 9.** SEAS average sea level trends over the 60-year time period from 1950 through 2009 shown plotted as trend values with standard error (upper plot) and as color maps (bottom panels) for each of the reconstructions.

trends in the western Pacific than those observed during the satellite record.

What is driving these changes in the western Pacific sea level trends? Merrifield et al. (2012) showed that, when detrended by GMSL, the western Pacific sea level is correlated with the low-frequency variability of the Pacific Decadal Oscillation (PDO) and the Southern Oscillation Index (SOI). This sea level signal is driven by anomalous decadal wind variability over the equatorial Pacific and propagates along the Rossby waveguide through the SEAS archipelago, reaching as far south as Fremantle on the western Australian coast. Figure 6 shows the impact of the Pacific wind forcing induced sea level variability on the SEAS sea level trends determined from the bivariate reconstruction for each of the independent 17-year time periods. Figures 7, 8 and 9 show SEAS averaged sea level trends, error estimates, and SEAS averaged maps for each of the reconstructions over the two 17-year time periods, 1959–1975 and 1976–1992, and the 60-year time periods, 1950–2009, respectively.

### Conclusions

Our initial comparisons of sea level trends show good agreement between global sea level reconstructions in areas and times of larger signal to noise associated with strong decadal sea level variability forced by low frequency wind forcing.

SEAS regions along the deepwater Rossby waveguide connecting the Pacific and Indian Oceans are most affected by this variability.

The good news for the SEAS region is the likelihood that recent strong sea level trends observed during the altimetry record will abate as trade winds fluctuate on decadal and multi-decadal time scales.

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## ARCP2011-21NSY-MANURUNG

### PROJECT TITLE

**Reconstruction of Sea Level Change in Southeast Asia Waters Using Combined Coastal Sea Level Data and Satellite Altimetry Data**

### COUNTRIES INVOLVED

Indonesia, Italy, USA, Viet Nam

### PROJECT PERIOD

One-year project

### APN FUNDING

US\$ 45,000

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ARCP2012-04CMY-SALIK

# Socio-Economic Vulnerability of Mangrove Ecosystems to Climate Change in South Asia: A Case Study of the Indus and Ganges Deltas

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**ABSTRACT:** The present study is intended to understand the socio-economic vulnerability under a changing climate for coastal communities that are dependent on mangrove ecosystems in two important South Asian deltas: the Indus and Ganges-Brahmaputra. We use the Composite Vulnerability Index (CVI) approach to draw a general picture of vulnerable communities. We try to answer some key questions to understand how climate change is impacting mangrove ecosystems and dependent communities. Our assessment shows that these coastal communities are highly sensitive and exposed to climate change-driven threats. Further, poor access to basic facilities, inadequate income diversification, and low education levels are negatively affecting adaptive capacity of local populations. However, the communities' nature of dwelling, their strong family networks, and their ability to migrate on a timely basis when the need arises contribute to their adaptive capacity.

**KEYWORDS:** *Composite Vulnerability Index, climate change, exposure, sensitivity, adaptive capacity*

## Introduction

Mangroves are an important component of our natural ecosystems. They feed and breed an amazing diversity of economically and ecologically important flora and fauna (Valiela, Kinney, Culbertson, Peacock, & Smith, 2009; Walters et al., 2008) that generate livelihoods for dependent communities. However, the overdependence of mangroves on coastal waters and of local communities on mangrove resources, makes them highly vulnerable to slight changes in temperature, rainfall, or sea level, that are likely to result from climate change (Ellison, 2012). This is particularly true for South Asian mangroves (Belkin, 2009).

For the purpose of our study, mangrove forests in deltas of two major South Asian rivers were selected: the Indus River in Pakistan and the Brahmaputra in Bangladesh. Although the two rivers flow thousands of miles apart, they are common in that millions of lives and major socio-economic systems are dependent on them.

The Indus River Delta hosts 97% of the total mangroves forest in Pakistan. Besides providing local ecosystem services, Indus Delta mangroves generate handsome revenues which add to the national exchequer. It is estimated that they provide a breeding ground to approximately 90% of the total shrimps that are exported from Pakistan (Sivakumar & Stefanski, 2011).

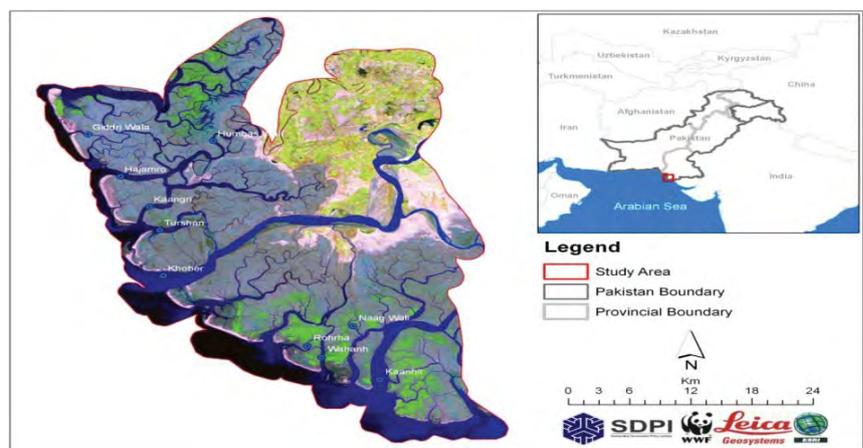
Similarly, the Ganges-Brahmaputra Delta (also known as Sundarban Delta) on the farther end of South Asia supports the largest single block of tidal halophytic mangrove forest in the world. The rich and unique diversity of life that the Sundarban mangrove forests support, and the threat imposed to them by overexploitation, led UNESCO to declare the Bangladeshi portion (6,000 km<sup>2</sup>) as a world heritage site in 1997 (UNESCO, 2010).

The research undertaken in this study was guided by the following key research questions: a) how do climate change stress factors impact both mangrove ecosystems and dependent communities, especially at the local level? b) What are the possible indicators of both the sensitivity of mangrove systems and dependent communities to such stresses? c) What is the coping potential of communities? d) What should be

the key adaptation options for increasing community resilience?

## Study Area

Two districts around each of the mangrove forests were selected for field research. They share the following features: (i) close proximity to mangrove forests; (ii) small and scattered settlements, usually around the fringes of creeks; (iii) high local dependence on mangrove resources (for livelihood generation and/or domestic consumption); and (iv) vulnerability to natural disasters, presently or in the past.



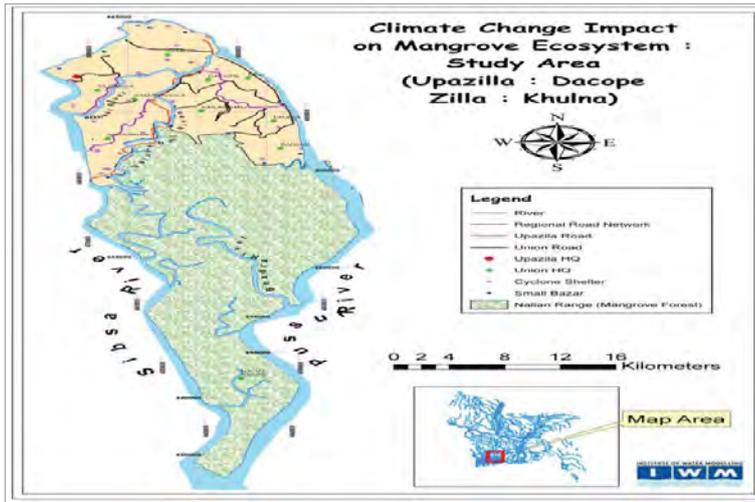
**Figure 1.** The Study Area – Keti Bandar, Indus Delta, Pakistan.

## Indus Mangroves

In Pakistan, the study was primarily carried out in the Keti Bandar area of Thatta district (Figure 1). The area is characterised by mangroves, mudflats, creeks and rich biodiversity. Currently, it constitutes 42 *dehs* (cluster of villages) with a total population of 12,000 and covers 60,969 hectares (Khatoon & Akbar, 2008). The area has been prone to natural disasters in the past. Local populations generate most of their income from fishing (77%) (Dehlavi & Adil, 2012) and agriculture (Hai & Khursheed, 2011).

## Sundarban Mangroves

The study on Bangladeshi Sundarban mangroves was carried out in Khulna district. The primary area of research was a sub-district (or upazilla) named Dacope (Figure 2), where the total population is 152,316 and covers 99158 hectares (Bangladesh Bureau of Statistics, 2012). It is surrounded by the Nalian



**Figure 2.** The Study Area – Upazilla: Dacope Zilla, Khulna, Bangladesh.

Range and the Pusur River (Figure 2). The area has reportedly experienced environmental problems that ranged from salinity intrusion and water-logging to extreme weather events such as cyclonic storm surge and droughts.

### Data used

The study relies on a mix of qualitative and quantitative data for indicators of exposure (E), sensitivity (S), adaptive capacity (A), and their variables, as listed in Tables 2 and 3. Primary data for S and A was collected from field surveys (during April 2013 in Pakistan; and May, 2013 in Bangladesh). It is complemented by secondary data that guided the direction and, later on, analysis of the research process. Data on indicators was collected from national surveys and relevant government and private centres. The data for the sub-index E was obtained from the Meteorological Departments of Pakistan and Bangladesh for the periods of 1951–2010 and 1986–2008, respectively.

### Methodology

In the present study, the Composite Vulnerability Index (CVI) provides an indicator-based estimation of socio-economic factors of the coastal area in relation to environmental and climatic parameters (Eriksen, Adger, Brooks, Kelly, & Bentham, 2004; Gornitz, Daniels, White, & Birdwell, 1994; Heltberg & Bonch-Osmolovskiy, 2011).

All the considered variables, presenting particular sub-index S, E and A, were normalised using Equation 1 (UN-ECLAC, 2003):

$$\hat{X} = \frac{(X - X_{min})}{(X_{max} - X_{min})} \dots Eqn. (1)$$

Where X is any considered variable, Xmax is the maximum value of the variable and Xmin is the minimum value of the variable among its investigated sample. The normalised variables were used to calculate the respective sub-indices (Exposure, Sensitivity and Adaptive Capacity) using Equations 2 to 4 respectively. The index values have been analysed through component analysis after categorising the normalised indices at different levels to

ensure the consistency in the results (Comer et al., 2012; Hammill & McCandless, 2013). Consequently, four categories of vulnerability levels have been developed to categorise the impact of indices of three components i.e., exposure, sensitivity, and adaptive capacity against vulnerability (Table 1). Finally, the CVI is calculated by using Equation 5.

$$\bar{E} = \frac{1}{6} \left[ \sum_{x=1}^{x=4} \frac{1}{12} \left[ \sum_{m=1}^{m=12} \hat{E}_{x,m} \right] + \frac{1}{2} (\hat{E}_5 + \hat{E}_6) + \hat{E}_7 \right] \dots Eqn. (2)$$

$$\bar{S} = \frac{1}{4} \left[ \frac{1}{3} \left( \sum_{x=1}^{x=3} \hat{S}_x \right) + \frac{1}{2} \left( \sum_{x=4}^{x=5} \hat{S}_x \right) + \frac{1}{4} \left( \sum_{x=6}^{x=9} \hat{S}_x \right) + \frac{1}{4} \left( \sum_{x=10}^{x=13} \hat{S}_x \right) \right] \dots Eqn. (3)$$

$$\bar{A} = \frac{1}{8} \left[ \sum_{x=1}^{x=4} \hat{A}_x + \frac{1}{2} (\hat{A}_5 + \hat{A}_6) + \frac{1}{2} (\hat{A}_7 + \hat{A}_8) + \frac{1}{2} (\hat{A}_9 + \hat{A}_{10}) + \frac{1}{2} (\hat{A}_{11} + \hat{A}_{12}) \right] \dots Eqn. (4)$$

$$CVI = \frac{1}{3} [\bar{E} + \bar{S} + (1 - \bar{A})] \dots Eqn. (5)$$

Where  $\hat{E}_x$ ,  $\hat{S}_x$ ,  $\hat{A}_x$  are all the normalised variables belonging to Exposure, Sensitivity and Adaptive Capacity sub-indices and scaled accordingly (see Tables 2 and 3).

### Results and Discussion

Our analysis of exposure indicators shows that the higher index values for climatic parameters in both regions. This increasing incidence of abrupt changes in the temperatures, precipitation, and SST can trigger many bio-physical processes in the coastal areas and can impact on mangroves vegetative and reproductive growth (mostly negatively due to abrupt decline in temperature). The most significant of these could include habitat loss, reduced food yield, and increased salinity. In the case of Bangladesh, increased salinity of deltaic waters is already a major problem.

Rises in SSTs also increase vulnerability.

Index value Scale	Exposure/ Vulnerability	Sensitivity/ Vulnerability	Adaptive Capacity/ Vulnerability	CVI
$0.0 \leq CVI \leq 0.3$	Low/ Low	Low/Low	Low/ Very high	Low
$0.31 \leq CVI \leq 0.5$	Medium/ Medium	Medium/ Medium	Medium/ High	Medium
$0.51 \leq CVI \leq 0.7$	High/ High	High/ High	High/ Medium	High
$0.71 \leq CVI \leq 1.0$	Very High/ Very High	Very High/ Very High	Very High/ Low	Very High

**Table 1.** Categorisation of vulnerability levels (Adopted and transformed from Comer et al., 2012 and Hammill & McCandless, 2013).

Moreover, inadequate fresh water flows in both study areas have resulted in highly sensitive/vulnerable and it has also impacted agriculture and fisheries production allowing sea water intrusion. This value reflects a very high impact on the economy of the community that depends entirely on fisheries.

Further, considering the relation between the exposure to and the cost of climatic disasters, the respective variables showed high index values, as the climatic disasters are quite frequent in these areas. The fact that communities were not financially supported during and after the disasters that made them highly sensitive/vulnerable, owing to a high rate of poverty in the area. Water and sanitation was inadequate in the two study areas, directly affecting health and nutrition.

It was obvious that the lack of income diversification, high dependency ratio, low education levels, and lack of adequate basic facilities all contributed towards low adaptive capacity. Not surprisingly, these factors also contributed to communities' high vulnerability and low resilience in both mangrove deltas. However, it is promising that these local communities have strengths in that their nature of dwelling, their family networks, and their ability to migrate efficiently when the need arises. These factors contribute to their enhanced adaptive capacity to climate change.

## Adaptations Options and Conclusions

Improving access to basic facilities is key to enhancing adaptive capacity of dependent communities in responding to climate change. It is recommended that governmental authorities in both regions prioritise improving access to basic facilities such as safe and clean drinking water, sanitation, and environmental hygiene. This should be done in support with local municipal authorities. Also linked to this is the need to invest in building climate-compatible shelters that

are disaster-resilient.

There is a need for substantive investment in education sector in the study areas. Its benefits would include: a) access to more/better economic opportunities; b) skill diversification; c) decreased dependency ratio (assuming that more household members enter the workforce); and d) informed climate change responses at the household level.

Based on the study, there is a need for key adaptation options that can provide useful climate change intervention strategies for the two study areas. Functions of such would include: (1) Provision of safe drinking water and sanitation facilities; (2) Ensuring environmental flows; (3) Safeguard from the climatic disasters and settlements out of the risky areas; Improving education access; and (4) Capacity development for climate preparedness and innovations:

Scientific and local knowledge regarding climate change needs to be enhanced and coordinated. Such knowledge further needs to be integrated into policy procedures for informed climate-preparedness planning. Closely linked to this is also the need to strengthen institutional capacities of local development departments (e.g. municipal and management authorities) working in coastal areas. There is also a great need for improving inter-departmental coordination for more coordinated and efficient disaster preparedness and response.

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## ARCP2012-04CMY-SALIK

### PROJECT TITLE

**Impact of Climate Change on Mangroves Ecosystem in South Asia**

### COUNTRIES INVOLVED

Bangladesh, India, Pakistan, Sri Lanka, USA

### PROJECT PERIOD

Two-year project

### APN FUNDING

US\$ 85,000

### PROJECT LEADER

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**CBA2012-06NSY-ZHANG**

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

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**ABSTRACT:** In order to enhance Integrated Marine Biogeochemistry and Ecosystem Research (IMBER) in the Asia-Pacific region, the present project, which began in May 2012, brought together about 20 marine scientists and capacity building experts from 14 countries to share their experience in capacity building and case studies, assess capacity building needs, and consider potential collaboration for future capacity development for IMBER-related research. The project identified capacity building needs in the context of marine scientific research, evaluated current capacity building efforts within IMBER and other oceanic research programs active in the Asia-Pacific region, summarised critical issues and gaps that need to be addressed, analysed the challenges faced and discussed potential solutions to improve research capacity in the region. The results from this project show that three marine research topics, namely, climate change impact, ecosystem health and food security require top capacity building attention. Some key suggestions for effective capacity development include: building and sustaining a regional network for capacity building, promoting regional involvement in capacity building, and developing human capital. These practical suggestions have been published in *Eos, Transactions American Geophysical Union* (Hu et al., 2013) and *Marine Pollution Bulletin* (Morrison et al., 2013).

**KEYWORDS:** *capacity building, marine science, needs assessment, IMBER, Asia-Pacific*

## Introduction

Global change, as one of the vital factors threatening human societies, has become a dominant challenge to environmental safety and global sustainable development. To develop a comprehensive understanding of and accurate predictive capacity for, ocean responses to accelerating global change and the consequent effects on Earth System and human society, IMBER was initiated in 2004 by the International Geosphere-Biosphere Programme (IGBP) and the Scientific Committee on Oceanic Research (SCOR). One of the priorities of the IMBER Science Plan and Implementation Strategy is to promote capacity development along with integrated studies of biogeochemistry and end-to-end food webs. The Capacity Building Task Team (CBTT) was therefore established at an early stage of IMBER's implementation.

The Asia-Pacific region encompasses more than half of the world's population and is also home to some of the world's largest economies (e.g., US, Canada, Russia, Japan, China, India, etc.). The marine ecosystem in this region, especially at a number of



**Figure 1.** Participants of the 2012 Capacity Building Workshop.



**Figure 2.** The workshop ended with plenary reports/Question and Answer session.

## HIGHLIGHTS

- » Mapping international, regional and national capacity building activities on marine science in the Asia-Pacific region.
- » Identification of capacity building needs in the context of marine scientific research.
- » Identification of capacity building needs and challenges for IMBER relevant research, providing potential solutions to the challenges.
- » Three marine research topics require top capacity building attention: climate change impacts, ecosystem health, and food security.
- » Regional/international capacity building resources, networking and potential collaboration opportunities were explored.

small, Pacific Island states, is particularly susceptible to human-induced climate change (Dupont et al., 2008). However, developing and emerging countries in the Asia-Pacific region are not very involved in international marine research in the open sea across the globe.

To enhance the scientific capacity of marine research in the Asia-Pacific region, especially in less developed countries, this project was proposed and an international workshop was convened as the main activity. The main objectives of the project were (1) to synthesise current capacity building efforts, analyse successes and lessons learned, and identify whether they meet the requirements for improved capacity building within the IMBER community, particularly in the Asia-Pacific region; and (2) to provide suggestions for improved capacity building within the IMBER community, particularly in the Asia-Pacific region.

## Methodology

The main activity of this project was the workshop referred to above held from 31 July to 4 August 2012 at the East China Normal University (ECNU), Shanghai, China. Participants comprise about 20 scientists from eleven APN member countries, additional IMBER CBTT members and representatives of international agencies (Figure 1).

These participants were chosen on the basis of their actual or potential involvement in marine research and relevant capacity building knowledge in the Asia-Pacific region. The international organisations involved in this effort included IMBER,

APN, SCOR, IOC/WESTPAC (Intergovernmental Oceanographic Commission, Sub-commission for the Western Pacific) and POGO (Partnership for Observation of Global Oceans).

The workshop opened with discussion of the goals and activities of IMBER, a review of its objectives, and an overview of capacity building concepts and processes. This was followed by a series of presentations from all participants that focussed on evaluation of recent activities and analysis of capacity needs.

After this plenary discussion, proposals for future action were developed in two complementary working groups, the first group involving the regional country representatives and the second group involving participants from IMBER and other international organisations. After the working group discussions, all participants met in a plenary session to consider outcomes and develop an agreed integrated set of future actions (Figure 2).

## Results and Discussion

The survey of capacity building activities on marine sciences in the Asia-Pacific region from 2007 to 2012 demonstrated that current national/regional capacity building efforts do not fully address the tremendous marine research needs in the Asia-Pacific region, where capacity development needs for marine science are predominantly driven by social and economic priorities. The top three marine research topics identified as priorities for capacity building efforts were climate change impacts, ecosystem health, and food security. Capacity development efforts particularly needed for each topic were summarised in Table 1.

The following challenges of the regional capacity building activities were analysed and published in the Marine Pollution Bulletin (Morrison et al., 2013): appropriate alignment of the research goals and societal and policy-relevant needs; training in

Social and Economic Priorities	Capacity building efforts needed
1. Climate change impacts <ul style="list-style-type: none"> <li>» Ocean response to climate change</li> <li>» Disaster risk reduction</li> <li>» Mitigation of natural disasters</li> </ul>	New observation techniques and methods Skills in interpretation of data Data calibration Numerical models on physics, biogeochemistry, ecosystems Downscaling global models to regional and national levels Prediction on ecosystem response and evolution Vulnerability assessment of impact on ecosystem of sea level rise, temperature increase Early warning system and techniques
2. Ecosystem health <ul style="list-style-type: none"> <li>» Reducing eutrophication, contamination, pollution</li> <li>» Reducing incidence of harmful algal blooms (HABs)</li> <li>» Addressing habitat loss</li> <li>» Reducing coastal erosion, sea intrusion, land subsidence</li> </ul>	Identification and management of nutrient/pollution sources Composition and structure of food-webs from end to end Understanding nutrient transport, transformation, biogeochemical cycles Prediction of HABs Monitoring and developing early warning systems, formulating decision tools Methods of organic pollution estimation Use of isotopes/rare earth elements as tracers Natural recovery and mangrove rehabilitation Appropriate methods/technology for coastal protection Adaptation and mitigation Mapping habitats and potential of resources
3. Food security <ul style="list-style-type: none"> <li>» Sustaining fisheries production</li> <li>» Assuring seafood safety</li> </ul>	Methods of collecting oceanic data Skills in interpretation of data Monitoring and developing early warning systems, decision tools Aquaculture technology Understanding oceanic food webs and changes in production system e.g. aquaculture Science integrated marine aquaculture Adaptive ecosystem-based management

**Table 1.** Synthesis on capacity development needs for marine sciences in the Asia-Pacific region (IMBER CBTT, 2012).

	IAEA	IFS	INOC	IOC	IOI	PICES	POGO	SCOR	START
Grants to attend meetings	X	X		X		X		X	X
Grants for training in data and information management			X	X					
Summer schools			X	X		X		X	
Shipboard experience			X	X			X		
Visiting professorships							X	X	X
Centres of excellence in oceanography training				X			X		
Distance learning				X					
Alumni networks							X	X	
Mentoring					X			X	
Regional graduate networks									

**Table 2.** Matrix of capacity building approaches for ocean science, observations, and data/information management (Morrison et al., 2013).

multidisciplinary research; increasing capacity for overall synthesis of scientific data; building the capacity of technical staff; keeping highly qualified personnel in marine scientific research roles; cross-cultural issues in training; minimising duplication in training activities; improving linkages among human capital, project resources and infrastructure.

Some key suggestions to help enhance the regional marine research capacity (Hu et al., 2013) were also identified. These include (1) building a regional capacity building platform, targeting the aforementioned regional research priorities in collaboration with relevant institutions/organisations and regional programmes/projects; (2) promoting globalisation by shifting the locations of capacity building activities from region to region with particular focus to developing countries; and (3) sustaining network and facilitating the emergence of new generations researchers focusing on marine research in this region.

During the workshop, existing regional/international capacity building resources were explored (Table 2). Potential collaboration and dedicated financial resources for capacity building activities targeting the regional needs were also discussed. It is important for scientists and organisations/institutions in the

region to be aware of these resources and to utilise them to the fullest extent possible.

## Conclusions

The proposed objectives of this project have been fully achieved through analysing capacity building approaches of the IMBER project and other marine science programmes/projects in the Asia-Pacific region, and by examining the successes and lessons learned from regional capacity building activities. The full content of those analysis and discussions could be found in the final project report. Based on the results from this project, a strategic paper “Developing human capital for successful implementation of international marine scientific research projects” has been published in Marine Pollution Bulletin (Morrison et al., 2013). Practical suggestions summarised in that paper will be distributed widely to enable the relevant agencies and projects to develop appropriate capacity building strategies.

As a follow-up action to the project, IMBER decided to hold its 2014 summer school (ClimEco4) in China to benefit more students and early career scientists in the Asia-Pacific region. Moreover, this project developed linkages between

international/regional organisations and countries from the APN region, which may facilitate future collaboration, not only on capacity building activities, but also on marine research in this region.

The Asia-Pacific region is highly diverse geographically, culturally and ecologically. The marine research capabilities of the countries in this region differ greatly. There are obvious similarities among some countries and there needs to be greater support from more advanced countries in this region to raise the level of research capacity in those countries that need and desire that support.

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## 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

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

### PROJECT DURATION

One-year project

### APN FUNDING

US\$ 27,275

### PROJECT LEADER

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**CBA2012-07NSY-ARIDA**

# Building Capacity on Access and Benefit-Sharing in Southeast Asia

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**ABSTRACT:** Fair and equitable sharing of benefits arising from the utilisation of genetic resources is one of the core objectives of the Convention on Biological Diversity (CBD). To achieve this objective, the Nagoya Protocol (NP) on Access and Benefit-Sharing (ABS) was adopted at the Tenth Meeting of the Conference of the Parties of the CBD in October 2010. Implementation of the Protocol requires building capacities to implement and comply with the obligations of the Protocol, including developing and implementing domestic legislative, administrative or policy measures on ABS. It also requires countries to develop research capabilities to add value to genetic resources and capacity to negotiate mutually agreed terms. To enhance understanding of the policy, mechanisms and implementation of the NP, a capacity building workshop for Southeast Asian key stakeholders was conducted. About 56 representatives from various sectors participated in the 3rd Regional Workshop on ABS held in Malaysia in December 2012. The four-day workshop covered key topics on ABS. A visit to the Forest Research Institute Malaysia (FRIM), which included discussions with representatives from indigenous and local communities (ILCs) on their experience in documenting traditional knowledge associated with genetic resources, provided valuable input on the interface of science and policy. Overall, the regional workshop analysed guidelines on ABS, developed procedures for benefit-sharing and ABS implementation in different countries, and prepared participants to craft national roadmaps towards developing ABS legal frameworks.

**KEYWORDS:** *access and benefit-sharing, genetic resources, traditional knowledge, ASEAN*

## Introduction

Effective implementation of the NP requires building capacities in developing regulatory frameworks, especially to understand the legal, institutional, administrative, scientific and technological aspects of ABS. Moreover, ILCs need support to prepare them in national ABS processes because more than 80% of the population in developing countries still depends on traditional medicine for their daily needs, thus making traditional knowledge a crucial part of the scientific knowledge base.

The ASEAN Centre for Biodiversity (ACB) with support from the CAPaBLE Programme of the APN convened a training workshop on building capacity involving ABS ASEAN national focal points, academia, scientists, researchers, lawyers, policy makers, representatives from industries, ILCs, and NGOs. This was held complementary to a workshop under the UNEP-GEF Regional ABS Project “Building Capacity for Regionally Harmonized National Processes for Implementing CBD Provisions on Access to Genetic Resources and Sharing of Benefits.”

The training workshop aimed to: (1) build capacity in developing regulatory frameworks and mechanisms to effectively implement the NP; (2) understand the legal, institutional, administrative, scientific and technological aspects of ABS; (3) help prepare ILCs in their participation in national ABS processes through in-depth training of their representatives and trainers such as key educators and NGOs; and (4) learn about recent trends, developments and best ABS practices from resource persons from Japan and other developed country partner organisations and ABS experts.

## Methodology

The training workshop was convened on 10-13 December 2012 in Kuala Lumpur, Malaysia. Fifty-six (56) participants took part, representing providers, regulators and users of genetic resources from the AMS (except Indonesia) and Timor Leste. Resource speakers were from the Centre for Biodiversity Law (CEBLAW)-Malaysia, United Nations University-Institute for Advanced Studies (UNU-IAS), Environment Division-ASEAN Secretariat, FRIM, Sarawak Biodiversity Centre, Third World Network, and Japan Bioindustry Association.

The workshop was built on two previously held workshops supported under the auspices of a UNEP-GEF project (Building Capacity for Regionally Harmonized National Processes for Implementing

## HIGHLIGHTS

- » Enabling ABS stakeholders to raise their critical understanding of the legal, institutional, scientific and technological capabilities in terms of discussions on ABS topics including bioprospecting, biotechnology and biopiracy.
- » Providing capacity building opportunities for ASEAN Member States (AMS) and Timor Leste participants in the development of country ABS legal frameworks.
- » Facilitating exchanges amongst participants, especially in experiences of actual ABS processes through field visits and forums on the linkages between and among science, traditional knowledge and policy development.
- » Interactive sharing of the mechanisms on benefit-sharing and country experiences on ABS, as well as the experiences of a Japanese Bioindustry.

CBD Provisions on Access to Genetic Resources and Sharing of Benefits). The workshop comprised lectures, discussions and a field visit. The activity enhanced the understanding of the participants about the procedural aspects of ABS such as Prior Informed Consent (PIC), Mutually Agreed Terms (MAT), fair and equitable sharing of benefits, and other relevant issues.

Lectures focused on developing national laws to implement the Protocol; benefitting from traditional knowledge; preparation and assessment of national roadmaps; and reviewing the draft ASEAN ABS Framework. The workshop provided a venue for participants to scrutinise ABS practices in some specific countries, including national experiences on PIC, MAT and existing model instruments. The training included preparing ILC representatives in their participation in national processes. The perspectives of the industry sector in the region were incorporated into the design.

A visit to FRIM provided additional views of the applications of the ABS mechanism. A special presentation was made and discussion was held during the field visit regarding an ABS arrangement to document traditional knowledge of medicinal and aromatic plants of an indigenous community from peninsular Malaysia.

## Results and Discussion

As countries prepare towards implementation of

the NP, lectures and discussions regarding development of national ABS laws, and the different processes and elements that need to be considered, are very relevant. Professor Gurdial Singh Nijar from CEBLAW divided his presentation into three sessions.

The first session examined the important articles of the NP and what is required of Parties to fulfill their obligations under the Protocol. The second session examined the pre-NP ABS laws

of Viet Nam and the Philippines, assessing key provisions of these laws in light of the Protocol. This session sought to develop the participants' capacity to identify key issues important to their national interest and needs, so as to create national laws to protect their national interests in compliance with the NP. The third session presented a step-by-step process that a developing country could take towards developing an ABS legal framework.

Workshop Topics	Speakers
Ratification of the Nagoya Protocol and Way Forward Towards Entry into Force	Mr. Olivier Rukundo Programme Officer ABS, SCBD
Developing National Law to Implement the Nagoya Protocol by Examining All Relevant Articles (highlighting elements of NP)	Prof. Gurdial Singh Nijar Centre of Excellence for Biodiversity Law (CEBLAW),
Incorporating Elements of the Nagoya Protocol: Policy Review of Selected National Policies on ABS	Prof. Gurdial Singh Nijar Centre of Excellence for Biodiversity Law (CEBLAW),
Preparing and Assessing National Roadmap in Developing and Implementing ABS Legal Frameworks	Prof. Gurdial Singh Nijar Centre of Excellence for Biodiversity Law (CEBLAW)
The Draft ASEAN ABS Framework and the Nagoya Protocol	Dr. Raman Letchumanan Head, Environment Division ASEAN Socio-Cultural Community Department ASEAN Secretariat
Developing Regional Benefit-Sharing Procedures and/or Mechanisms: Focus on PIC, MAT, Compliance, Ownership, and IPR	Mr. Geoff Burton Adjunct Senior Fellow UNU-IAS
Briefing on the Documentation of Medicinal & Aromatic Plants of the Indigenous peoples in Malaysia Introduction & progress to date of the project Bio-Propecting Sharing Experience by Indigenous leader	Dr. Norini Haron Dr. NikMusa'adah Mustapha Mr. NoryaAbas
Biopiracy case studies and the importance of ABS laws	Ms. Lim Li Ching Third World Network
Implementing PIC and MAT: Procedures and experiences in selected countries	Dr. Rita Manurung Chief Operating Officer Sarawak Biodiversity Centre  Atty. Elpidio Peria Legal Adviser on ABS Philippines  Mr. Geoff Burton
Implementing ABS in Southeast Asia: Experiences of an industry	Dr. Sumida Seizo Technical Advisor Japan Bioindustry Association

**Table 1. Presentations during the ABS Training Workshop.**

The ASEAN Regional Framework on ABS was drafted in 2005 even before the NP came into effect. At the workshop Dr. Raman Letchumanan of the ASEAN Secretariat provided historical background on the regional draft framework on ABS, emphasising that the Framework Agreement has a set of minimum standards.

The workshop concluded that benefit-sharing procedures, including negotiating MAT and permits, are necessary elements in ABS policies, especially as countries gear up to establishing their own ABS policies. Requirements to develop “trusted collections,” referring to materials that are being held in trust on behalf of countries from where the materials originated, should also be set up in accordance with the requirements of provider countries with respect to national obligations of collections and materials acquired.

The visit to FRIM showcased an example of the working linkages between science, traditional knowledge and policy. Ensuring that the local community is involved and empowered from the outset was emphasised in the discussions on their project “Documentation of Traditional Knowledge on Medicinal and Aromatic Plants Used by Orang Asli Peninsular Malaysia.” This project focused on a rapid rural appraisal involving the local community and on including local community members as part of the National Technical Working Committee.

The experiences of the Sarawak Biodiversity Centre (SBC), Malaysia and the Philippines on actual implementation on PIC and MAT were shared. The SBC has been facilitating (a) research and development and bioprospecting programmes for sustainable utilisation of the state’s biodiversity, and (b) processes for application for research permits (with detailed elements found in the licensing agreement). The Philippines, on the other hand, has national policies in place addressing bioprospecting - Executive Order 247 and the Wildlife Act.

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shared, from a different perspective, Japan’s experience in implementing ABS, including the institutional set-up, awareness raising activities, lessons learned, tools, and key points needed to ensure successful partnerships and collaborations. Under its National Strategy for Biodiversity, Japan is expected to ratify the NP by 2015, and legally binding compliance measures will have to be put in place before ratification.

## Conclusions

Vital to the development of national ABS legal frameworks is the need to examine existing obligations with other agreements vis-à-vis the provisions of the NP. Since the NP defines sovereign rights of countries and not ownership over genetic resources, there is a need for countries to establish clear regulatory requirements for compliance, especially in reaching fair terms for both local and foreign applications.

The review of selected national ABS policies led to further identification of capacity building needs, including awareness raising activities. It also drew attention to the need to update current legislation in order to fully comply with new obligations under the NP, highlighting the compliance provisions.

Developing regional benefit-sharing provisions and mechanisms gives the opportunity to focus on the elements of PIC, negotiating MAT, and developing the concept of “trusted collections,” which make such material available on terms as desired by the country of origin.

Traditional knowledge should be integrated into national systems and the CBD ABS mechanism to make the process transparent and allow users to follow the process. The NP provides for States to take measures in accordance with domestic law such as setting in place some form of documentation (community protocols) to set up rules and procedures on use of traditional knowledge.

The training workshop, with full

participation of critical stakeholders, effectively built capacity in implementing the NP on ABS and developing national access and benefit-sharing procedures with full participation of critical stakeholders. The workshop provided detailed guidance for country representatives in developing national roadmaps towards ABS legal frameworks.

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### Acknowledgements

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financial support for the participation of key stakeholders in the Third Regional Workshop on ABS: Developing a national roadmap towards ABS legal frameworks.

### Project Publications

Foronda, A. C. T. M. (2013). An Urgent Need: Institutionalising Access to Genetic Resources and Benefit Sharing in Southeast Asia (Policy Brief). ASEAN Centre for Biodiversity.

ASEAN Centre for Biodiversity Policy Brief Series, ABS Issue 1 June 2013. An Urgent Need: Institutionalising Access to Genetic Resources and Benefit Sharing in Southeast Asia.

## 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, Timor Leste, Thailand, Viet Nam

### PROJECT DURATION

One-year project

### APN FUNDING

US\$ 40,000

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CBA2012-08NSY-HONGBO

# Marine Invasive Species in the Northwest Pacific Region of China

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**ABSTRACT:** China is a large coastal country vulnerable to invasive species. In the past decades, about 30 major marine invasive species (MIS) were recorded in the Northwest Pacific including NOWPAP region, where parts of China's marine areas are situated. MIS issues are threatening and impacting native communities and ecosystems, including the economy and public health. In this paper, the authors show the status of MIS in the NOWPAP region of China and the impacts of MIS on the country and its ecosystems. While great efforts are being made in the prevention, detection and management of MIS, more action is needed at both scientific and political levels.

**KEYWORDS:** *Marine Invasive Species (MIS), impact, management of MIS*

## Introduction

China is a large coastal country with 18,000 km of mainland coastline. There are more than 65,000 islands over 500m<sup>2</sup> in size and about 30,000,000 km<sup>2</sup> of sea area under China's jurisdiction. The marine area of China spans a latitude of 38 degrees and three temperature zones containing rich and unique marine ecosystems. On the other hand, such features make the country more vulnerable to invasive species, as many alien species are likely to find their suitable habitat there. In recent years, the spread of alien species has accelerated because of multiple factors, such as large scale mariculture, fish trade, ornamental fish in aquarium husbandry, extensive exchange of invertebrates and algae, shipping (especially ballast water discharge), as a result of the rapid development of China's trade and transport systems in the past decades (Liang & Wang, 2001).

The NOWPAP region refers to the marine region

surrounded by China, Korea, Japan and Russia, which belongs to the temperate climate zone, with heavy shipping traffic every year. According to statistics, in recent years, there are about 30 major marine invasive species (MIS) recorded in the NOWPAP region, and China's marine ecosystem located along the Northwest Pacific coast is also effected by biological invasion.

Pathways of MIS introduction to the NOWPAP region of China include shipping and ballast water, which is the most common medium of MIS around the world, in addition to intentional introduction and aquaculture (Xu et al., 2004; Xu & Qiang, 2011). China had introduced at least ten species of fish, two species of shrimp, nine species of shellfish, one species of echinoderm and four species of algae in mariculture. Few species among them are suitable for mariculture or could bring significant economic benefits, and the introduction of these species could be potentially dangerous to the marine environment of China (Hao et al., 2005).

No.	Scientific name	English name	Distribution
1	<i>Laminaria japonica</i> (Areschoug, 1851)	Kelp	Most coastal areas of China
2	<i>Macrocystis pyrifera</i> (Agardh, 1820)	Giant kelp	Sea areas from Dalian (Liaoning Prov.) to Changdao Island (Shandong Prov.)
3	<i>Undaria pinnatifida</i> (Suringar, 1873)	Asian kelp	most coastal areas of China
4	<i>Desmarestia ligulata</i> (Lamouroux, 1813)	Color changer	Sea areas of Dalian, Lvshun (Liaoning Prov.), and Shandong Prov.
5	<i>Spartina alterniflora</i> (Loisel)	Smooth cordgrass	Coastal areas from Liaoning to Jiangsu Prov.
6	<i>Spartina anglica</i> (C.E. Hubbard)	Common cordgrass	Coastal areas of Jiangsu Prov.
7	<i>Haliotis discus</i> (Reeve, 1846)	Disk abalone	Coastal areas of Dalian (Liaoning Prov.)
8	<i>Haliotis gigantea</i> (Gmelin, 1791)	Giant abalone	Coastal areas of Liaoning and Shandong Prov.
9	<i>Haliotis rufescens</i> (Swainson, 1822)	Red abalone	Coastal areas of Liaoning and Shandong Prov.
10	<i>Haliotis fulgens</i> (Philippi, 1845)	Green abalone	Coastal areas of Liaoning and Shandong Prov.
11	<i>Argopecten irradians</i> (Lamarck, 1819)	Bay scallop	Coastal areas of Liaoning and Shandong Prov.
12	<i>Patinopecten yessoensis</i> (Jay, 1857)	Giant Ezo scallop	Coastal areas of north China, especially Liaoning and Shandong prov.
13	<i>Crassostrea gigas</i> (Thunberg, 1793)	Pacific oyster	All the coastal areas
14	<i>Mercenaria mercenaria</i> (Linnaeus, 1758)	Hard-shell clam	Coastal areas of Shandong Prov.
15	<i>Panopea abrupta</i> (Conrad, 1849)	Pacific geoduck clam	Coastal areas of Shandong Prov.
16	<i>Litopenaeus stylirostris</i> (Stimpson, 1871)	Blue shrimp	Coastal areas of Shandong and Jiangsu Prov.
17	<i>Litopenaeus vannamei</i> (Boone, 1931)	White shrimp	Coastal areas of Jiangsu Prov.
18	<i>Marsupenaeus japonicus</i> (Bate, 1888)	Kuruma prawn	Coastal areas of the north China
19	<i>Strongylocentrotus intermidus</i> (A. Agassiz, 1863)	Sea urchin	Coastal areas of Dalian(Liaoning Prov.) and Rongcheng(Shandong Prov.)
20	<i>Oncorhynchus Kisutch</i> (Walbaum, 1792)	Coho salmon	Coastal areas of Liaoning Prov.
21	<i>Oncorhynchus mykiss</i> (Walbaum, 1792)	Rainbow trout	Coastal areas of Liaoning and Shandong Prov.
22	<i>Salmo salar</i> (Linnaeus, 1758)	Atlantic salmon	Coastal areas of Liaoning Prov.
23	<i>Paralichthys dentatus</i> (Linnaeus, 1766)	Summer flounder	Coastal areas of Shandong Prov.
24	<i>Paralichthys lethostigma</i> (Jordan & Gilbert, 1884)	Southern flounder	Most coastal areas of China
25	<i>Verasper moseri</i> (Jordan & Gilber, 1898)	Barfin flounder	Waters to east of northern China
26	<i>Solea senegalensis</i> (Kaup, 1858)	Senegalese sole	Coastal areas of Shandong Prov.
27	<i>Solea solea</i> (Linnaeus, 1758)	Common sole	Coastal areas of Shandong Prov.
28	<i>Anguilla anguilla</i> (Linnaeus, 1758)	European eel	Coastal areas of Jiangsu Prov.
29	<i>Anguilla rostrata</i> (Lesueur, 1821)	American eel	Coastal areas of Jiangsu Prov.
30	<i>Morone saxatilis</i> (Walbaum, 1792)	Striped bass	Coastal areas of Shandong Prov.
31	<i>Sciaenops ocellatus</i> (Linnaeus, 1766)	Redfish	Most coastal areas of China
32	<i>Halocynthia roretzi</i> (Drasche, 1884)	Sea squirt	Coastal areas of Liaoning and Shandong Prov.

**Table 1.** Main marine invasive species in the NOWPAP region of China.

The major marine invasive species in the NOWPAP region of China include 6 plants (including phytoplankton), 13 invertebrates, 12 fishes and 1 other species (Table 1).

MIS may have huge threats and impact on native communities and ecosystems including in terms of economy and public health. Smooth cordgrass (*S. alterniflora*) distribute in almost all the coastal areas

of south China. They occupy niches of native species, and destroy the habitat of native birds and aquatic species, threatening local biodiversity. They also clog waterways, affecting water exchange and cause red tide (Chen et al., 2004). Adverse effects such as native species reduction, landscape loss, breeding degradation, diseases, frequent red tides, etc., which were possibly caused by MIS, not only result in economic loss on marine-based industry, but also trigger a series of social problems indirectly (Liang & Wang, 2001). The Ministry of Environmental Protection of China carried out an evaluation on invasive alien species during 2001-2003, and it showed that each year invasive alien species may cost about 14.5 billion dollars of loss in China, including direct loss in agriculture and indirect loss in ecosystems, genetic resources, and so on (Xu & Qiang, 2004). As an example, the mass mortality of *Chlamys farreri*, which was introduced from Taiwan Province, was considered as a major reason for the spread of shrimp viral diseases across China's aquaculture sites since 1993. Shrimp viral diseases and other invasive-species-related diseases led to a loss of more than 483 million dollars in 2002 (Zhu & Zhao, 2004).

The Chinese government has made great effort in the prevention, detection and management of MIS. The Ministry of Environmental Protection announced the first list of invasive species in 2003, and the second list in 2010, with 35 species in total, including 1 MIS, Smooth cordgrass (*S. alterniflora*). In 1990, the concept of Pest Risk Analysis (PRA) was formally introduced into China, and China's first PRA institution, the "PRA Office" was formally established in 2000 by the Animal and Plant Quarantine Institute, General Administration of Quality Supervision, Inspection and Quarantine, as the leading institute in China's PRA work. In 2002, the PRA Office intercepted 22,448 batches of pests from 1,310 alien species. In September 2002, as part of the world's ballast water management project, the first ballast water risk assessment in China was carried out in Dalian port. The team, comprising experts from relevant departments and institutes, successfully conducted a simulation analysis of the environment and biological parameters of the port, and built a regional geographic information system. At present, similar risk assessments of ballast water have been launched in many ports in China. Furthermore, the Chinese government has also created a number of databases for the control and management of MIS. In 2012, the Atlas of MIS in the NOWPAP Region of China was developed.

With financial support from APN and human

resource support from the First Institute of Oceanography of State Oceanic Administration of China, the Regional Workshop on Marine Invasive Species Problems in Northwest Pacific Region was held in Qingdao, China, from 23-24 October 2012. The workshop was hosted by the Data and Information Regional Activity Center (DINRAC) of NOWPAP. With technical support from related organisations, the agenda of the workshop included three major topics: Current situation of MIS problems in NOWPAP member countries; impacts of MIS on ecosystems and environment in NOWPAP member countries; and current policies and measures on preventing and controlling MIS problems in the NOWPAP member countries and future needs for policies, measures and regional cooperation. Through this workshop, experts and officials from NOWPAP member countries exchanged knowledge and understandings of the current situation of MIS issues in the region, the measures to prevent and control MIS problems, and the necessary policies and measures to tackle these problems. Moreover, this workshop served as a platform to strengthen the linkage between science and policy. The workshop recommended that more investigation of and research on MIS are needed, and countries in the NOWPAP region need to provide resources to strengthen the investigation and researches on this issue, to develop regional cooperation on data sharing in the framework of NOWPAP, as well as close cooperation with other international organisations, and that increased ratification of the Ballast Water Management Convention of the International Maritime Organization is essential to prevent the further spread of MIS.

However, there are still many gaps in the prevention, detection and management of MIS, as well as in relation to the global and regional developments dealing with marine and coastal biodiversity. The current national legislations and management systems for MIS need to be utilised to further prevent and control MIS, including the control of sources of MIS introduction and spread, routine monitoring to detect and implement rapid response to eradicate or control MIS before they spread, and long-term responses to mitigate the impacts of MIS. Although more attention has been received for marine biodiversity, it is also believed that more measures need to be adopted for eliminating marine bio-invasion, including policy and legal system's improvement as well as related capacity building. As a result, the introduction of alien marine organisms and other activities such as stock enhancement releasing, religious releasing, etc., has been accelerating the pace of alien species invasion, causing

potential danger to the marine environment of China (Liu et al., 2008; Li & Huang, 2011).

As a global problem, MIS has attracted large amounts of attention from many countries as well as a number of international organisations. In order to strengthen the management of MIS, many countries including the USA, Australia and New Zealand, have developed their own strategies for the management of MIS, and also established a variety of guidelines and corresponding legislations. In accordance with international experience and practices, the Chinese Government is recommended to achieve the following aspects in the future:

- Urgently establish laws and regulations for the management of MIS.
- Strengthen institutional capacity and improve multi-sectoral coordination and management mechanisms.
- Enhance the infrastructure of MIS management systems.
- Implement appropriate measures of prevention, elimination, control and restoration for the introduction of MIS.
- Reinforce scientific research and provide a scientific basis for the management of MIS.
- Develop regional cooperation in data sharing under the framework of NOWPAP, and collaborate closer with other international organisations.
- Design education and training programmes to raise public awareness.

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## CBA2012-08NSY-HONGBO

### PROJECT TITLE

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

### COUNTRIES INVOLVED

China, Japan, Korea, Russia

### PROJECT DURATION

One-year project

### APN FUNDING

US\$ 32,250

### PROJECT LEADER

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**CBA2012-12NSY-CRUZ**

# Conservation Farming Village (CFV) Programme for Protecting Uplands and Building Resilient Communities

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**ABSTRACT:** The Conservation Farming Village (CFV) programme was designed to transform erosive farming in sloping lands (uplands) into a strategy for improving the income and quality of life of farmers and for promoting the resilience and sustainability of upland areas. It involves the active collaboration of upland communities, local government units (LGUs), and academia in enhancing the capability of upland communities in practicing conservation farming and other related technologies. Prior to this project, 75 initial upland communities in five different towns were implementing the CFV programme. This project aimed primarily to build the capacities of upland farmers and communities, LGU executives, and technical personnel to implement the CFV programme in other upland areas, especially on sloping lands, in the country. The target of the project was to facilitate the establishment of at least one new CFV model farm in each of the 15 new provinces. Enhanced capability of the farmers and LGUs were vital to the success of CFV in these sites. Five training courses were conducted with 272 participants consisting of farmers, LGU officials and academia. Participants visited existing CFV sites. Eighteen farms were established in the eleven provinces where CFV capacity building activities were implemented.

**KEYWORDS:** *conservation farming village, capacity building, local government units, sloping land management, agroforestry*

## Introduction

The implementation of the Philippine Republic Act 7160 in 1991 mandated that local executives 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 programme for transforming traditional farming systems in sloping lands into sustainable upland production systems and stimulating climate-resilient upland community development. The CFV programme adopts a community-based participatory approach to technology development, promotion and utilisation, and a multi-level technology promotion mechanism that will capacitate local extension/change agents.

CFV started from the upland development programmes funded by the Philippine Council for Agriculture, Aquatic and Natural Resources Research and Development (PCAARRD) entitled Environmental and Productivity Management of Marginal Soils in the Philippines; ASIALAND Network: Management of Sloping Lands for Sustainable Agriculture in the Philippines, implemented from 1997-2004 in the Provinces of Batangas, Catanduanes, and Camarines Sur; and the National Programme on Sustainable Upland Farming Through the Establishment of “Barangay Sagip-Saka (Conservation Farming Villages–CFVs) from 2009 2011.

Following lessons learned from previous CFV practices, the present study was conducted to build the capacities of LGU executives and their technical personnel to undertake CFV. In turn, these LGU personnel are expected to help upland farmers improve their economic conditions by strengthening their capacities to manage the natural resources,

thereby protecting their communities against environmental degradation while sustaining their sources of livelihood.

Technology adoption among farmers is very often met with doubt. The “Theory of Diffusion” explains how, why and at what rate new ideas and technology spread through cultures. According to Rogers (1962), this theory has five main elements: innovation, communication channels, time, and a social system. This paper explains the processes the CFV programme went through in order to enhance farmers’ adoption of sloping land management technology and building resilient communities.

## Methodology

### *CFV Concept*

The conceptual framework for CFV involves three stages — formation, consolidation and integration. (Figure 1). CFV involves a tripartite collaboration among the state university or college (SUC), the local government unit (LGU) and farmers. The CFV project was implemented in 11 provinces in the Philippines from 29 June 2012 to 28 June 2013 through the present project supported by APN: Enhancing the LGU Capacity for Implementing Conservation Farming Villages as a Strategy for Climate Change Adaptation and Upland Development.

### *Selection of Provincial Participation*

The implementation of this project built linkages established by the University of the Philippines Los Baños (UPLB) with the existing state colleges and universities and local government units in five provinces in the Philippines. These are the Ifugao State University and the town of Alfonso Lista, Ifugao; Bicol University College of Agriculture and Forestry and Ligao City, Albay; Silliman University and La

## HIGHLIGHTS

- » CFV is a model village, where farmers practice conservation farming and other sloping agricultural land technologies.
- » CFV enhances the transfer of conservation farming technologies and practices.
- » Training courses coupled with visits to CFV farms prove beneficial for prospective adopters of the technologies.
- » Farmers practicing conservation farming technologies were able to share their experiences, including best practices, with other farmers interested in implementing conservation farming.
- » Active LGU participation is vital in creating an enabling environment for farmers and farming communities, and in mobilising and improving accessibility to technical, financial and other resources.

Libertad, Negros Oriental; University of Southeastern Philippines and the Panabo City, Davao del Norte; and General Nakar, Quezon for UPLB.

*Criteria for Selecting the Provinces to for Implementation of the Programme*

A project management team composed of five school representatives and UPLB project staff selected the provinces to receive the capacity building. These were provinces proximal to existing CFV sites where a majority of the municipalities have numerous farms in upland areas. The geographical locations of the selected provinces are shown in Figure 2.

**Capacity Building**

Establishment of a program to assess needs was deemed to be critical for training and development (Miller & Osinski, 2002), especially capacity building, in order to identify gaps in knowledge, attitudes and skills that affect individual performance, while taking into account important constraints (International Service for National Agricultural Research [ISNAR], 2001).

Tools were developed to assess the training needs of LGU personnel and farmers on topics related to sloping land management, and the training needs assessment was conducted by partners from academic institutions situated near or within the provinces. Results of the training needs assessment provided

the basis for designing the training activities aimed at developing the capability of the LGUs.

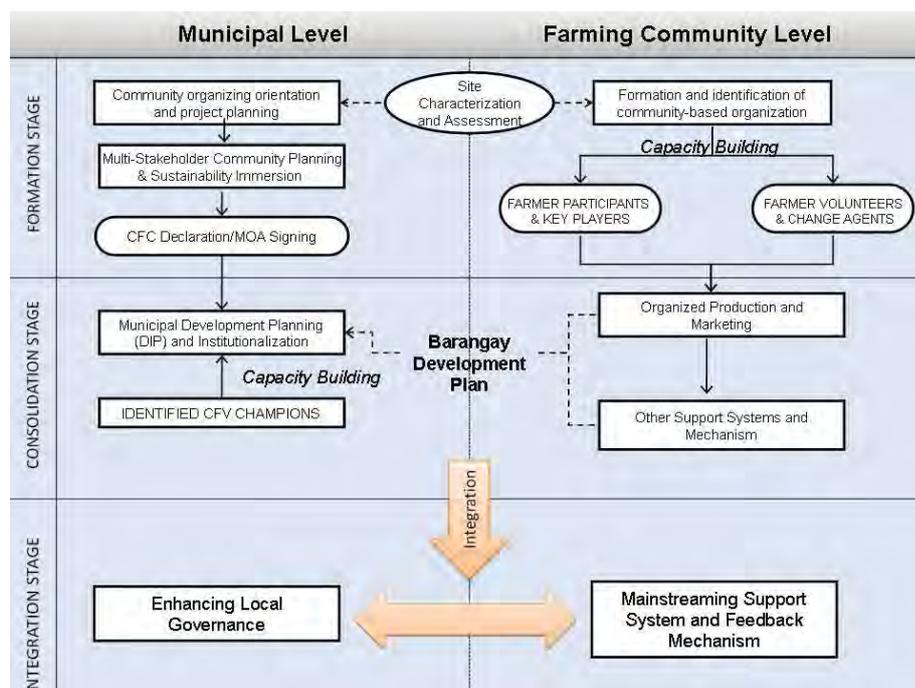
Training was then provided to LGU executives, LGU technical personnel, and farmers. The training was conducted through lecture-discussion, hands-on/practicum, and cross visits to CFV farms.

From among those who attended the training course and were willing to develop their farms into model CFV farms, a number of farmers were chosen as Farmer Volunteers (FVs). The physical attributes of the FVs' farms were assessed using the Agroforestry Land Capability Mapping Scheme, or ALCAMS (IAF and Kapwa Upliftment Foundation, Inc., 1994). ALCAMS takes into consideration the slope of the area, vegetation, and soil fertility to determine the agroforestry system most suitable for the farm given the current conditions of the land. However, decisions as to the species made by, and not imposed on, the farmers, based on their specific needs and on other information regarding the market situation in their localities.

**Results and Discussion**

*Results of the Training Needs Assessment*

The socio-demographic profile of the respondents is shown in Figure 3. Similar to the study of Maharashtra (2010) there are more male than female respondents (<http://www.strcmsgdnh.org/pdf/Training-Needs-assessment-Final-Report.pdf>.) Most of the



**Figure 1.** Conceptual framework for the establishment of Conservation Farming Village (CFV).

respondents from the LGU are college graduates and are mostly between 31 to 40 or 51 to 60 years old. A majority of the respondents have attended training courses related to upland development.

The topics identified by LGU personnel as being of the highest priority to them were climate change and upland development, followed by soil erosion control (Table 1). Community organising ranked third and marketing strategies, fourth.

The training needs identified by the farmers are shown in Table 2. Understanding climate change and upland development was ranked number 1, followed by the need to understand how best to organise farming communities. Soil erosion and its control were ranked third.

### Training Implementation

Rank	Suggested Topics	Weighted Score* n = 62
1	Climate change and upland development	636
2	Soil erosion and its control	620
3	Community organising	609
4	Farm and farmer profiling	577
5	Cropping combinations appropriate for sloping areas	562
6	Soil fertility management	557
7	Basic Concepts of Watershed Management	548
8	Multistakeholder community development planning	491
9	Local policy/ordinance formulation	481
10	Barangay Development Planning	473
11	Livelihood support mechanism	432
12	Community Sustainability Indicators	351
13	Alley cropping	333
14	Financial management	318
15	Marketing strategies	312

**Table 1. Results of training needs assessment for LGU personnel in the target provinces.**

\* The weighted scores were computed based on topics given first priority 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>)



**Figure 2. Location map of Conservation Farming Villages (CFV) sites.**

Training courses were then developed specifically for each provincial cluster, to meet the needs identified by the prospective participants both from the LGUs and the farmers. Five training courses were implemented with a total of 272 participants composed of farmers, LGU officials, and the academia. Follow-up and knowledge-sharing activities after the training were conducted by the participants in their respective areas, involving other farmers.

### Farm Development

For the cluster adjacent to UPLB, ALCAMS was used to determine the best agroforestry system to be implemented in the demonstration farms (Table 3). Results of ALCAMS showed that the farms were generally suitable for agroforestry, albeit requiring incorporation of soil and water conservation measures like terracing, mulching, contour hedgerows, and drainage systems/canals.

Eighteen CFV farms were established through this project. UPLB, USEP and BUCAF have three farms each while IFSU developed five and SU developed four.

### Spin-offs from this APN Project

Outside of the proposed provincial coverage of the CFV Project under the APN, the Fostering Education and Environment for Development, Inc., a local NGO

in the Philippines concerned primarily with rural development and environmental protection, requested the support of CFNR-UPLB in implementing CFV in the Baroro Watershed, which covers three municipalities of La Union Province in Northern Philippines. Support of the Project in this new site for CFV expansion is guaranteed even after the completion of this APN Project, by the provincial government and the province's representative to the Philippine Congress. This is a welcomed opportunity to demonstrate the potential of CFV as an integral component of the Watershed Ecosystem Management approach being implemented in the Philippines.

**Conclusions**

The project was implemented to build the capacities of LGU executives and their technical personnel to undertake sustainable development and build resilient communities in upland areas.

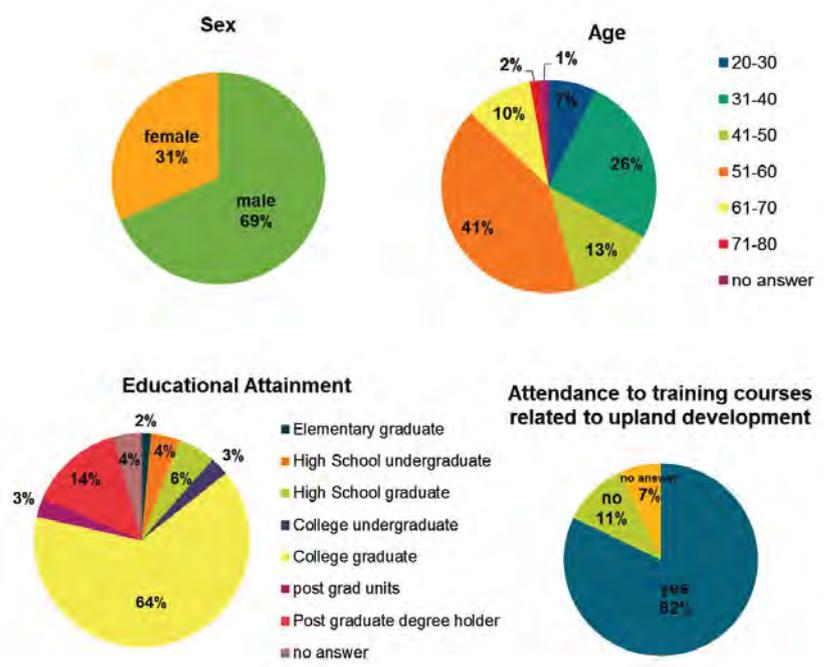
CFV knowledge and skills were transferred from the experts from the academe to the LGU personnel/office in charge of environment and natural resources or agriculture, which were in turn passed on to the potential farmer adopters, in 11 provinces of the Philippines. The CFV programme enabled LGU executives to empower farmers to adopt technologies geared towards upland development.

Sustainable farming in the sloping lands could not prosper unless LGUs embrace fully the responsibility of being the primary facilitators of mobilising resources that are needed by the farmers for sustainable upland development through CFV. The sheer immensity of the resources required to veer the management of uplands away from the path of degradation to sustainable development would be overwhelming for farmers alone to shoulder. Capitalising on farmers' ability and commitment, LGUs must appreciate the value of establishing active collaboration between upland communities, LGUs, and academia to enhance the capabilities of these

Rank	Suggested Topics	Weighted Score* n= 8
1	Climate change and upland development	101
2	Community organising	85
3	Soil erosion and control	65
4	Local policy/ordinance formulation	60
4	Farm and farmer profiling	60
5	Basic concepts of watershed management	54
6	Cropping combinations appropriate for sloping areas	53
7	Multi-stakeholder community development planning	45
8	Livelihood support mechanism	44
9	Soil fertility management	42
10	Marketing strategies	40
11	Alley cropping	30
12	Barangay Development Planning	15
13	Financial management	14
14	Community Sustainability Indicators	13

**Table 2. Training needs of farmers in the target provinces.**

\* The weighted scores were computed based on topics given first priority 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](http://ftp.cgiar.org/isnar/papers/tna-radio.pdf))



**Figure 3 (right). Socio-demographic profile of respondents.**

Provincial Cluster	Location	Slope	Vegetation	Soil Fertility	Suitability for Agroforestry
Batangas	Sitio Ulupong, Barangay Sawang, Lobo, Batangas	18-45%	brushland	Medium	Conditionally suitable for agroforestry
Laguna	Barangay Atisan, San Pablo City, Laguna	18-30%	brushland	medium	Conditionally suitable for agroforestry
Rizal	Sitio Pawpawan, Barangay San Salvador, Baras, Rizal	18-30%	brushland	Low	Conditionally suitable for agroforestry

**Table 4. Land suitability for agroforestry of identified farms adjacent to UPLB.**

communities in practicing conservation farming and other related technologies in order to better pursue the development of these communities.

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## CBA2012-12NSY-CRUZ

### PROJECT TITLE

Enhancing the LGU Capacity for Implementing Conservation Farming Village as a Strategy for Climate Change Adaptation and Upland Development

### COUNTRIES INVOLVED

Philippines

### PROJECT DURATION

One-year project

### APN FUNDING

US\$ 45,000

### PROJECT LEADER

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# ARCP PROJECTS

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*Regional research projects funded under the*  
**Annual Regional Call  
for Research Proposals  
(ARCP)**

# Greenhouse Gas Budgets of South and Southeast Asia

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## Project Objectives

We aim to establish the mean greenhouse gas (GHG) budgets and variability for South Asia and Southeast Asia for the period 1990 to 2009. This will be achieved by analysing atmospheric GHG inversions (top-down) and bottom-up estimates based on terrestrial biogeochemical models, remote sensing data, and flux and forest inventory datasets. The project will estimate the contribution of emissions from different sources to the total anthropogenic GHG emissions and subsequently provide information on which climate policies can harvest the highest climate benefits. This is being achieved through cooperation between scientists from South and Southeast Asia, and experts from other parts of the world.

## Work Undertaken

During the first two years of the project, two international workshops were held, one in South Asia (Physical Research Laboratory, Ahmedabad, India) and one in Southeast Asia (Center for International Forestry Research, Bogor Indonesia). These workshops provided information that allowed us to summarise the carbon budgets of the two regions in collaboration with the scientists involved (Patra et al., 2013a,b, Sarma et al., 2013, Canadell et al., 2013). These two workshops emphasised the development of new products using the regional-based scientists' skills, as well as further improving the research facilities. In this regard, an air sampling site in Comilla, Bangladesh was established and CO<sub>2</sub>, CH<sub>4</sub>, CO, N<sub>2</sub>O, SF<sub>6</sub> and H<sub>2</sub> analyses of air samples collected weekly have been conducted in the NIES laboratory since June 2012. This is a critical new sampling station in order to sample and analyse the carbon budgets of South and Southeast Asia region.

This year, one of the Project Investigators visited

the hill-top of Queensberry tea estate in Nawalapitiya, Sri Lanka, to extend the GHG measurement network. It is envisaged that a flask air-sampling project will begin in 2014. In order to use these new measurements along with existing measurements, efforts to strengthen the numerical simulation capability within the regions of interest are underway. In addition, a 20-core workstation has been purchased for researchers at the University of Sri Jayewardenepura to conduct forward and inverse modelling of CO<sub>2</sub>.

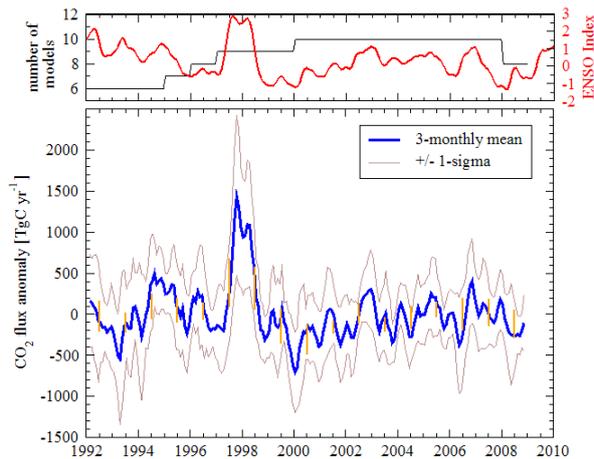
Last year, the project reported the decadal mean budget of carbon exchanges from South Asia. This year, the project focuses on budgeting carbon fluxes for Southeast Asia.

Figure 1 shows that CO<sub>2</sub> fluxes for Southeast Asia have large interannual variations in relation to natural climate variability, e.g., ENSO. The positive phase of ENSO is known to cause less rainfall and thus warmer and drier air temperatures, which trigger enhanced biomass burning by clearing peat, deforested biomass or frequent occurrence of natural forest fires.

During our assessments we observed that lack in existence of organised databases and, more fundamentally, a lack of long-term quality-controlled data of GHG concentrations and related natural and anthropogenic activities. For example, the large spread in top-down estimated CO<sub>2</sub> fluxes mainly arises from the lack of in situ

## HIGHLIGHTS

- » South Asia carbon budget completed using bottom-up and top-down estimations.
- » GHG measurements from Comilla, Bangladesh completed within 1.5 years.
- » Southeast Asia carbon budget submitted December 2013.
- » New collaborative research with colleagues in Sri Lanka initiated in 2014.



**Figure 1.** Interannual variations in CO<sub>2</sub> fluxes as estimated by the top-down/inverse models for Southeast Asia.

measurements of CO<sub>2</sub> concentrations. The present air-sampling programme will only partly address this issue of a sparse observation network. The research team believes that a large scale inter-governmental effort is needed for gathering and harmonising datasets, which are crucial for recording the state of regional and global climate.

### Project Publications

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### Acknowledgements

Administrative support for this APN project is provided by JAMSTEC. Partial support for air sampling programme at Comilla is also received from JAMSTEC. The analysis of air samples for GHGs is funded by NIES. We appreciate the intellectual infrastructure prepared by a large number of institutions worldwide under GCP RECCAP.

## ARCP2013-01CMY-PATRA/CANADELL

### PROJECT TITLE

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

### COUNTRIES INVOLVED

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

### PROJECT DURATION

Year 3 of a three-year project

### APN FUNDING

US\$ 150,000

### PROJECT LEADERS

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ARCP2013-02CMY-FORTES

# Seagrass-Mangrove Ecosystems: Bioshields against Biodiversity Loss and Impacts of Changes along Indo-Pacific Coasts

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## Project Objectives

The project investigates the structure and function of seagrass and mangrove ecosystems in order to develop a model for the ecosystem's natural biological function as a biological protector (bioshield), to mitigate local and global change along the Indo-Pacific coast. This is being conducted in six sites in three countries. The model is expected to support decision-making and will be used to build the capacity of stakeholder communities and governments so that they can utilise ecosystem goods and services more efficiently, while adapting to environmental change. We will use the results to reinforce a growing consensus that places priority on the conservation of seagrass and mangroves in the region.

## Work Undertaken and Results to Date

A number of modifications were made to the original methodology, which presented a more useful approach in bioshield environmental monitoring. The new approach adopted is considered a first in the world and there are now more parameters under investigation including hydrodynamic, water quality and meteorological parameters.

We have observed a significant reduction in dugong sightings since 2012, which may be related to a number of factors, including the higher frequency of typhoons, heightened tourism activities (Mati, Davao) and the construction of a coal-fired power plant (Malita, Davao). As a result, the research team had to abandon

measurements of seagrass consumption of dugong.

Due to the approaching 'super' Typhoon Haiyan in November 2013, the research team had to abort the seagrass (dive) sampling at the site in southern Philippines. Fortunately, a scheduled stakeholders' workshop convened a day earlier. In addition, the Focused Group Discussions and on-site workshops were limited to the Philippines sites, while those scheduled in India and Indonesia have been postponed until the third year of the project activities (in 2014).

## Project Publications

### Published

- Arriegado, D. M., Nakajima, Y., Matsuki, Y., Lian, C., Nagai, S., Yasuike, M., ... Nadaoka, K. (n.d.). Development of novel microsatellite markers for *Cymodocea rotundata* Ehrenberg (Cymodoceaceae), a pioneer seagrass species widely distributed in the Indo-Pacific. *Conservation Genetics Resources*, 1–4. doi:10.1007/s12686-013-0025-3
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- Mochizuki, M., Asada, A., Ura, T., Yamamuro, M., Fortes, M. D., & Jimenez, L. A. (2013). Off-line observation system based on acoustic video camera for understanding behavior of underwater life. In *Underwater Technology Symposium (UT), 2013 IEEE International* (pp. 1–4). doi:10.1109/UT.2013.6519828
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- Yamamuro, M & King, G. (2012). Application and

## HIGHLIGHTS

- » Eutrophication (N and P) from fish cages has caused a decline in seagrass fish, macroinvertebrate diversity, and *Thalassia* (seagrass) density and cover.
- » Eutrophication (N and P) from fish cages has caused an increase in infaunal density, *Enhalus* density and cover, growth rates and aboveground biomass. Within the cage area, there is common hypoxia and even occasionally anoxia.
- » In Chilika Lake (India), seagrass beds apparently act as carbon sinks. In Pari Island, (Indonesia), transplanted *E. acoroides* shows higher faunal diversity than bare areas.
- » For dugongs, work was stopped due to a decline in sightings. More data is needed to determine if this might be a result of increased frequency of natural hazards or to non-sustainability of coastal management in the area.
- » The period of greatest change in fractional seagrass density and cover (2001-2004) coincided with a peak period in the number of fish structures, which brought about fish kills. Recently, however, water nutrient availability shows no significant decrease despite a reduction in fish structures.
- » Rains coinciding with near tide bring significant amounts of nutrients, silt and hypoxic waters from fish cage areas to the Seagrass Reserve.
- » In Cebu, mono-specific plantation of the mangrove *R. stylosa* significantly reduces species richness and variety of mangrove vegetation. In Bolinao, they are planted on reefs or over shallow seagrass, necessitating construction of small rock walls. These structures decrease flushing, trap mud and increase turbidity, thus, harm the surrounding environment.
- » The resulting changes in seagrass and mangrove structure imply changes in the goods and services the communities provide, hence, a disruption in their bioshield function.
- » These results emphasise the importance of seagrass and mangroves in enhancing conservation policies by prioritising research in areas degraded by eutrophication, mariculture, and 'reforestation' areas.
- » These findings have been input to an integrated decision-support system, which is guiding the development of the framework for a Marine Emergency Contingency Policy for the study sites.

modification of simplified water quality checker in remote areas. Paper presented at the ASLO Aquatic Science Meeting 2012, Lake Biwa, Shiga, July 8-13 2012.

## Acknowledgements

Sincere gratitude goes to the faculty and staff of the Southern Philippines Agri-business Marine and Aquatic School of Technology (SPAMAST) and Davao Oriental State College of Science and Technology (DOSCAST) for the on-site preparation and facilitation of project activities. We are likewise grateful to the Asia-Pacific Network for Global Change Research (APN) for the funds; to the Marine Environment and Resources Foundation (MERF) for fund administration; and associated offices of our partner institutions for providing substantial technical and administrative input.

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## ARCP2013-02CMY-FORTES

### PROJECT TITLE

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

### COUNTRIES INVOLVED

Australia, Japan, India, Indonesia, Philippines

### PROJECT DURATION

Year 3 of a three-year project

### APN FUNDING

US\$ 121,750

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ARCP2013-03CMY-HERATH

# Adaptation Strategies to Enhance Resilience of Rice Terrace Farming Communities

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## Introduction

This project aims to develop ecosystem-based adaptation measures to enhance the resilience of traditional 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. The two sites selected are 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). This year, several visits were made to both sites to continue with the environmental observations and to conduct questionnaire surveys to assess the societal and economic status among terrace communities.

In Hani rice terraces, the following activities were carried out: (a) workshop to discuss project progress and strategy and a field trip to enhance environmental

monitoring; (b) field visit to download field observations and vertical soil profile measurements in one site; (c) field visit to compile water level data, equipment maintenance; and (d) vertical soil profile measurements in two additional sites, water balance measurements at a rice field and questionnaire survey on residents perception on living conditions.

In Ifugao rice terraces, the installation of a field weather station was delayed due to difficulty in finding an appropriate location in compliance with activities permitted in this world heritage site. This was resolved with the inclusion of the State University of Ifugao as the responsible project member for the installation and maintenance of equipment, and monitoring. A modeling workshop took place in Manila with colleagues of University of Philippines, and an extensive field survey was organised to carry out questionnaire surveys at Batad and Kiangan villages on the threats and opportunities for sustainable development of Ifugao rice terraces.

## HIGHLIGHTS

- » Social and cultural heritage in Ifugao terraces in Philippines is pivotal to the function, and resilience, of rice terrace systems. Rituals, spiritual understandings, artistic expressions, such as chants, dances and crafts, and traditional social institutions, are integral to those systems' physical functioning.
- » A large proportion of farmers in Kiangan in Ifugao prefer to grow new lowland rice, with pressures on labor scarcity due to out-migration, insufficiencies in rice produce to feed a growing population, and the heat-resistance of lowland rice in the face of climate change. There was a strong perception that changing weather patterns give rise to erosion, landslides and pests.
- » There are large-scale social changes taking place in Hani rice terraces in Yunnan, China, due to increasing tourism in the area. The declaration of the site as a world heritage site may help preserve balanced development in the region.
- » There is potential to use existing water harvesting structures to store excess rainfall and improve the water cycle, especially in the sandy-forested areas. Current levels of irrigation facilities are adequate to serve the fields if ample water supplies can be guaranteed from upstream.

## Hani Rice Terrace Observations

### Environmental observations

In the field survey, the potential for enhancing hilltop ponds, currently privately owned (Figure 1), was identified as a measure to retain increasing rain intensities to prevent floods and mudslides in the terraces, and as a viable means to recharge groundwater to increase yearlong water supply and yearlong yield to downstream terraces (Figure 2). For this purpose, it is necessary to model the water cycle and potential intervention measures. Figures 3 and 4 show the automatic weather station and the measurements being made in the small hilltop watershed in order to model the hydrology of the area.

Soil profile measurements were carried out in three sites up to a depth of 3 m. The sites were: (a) forest with sandy soils; (b) grass land with loam and sand; and (c) forest with clay soil. It was observed that in the topsoil layer (0-20 cm), effective porosity was around 30% for (a), and 25% for (b) and (c). At a depth of 20-40 cm, effective porosity varied from 25-20% for all soils. At the 40-60 cm depth range, the observed effective porosity was 25%, 20% and 16% respectively, for forest with sand, grassland and forest with clay sites. The effective porosity rapidly decreased for forested areas with clay soil after 60 cm to varying from 8% - 15%. These results are important in selecting fields for recharging facilities so that groundwater storage can be maximised.

The drainage density of the Quanfuzhuang basin was estimated by selecting slope and distance from the rivers and canals as two resistant factors to show that 70% of the area has stable water supply. A detailed analysis of two villages, Dayutang and Xiaozhai showed an increase of 86.1% and 86.6% of irrigation coverage when self-irrigation and two-way irrigation is considered.

### Socio-economic observations

Rapid changes are taking place in the region associated with tourism. Tourism is promoted in a centrally planned manner, to provide opportunities to villagers to benefit from the influx of tourists, starting with village restaurants. With the declaration of Hani



**Figure 1.** Catchment top, traditional ponds; **Figure 2.** Hani rice terraces in winter; **Figure 3.** Hani weather station; **Figure 4.** Flow measurements at hilly-forested watershed.

rice terraces as a UNESCO world heritage site in 2013, an increase of visitors can be expected. Presently, the major beneficiaries are the villages located at the top of the terraces who can cater to tourists and who also have access to abundant water resources. Increasing wealth from tourism will have profound effects on the terraces. The infrastructure, roads, amenities and viewing spots in the upper region are also affecting terrace farming and maintenance. Figure 7 shows a replacement of traditional terraces with concrete structures in the upper reaches of Hani terraces. Declaration of the Hani as a cultural heritage site will bring new challenges to balancing tourism-based development with traditional rice farming practices in the region.

### *Ifugao rice terraces questionnaire survey findings*

Questionnaire surveys were carried out in Batad and Kiangan. The rice terrace systems are embodiments and expressions of Ifugao culture, and represent identities, heritage and a sense of home to people in Kiangan as much as they are the foundation of its material livelihoods. All of these aspects are of primary importance, and combine in a complex, dynamic and adaptable system whose physical, social, cultural, economic and spiritual dimensions are interdependent and inseparable.

Ifugao's social and cultural heritage is pivotal to the function, and resilience, of the rice terrace systems.



**Figure 5.** Tourists in viewing areas; **Figure 6.** Bunds replaced with concrete; **Figure 7.** Rice terraces in Kiangan, Ifugao; **Figure 8.** Batad terrace cluster, Banaue, Ifugao.

Rituals, spiritual understandings, artistic expressions such as chants, dances and crafts, and traditional social institutions are integral to those systems’ physical functioning.

Having endured and adapted in the face of considerable challenges over centuries, Ifugao communities like Kiangan are now facing a combination of systemic changes and challenges unprecedented in nature

or scope. These include changing cultivation patterns, especially the introduction of lowland rice; out-migration and terrace abandonment; physical and climate changes; pressures on cultural heritage; and the rise of tourism, among others. All such challenges are interconnected in their drivers and impacts.

Nonetheless, in Kiangan, there is astute awareness of these challenges and active responses are underway to overcome, absorb or adapt to them, under organised community leadership and direction. Many of these may be considered among the latest examples in Ifugao’s long tradition of adaptation and endurance.

### Publications

Wang D., Jiao Y., He L., et al. Assessment on the irrigation-water stability of the Hani Terrace Landscape based on river-ditches connectivity. *Acta Ecologica Sinica* (In Chinese, submitted).

Zong L., Jiao Y., Xiang D., et al. Vertical changes of soil moisture and holding capacity of Soil water in the water source area of Hani rice terraces landscape. *Journal of Mountain Science* (In Chinese, submitted).

## ARCP2013-03CMY-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

Year 3 of a three-year project

### APN FUNDING

US\$ 135,000

### PROJECT LEADERS

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ARCPC2013-04CMY-MEINKE

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

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## Introduction

Asia is currently responsible for 95% of world rice production, and anticipated future increases in production must come from this region. A further challenge is that these required increases must be achieved without negatively impacting on people and the environment. Advances in the understanding of rice systems make it feasible to use simulation modelling to integrate disciplinary knowledge and evaluate possible technologies and policies.

The project aims to empower the next generation of scientists and policy makers in providing the most pertinent advice for decision-making when it comes to redesigning current approaches in resource allocation, agronomy and knowledge dissemination.

## Project Themes

At the inception meeting at the University of Peradeniya, Sri Lanka, the project team identified the following research themes, and designed multi-country research to address them:

## HIGHLIGHTS

- » The project aims to develop more productive and sustainable rice systems through simulation modelling.
- » Research themes include more efficient resource use, improved system performance, and resilience to climate risk.
- » Aerobic rice in Pakistan can lead to improvements in the efficiency of water use, and resultant efficiencies in labour and energy.

## Focus Study: Aerobic Rice in Pakistan

Rice is a highly valued cash crop and the second most important staple food in Pakistan. Paddy fields are mostly irrigated and cover 2.7 million ha, with annual production of about 6 million tonnes. Historically, water availability has been a decisive factor for total rice production in the water-limited country. In recent years (2010-2013), paddy production was affected badly by intense rains, overflowing rivers and, occasionally, rainfall early in the

Theme	Sub-project title
1. Resource use and management	To develop locally-adaptable, sustainable rice systems having high resource use efficiencies throughout South Asia
2. Rice system performance	Identification of efficient rice production systems in Asia
3. Climate risk	Assessing climate risk and devising adaptation strategies for Asian rice systems

**Table 1.** Themes of the project.

season. These extremes resulted in a 10% decline in cultivated area and production in the last fiscal year (2.3 million ha and 5.5 million tonnes, respectively).

Limited water storage capacity related to the size and number of dams prevents the effective use of flood water, and farmers often experience water shortage during the rice growing season. Strategies aimed at rational use of water are required to safeguard sustainable rice production and food security.

Masood Awan from the University of Agriculture, Faisalabad-Pakistan, evaluated the potential of an alternate production system, aerobic rice. The aerobic rice system involves cultivating rice in unpuddled, dry direct-seeded, non-flooded fields. This system aims to improve resource-use efficiency of rice-based cropping systems, in particular water, labour and energy.

Field experiments during 2009 and 2010 at the research station of the University of Agriculture, Faisalabad-Pakistan, investigated the possible irrigation water savings and crop performance under aerobic conditions. Water productivity (g grain kg<sup>-1</sup> total water input) improved significantly with values up to 0.38, significantly higher than the national average value of 0.16 under conventional flooded cultivation. This might save farmers three to four irrigations, offering a leverage point where water scarcity is a greater threat to production than land scarcity.

Surveys of rice and non-rice farmers of Punjab Province in three major cropping systems (rice-wheat, mixed-cropping and cotton-wheat) supported the basic biophysical research. Most farmers were unaware of the existence of aerobic rice and the possibility it offers, but expressed their keen interest in experimenting with it.

Aerobic rice is a transformational technology with significant potential, but it is not a silver bullet. There are risk factors associated with it that need to be considered on a case-by-case basis. Improved

eco-efficiencies of water, labour and energy might occur at the cost of decreased efficiencies of nitrogen and land use, and an increased reliance on biocides for managing weeds.

Risks of crop failure can be reduced by filling knowledge gaps through additional research and through farmer training. Targeted breeding programmes especially for basmati rice are needed to unlock the potential of aerobic rice in regions previously not considered for aerobic rice production.

Aerobic rice is a future production system to cope with resource constraints. A range of stakeholders aiming for the successful adoption of an aerobic rice system can benefit from the findings of this study, which will be published shortly.

## Project Publications

Awana, M. I., van Oort, P. a. J., Ahmad, R., Bastiaans, L., & Meinke, H. (In Press). Transformation of transplanted flooded rice system to direct seeded aerobic rice system: the farmers' perspective. *Land Use Policy*, In Press.

## Acknowledgements

We thank 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 (APN, 2004) who contributed significantly to the current project, its design and conduct.

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### ARCP2013-04CMY-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

Year 2 of a three-year project

#### APN FUNDING

US\$ 180,000

#### PROJECT LEADER

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ACRP2013-05NMY-LI

# Development of an Integrated Climate Change Impact Assessment Tool for Urban Policy Makers (UrbanCLIM): Progress on Dataset Development and Modelling

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## Project Objectives

The objectives of this project are to:

- 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 2013 software package applying system dynamics approaches.
- Conduct training workshops, disseminate results and produce peer-reviewed publications during the latter stages of the project.

## Work Undertaken and Results to Date

### *CMIP5 and RMIP3 Dataset*

CMIP5 data were released during 2012 and 2013. More than forty GCMs provided the regional climate projection (RCP) scenario simulations. The research team focussed on downloading and analysing the climate change data to transform it into climate information for applications such as UrbanCLIM.

Climate change patterns that are available via the CMIP5 GCMs have been processed and incorporated into UrbanCLIM for the following climate variables: precipitation, maximum, minimum and mean temperature,

## HIGHLIGHTS

- » CMIP5 and RMIP3 dataset development for UrbanCLIM.
- » Water resources modelling for Guangzhou and Pearl River Delta.
- » Application of extreme sea water level analysis tool
- » Annual and diurnal variation of anthropogenic heat estimation in Guangzhou City.

relative humidity, wind speed and solar radiation. Ocean related variables include: mean sea level rise, sea surface temperature, and net primary productivity of carbon by phytoplankton (INTPP). While at the surface level, the related variables include: dissolved nitrate concentration ( $\text{NO}_3$ ), dissolved oxygen concentration ( $\text{O}_2$ ), pH (pH), dissolved phosphate concentration ( $\text{PO}_4$ ), total alkalinity (TALK), dissolved iron concentration (DFE) and dissolved silicate concentration (SI). These datasets have been incorporated into SimCLIM for ArcGIS software, which can be accessed through <http://www.climsystems.com/simclimarcgis/> where free trials can be downloaded.

The data produced by the RMIP3 project has begun to be evaluated and processed based on availability and quality. Some RMIP3 data has been processed into UrbanCLIM format using a pattern scaling approach, where key climate change information is provided to the users. Based on the above-mentioned model results, the Asian regional climate projection was built, with the sources and magnitude of uncertainties detected and properly assessed. The project calculates the change and

variance of the Asian monsoon system in the future and its impacts on the Asian climate.

### ***Pearl River Delta Water Resources Modelling***

The research team carried out the first consistent and comprehensive assessment of sectoral water use in the Pearl River Delta (PRD) by analysing regional water use data from 2000 to 2010. The regional-scale water use model PRDWUM was developed to explore the possible driving forces underlying water use changes in domestic, industrial and agricultural sectors. Water intensities were calculated from annual socio-economic and water use data. We found that the PRD absolute water use stabilised dramatically in the industrial sector and early stabilisation was observed in the domestic sector. Results revealed large internal differentiation of sectoral water use among the cities in this region, with industrial water use intensity varying from -80 to +95% and domestic water use intensity by +/- 30% compared to the delta average. In general, those earlier-developed cities have higher water use intensities in the domestic sector. The modelling work is ongoing to incorporate more components into UrbanCLIM.

### ***Analysis Tool for Extreme Water Level and Wave Conditions***

The most extreme sea levels are storm tide events, which occur when storm surges combine with high astronomical tides. Methods for predicting extremes of either water level or waves are common practice, but assessment of the joint probability of high waves and high water levels is more important. The combination of these phenomena leads to extremely high water levels, thus increasing the risk of coastal flooding. Marginal distributions for wave and water

level data is examined using extreme value theory, preferably the Peak Over Threshold (POT) method was applied, and the joint probability of water level and extreme wave height was analysed using bivariate extreme value methods. In this tool, climate change projections incorporate mean sea level rise, wind speed (causing wave condition changes) with the future extreme water level analysis. This is a unique tool for analysis of climate change's potential accentuation of coastal inundation and hence should be incorporated into adaptation planning, design and implementation.

While the project is being carried out according to the objectives stated, some adjustments have been made to suit stakeholders' needs; including CMIP5 dataset and extreme water level tool development, so that UrbanCLIM can be developed in a more participatory way.

### **Project Publications**

Zhan J., Dan L. (2013). Annual and diurnal variation of anthropogenic heat estimation in Guangzhou city, Climatic and Environmental Research (doi: 10.3878/j.issn.1006-9585.2013.13149, in press)

Yao M, et al. (2013). Sectoral Water Use Trends in the Urbanizing Pearl River Delta, China (Manuscript submitted for publication)

### **Acknowledgements**

Monsoon Asia Integrated Regional Study (MAIRS), International Programme Office, partly funded the workshop and is supporting the implementation of this project. The development of the UrbanCLIM platform is also supported with co-funding from the Asian Development Bank and the New Zealand Government.

#### **ARCP2013-05CMY-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**

Year 2 of a three-year project

##### **APN FUNDING**

US\$ 135,000

##### **PROJECT LEADER**

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ARCP2013-06CMY-OUYNH

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

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## Project Objectives

This project aims to quantify the spatial and temporal variability of carbon fluxes and emissions (outgassing or evasion) from the Red River system and to evaluate their responses to variations 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 carbon transfer at the scale of the whole drainage network to the constraints resulting from human activities and natural conditions in the watershed. The model will be firstly validated to describe carbon transfer for both past and present situations, and then it will be used to explore various scenarios of change in climate and human activities at the 2050s horizon.

## Work Undertaken and Preliminary Results

### *Enlarging scientific cooperation*

In accordance with the project timeline, the first workshop of the project was held at Institute of Natural Products Chemistry (INPC), Viet Nam Academy of Science and Technology (VAST), in Hanoi, Viet Nam from 17-19 December 2012. More than 40 scientists

from a large variety of disciplines (i.e. biogeochemistry, microbiology, agronomy, hydrology) and different countries such as France, Germany, Singapore, China, Japan and Viet Nam attended the workshop. During the first workshop, various talks focused on riverine transfer of sediment and carbon. This first workshop provided information about project expectations in terms of objectives, main activities and expected outputs; and addressed the three main project issues: *i)* Data collection and exchange; *ii)* Training course for young scientists in model utilisation and carbon emission calculation; and *iii)* Website construction.

The second workshop will be held in Kunming city (Yunnan Province, China) in May 2014. During this next workshop, preliminary results of the first year of the project will be discussed and future activities will be planned in terms of deliverables (scientific papers, meetings presentations, student training). Enlarging future international cooperation will also be debated.

In addition to the ARCP workshop, many participants of the project attended other different international workshops and are currently participating in different international projects focusing on anthropogenic activity and climate change impacts on water quality and ecology. The present project could provide an excellent opportunity for the development of scientific cooperation not only for different Vietnamese and Chinese

**Figure 1.** In-situ measurement of the Red River water quality and laboratory analysis.



teams, but also to enhance international cooperation between young scientists with multidisciplinary senior researchers from developed countries (France, Germany). The participations of the different teams could definitely provide opportunities to enlarge international networking and communications to benefit our ARCP project.

### ***Dataset collection and analysis***

#### *Water sampling campaigns and laboratory analysis*

One of the major activities of the first year was to provide a dataset for the assessment of the present water quality of the Red River basin, both for model validation and for carbon transfer and emissions from the Red River system.

Monthly field campaigns have been underway since August 2012 by the INSP and Institute of Environmental Technology at nine gauging stations of the Red River system in order to implement a complete water quality database, which is still lacking for the Red River Basin (Figure 1). The physical-chemical variables of river water quality, such as temperature, pH, dissolved oxygen, turbidity, conductivity and salinity are measured using a Water Quality Checker tool (WQC 22A, TOA, Japan). Other water quality variables such as suspended solids, particulate and dissolved carbon, chlorophyll *a*, various species of nitrogen and

phosphorus, dissolved silica, abundance and composition of phytoplankton and periphytic diatoms, coliforms and major ions are measured at the laboratories of the different partners of the project (Figure 1).

About 100 agricultural and industrial wastewater samples in both dry and rainy seasons were taken and analysed for most of the variables mentioned above (Figure 2). The analytical results of agricultural and industrial wastewater quality will be synthesised in the second year of project.

#### *Collection and analysis of available dataset from different sources*

The climatic data from 13 meteorological stations and the hydrological data from nine gauging stations in the whole Red River watershed, in both China and



**Figure 2.** Industrial and agricultural wastewater sampling in the Red River basin.

Viet Nam terrain, have been collected from the 1960s up to now. The long-term discrete existing data for water quality of the entire Red River since the 1960s (including suspended solid concentrations), was collected during the first year of the project.

The Red River water discharge and suspended solids data were used for the paper “Impacts of Dams on Channel Degradation and Aggradations: An example of Lower Reach of Red River”, which was submitted to the *Hydrological Processes*. The main objective of this paper is to examine: i) the daily water and sediment regime changes as affected by the dams using measurements over a three-year period from 2008 to 2010; and ii) the channel degradation or aggradation before and after the two main stream dams in the lower reach of the Red River. After the first dam construction, the sediment inflow from the three main tributaries was lower than the sediment outflow, suggesting erosion processes. However, after the second dam construction in 1985, the sediment outflow from Son Tay was lower, indicating dominant deposition processes in the lower reach of the Red River downstream. The annual sediment deposition varied between 1.9 Mt/yr and 46.7 Mt/yr with annual mean value of 22.9 Mt/yr (1985–2010). The sediment deposition in the lower reach of the Red River showed an increasing trend, thereby accelerating river aggradation, which would change river channel capacity at the downstream of the Red River. The study revealed river channel changes from deposition to erosion, and then back to deposition as affected by the constructed dams. Effects of such changes on carbon fluxes and carbon burial will be estimated in the next step.

Other information concerning land use, population, agricultural and industrial development and hydrological management in the whole Red River basin was investigated during the first year project. Together with the hydrological and water quality data collected,

this information could help us to develop and write the paper “Long-term Biogeochemical Functioning of the Red River (Viet Nam): Past and Present Situations”, which is currently under revision for the journal *Regional Environmental Change*. The main objectives of this study were: i) to relate the pressure exerted by agricultural and urban development on water quality and nutrient deliveries of the river system at the scale of the Red River watershed; and ii) to document, as precisely as possible, the present state and the past 50 years of evolving pressures on the biogeochemical functioning of the Red River basin.

### **Training of young scientists**

#### *PhD students*

Under the framework of the present project, a Vietnamese PhD student, Mrs Nguyen Thi Mai Huong, will write a sandwich thesis in the period from January 2013 to December 2015. She has been financially supported by the IRD French Institution. Mrs Nguyen Thi Mai Huong is under the supervision of Drs. Quynh Le (INPC, Viet Nam) and Emma Rochelle-Newall (IRD, France) in Hanoi and Drs Josette Garnier and Gilles Billen (UMPC, France) in Paris. Mrs Nguyen Thi Mai Huong is studying the behavior of coliforms with the carbon fluxes, and will quantify the proportion of carbon issued from domestic waste water compared to the erosion and soils leaching.

In Singapore, two PhD students under Dr Lu’s supervision attended the first workshop in Hanoi. The topics of the two students are riverine carbon fluxes and outgassing, which are fully investigated in the APN project.

In Yunnan, the APN collaborator, Prof Zhou, is recruiting a PhD student who will also be involved in the APN project.

### *Undergraduate University students*

During the first year, six undergraduate students conducted research for their bachelor theses (from January 2013 to May 2013) at the Centre of Environmental Chemistry (INPC, VAST) and Laboratory of Hydro-biology (IET, VAST). In 2014, other undergraduate students from Hanoi University for Natural Resources and Environment (HUNRE) will be welcomed to conduct research in our laboratories with scientific topics related to the ARCP project.

### **Future Plan**

The research team has discussed the possibility of holding the second workshop in Kunming, Yunnan in May 2014. As mentioned above, during the second workshop, the research team will interpret and discuss the preliminary results of the first year project and the next activities, including enlarging future international cooperation.

To complete the database of water and wastewater quality of the Red River, water sampling and analysis will continue during the second year of the project. In addition to that, the long-term discrete existing data (since the 1960s) of the entire Red River basin, concerning meteorology, hydrology, land use, intensification

of agriculture, deforestation, increase in population and urbanisation, impoundment of reservoirs, etc, in both China and Viet Nam terrain is being continuously enriched.

In the second year of project, the data collection will be used for: i) modeling validation for describing the transfer of both dissolved and particulate carbon under the pressure of human activities and natural conditions for the present and past in the whole Red River basin; ii) calculating carbon emissions and fluxes from the Red River; and iii) characterising and identifying the factors (geology, rainfall, reservoirs, land use, agriculture, population, etc.) controlling carbon fluxes and emissions from this river. These results will be put into perspective with the figures given in the literature for other rivers in the world.

### **Acknowledgements**

This work was performed in the framework of the ARCP2012-11NMY-Quynh/ARCP2013-06CMY-Quynh project. The authors would like to thank the Asia-Pacific Network for Global Change Research (APN) and the National Science Foundation (NSF) for their financial support.

#### **ARCP2013-06CMY-QUYNH**

##### **PROJECT TITLE**

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

##### **COUNTRIES INVOLVED**

China, France, Singapore, Viet Nam

##### **PROJECT DURATION**

Year 2 of a three-year project

##### **APN FUNDING**

US\$ 120,000

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ARCP2013-07CMY-ROY

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

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## Project Objectives

In the last four to five decades coastal ecosystems in Bangladesh, China, India and Sri Lanka have undergone high degrees of alteration. Coastal dwelling is significant in these countries with nearly 27% of India's population living in coastal areas; 24% of Sri Lanka, almost 25% of Bangladesh; and 40% of China (Sri Lanka Census, 2012; United Nations, 2005; Islam, 2004; China Statistical Yearbook, 2011). Understanding the threats and opportunities for sustaining the wellbeing of their coastal communities is crucial, particularly in light of changing resilience with changing diversity of ecosystem services, as well as additional risks presented due to climate change.

The specific study objectives are to:

- Identify and characterise coastal ecosystems.
- Identify and understand traditional and new economic activities, and those involved in these activities, along the coastline; and changing patterns through community recall methods, and mapping of ecosystem services.
- Prepare an inventory of ecological functions based economic activities as well as otherwise and resilience level.
- Generate historical data on climate parameters to predict future scenarios for each specific study site.
- Incorporate a stakeholder behaviour analysis into an ecology–economy interaction framework.

## Work Undertaken and Results to Date

### *Inception Workshop*

An inception workshop was organised in January 2013 in Kolkata, India. This provided a platform to establish concrete research questions, hypothesis and methodology for analysis as well as timeline and deliverables. Team members from the four countries participated.

### *Field Visits to Selected Study Sites*

Two criteria were established for each study site, namely the characterisation by ecosystem type; and the level of alteration of the natural coastal ecosystem.

Research teams in the four countries conducted pilot field visits in order to understand the socio-economic and demographic characteristics of people living in the selected sites. The focus of these visits was to identify changing patterns of economic activities over the years and identify the reasons associated with these changing patterns. Results are summarised in the Table 1.

## Acknowledgements

The project would not have been possible without the financial grant from the Asia-Pacific Network for Global Change Research (APN). We gratefully acknowledge their financial support. We thank each country institution for hosting the project at the national level and for

Study sites	Traditional activities	New economic activities
Cox's bazar-Moheshkhali, Bangladesh	Fishing, fish business, fish drying, small scale business (grocery shop, tea stall), agriculture, betel leaves trading, hawking, photography, aquaculture	Fish drying, hotel and restaurant, shrimp frying, shop business, speed boat driving, beach concert, beach hawking, shrimp farming and salt production.
Coastal area of Tianjin, China	Mariculture, fishing, sightseeing, education	Leisure (vacation, theme parks, game experience, golf), business meetings.
Digha-Sankarpur, India	Agriculture, fishing, small-scale business (grocery shop, vegetable seller, tea stall), salt-making, manual-van driving, aquaculture, fishing net business, fish business, betel leaves trading, folk singing, masonry, blacksmith	Beach hawking, motorbike rides, tourist beach horse-riding and photography, shell-crafting, motorised and manual-van driving, hotels, resorts and restaurants.
Koggala, Sri Lanka	Agriculture, lagoon fishing, coastal fishing, fish trading, cottage industries, carpentry, small businesses	Export and hotel industry, tourist guest houses, cinnamon industry, souvenir shops, tourist transportation services.

**Table 1. Traditional and new economic activities in four study sites.**

the smooth conduct of activities to date. Officials from each country deserve due acknowledgement for their cooperation.

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### ARCP2013-07CMY-ROY

#### PROJECT TITLE

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

#### COUNTRIES INVOLVED

Bangladesh, China, India, Sri Lanka

#### PROJECT DURATION

Year 2 of a two-year project

#### APN FUNDING

US\$ 86,000

#### PROJECT LEADER

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ARCP2013-08CMY-DECOSTA

# A Study on Loss of Land Surface and Changes in Water Resources due to Sea Level Rise

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## Introduction

Sea level rise in the Asia-Pacific region as a result of global/climate change is being analysed using a Global Circulation Model (GCM). Together with digital elevation maps and GIS information systems, loss of land surface in coastal zones is being predicted. The forecast seawater level ranges will be used to predict salinity intrusion and resulting changes to water bodies. A composite model to forecast loss of land surface and changes to water bodies is envisaged as an output of the present activity, which will be used to develop management strategies to mitigate adverse effects of sea level rise and manage such changes.

Through meetings with collaborators, stakeholders, and policy and decision makers, a research plan has been established and the awareness of climate change impacts has been raised among the policy makers involved.

Average sea level rise in different locations in the Asia-Pacific region was corroborated using the GCM. The loss of land surface, inundation patterns, etc., were estimated at the study site in New Zealand, using GIS information and digital maps. In addition, impacts on groundwater due to sea level rise and salinity intrusion were investigated using FEFLOW.

Increasing sea levels and associated problems in the coastal region of Semarang City, including land

subsidence were also investigated. Tidal and flood management methods and the approximate rate of land subsidence, sea level position in the Semarang tidal station, together with specific parameters were validated and downscaling techniques for a climate change impact assessment established. For Sri Lanka, the risk of sea level rise and the importance of Geo Information were investigated.

The findings and results are presently being synthesized and, with further work, it is envisaged that cohesive management strategies could be developed to better manage climate change impacts on coastal zones.

## HIGHLIGHTS

- » Assessing and forecasting loss of land due to sea level rise.
- » Forecasting changes to groundwater due to sea level rise.
- » Developing a management strategy to mitigate changes due to sea level rise.

## Project Publications

Exploring changes in nitrate contamination in the coastal and hautere zone aquifers, Wellington, New Zealand, Proceedings of the 34<sup>th</sup> Congress of the International Association for Hydro-Environment Engineering and Research (IAHR).

Assessing the risk of sea level rise – Case study of Sri Lanka, Proceedings of 19<sup>th</sup> Congress of the IAHR Asian and Pacific Regional Division.

## Acknowledgements

The present project would not have been possible without the financial contribution of the APN, which is greatly appreciated. We also wish to take this opportunity to thank Unitec, Wellington Regional Council, Waikato Regional Council, Auckland University, University of Moratuwa, IIT Mumbai, Gajah Mada University, Kyoto University and all other collaborating organisations for the assistance and support given.

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### ARCP2013-08CMY-DECOSTA

#### PROJECT TITLE

**A Study on Loss of Land Surface and Changes in Water Resources Resulting from Sea Level Rise**

#### COUNTRIES INVOLVED

India, Indonesia, Japan, New Zealand, Sri Lanka

#### PROJECT DURATION

Year 2 of a two-year project

#### APN FUNDING

US\$ 79,000

#### PROJECT LEADER

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ARCP2013-09CMY-CARTER

# Coral Reef, Water Quality Status and Community Understanding of Threats in the Eastern Gulf of Thailand

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**ABSTRACT:** Coral reef benthic habitat in the east Gulf of Thailand (Thailand, Cambodia and Viet Nam) is diverse, with varying structural complexity, and partly affected by sediment loads. Water quality from rivers, streams and population centres indicate high levels of ammonia and contribution to sediment loads, resulting in degraded water quality in some areas. Biodiversity surveys, fish catch records and community surveys indicate fishing activities are removing top predators from the system. Local fishers reported halving of fish catch in the last five years; although fish size is reported to be unaffected. The effectiveness of Marine Protected Areas (MPAs) to protect key commercial species is evident in the Koh Rong (Cambodia) and Koh Chang (Thailand) Marine Parks. Marine systems do not recognise political boundaries, which presents a challenge for ensuring resilient reef systems. Transnational integrated management for the coral reefs appears to be essential to the provision of sustainable biodiversity protection and on-going food security.

**KEYWORDS:** coral reef status, water quality, experiential knowledge, east Gulf of Thailand, transnational management

## HIGHLIGHTS

- » Field surveys show that coral reef benthic habitat between Koh Chang Island, Thailand, along the Cambodian coastline and Phu Quoc Island, Viet Nam, is diverse, with varying structural complexity, and partly affected by water quality.
- » Field testing of water quality from rivers, streams and population centres indicate high levels of ammonia and contribution to marine sediment loads, resulting in degraded water quality in some areas.
- » Biodiversity survey data suggest current fishing activities are removing top predators from the system.
- » Local fishers reported halving of fish catch in the last five years; although fish size remains stable.
- » Tipping points for the resilience and survival of targeted fish species remains unclear, but transnational integrated management for the coral reefs appears to be essential to the provision of sustainable biodiversity protection and on-going food security.

## Research Objectives

The impact of fishing activities, water quality and land use practices on coral reef status and health is poorly understood in the contiguous coastal zone of the east Gulf of Thailand. This project seeks to assess these variables in Koh Chang Island, Thailand in the north of the gulf and along the Cambodian coastline to Phu Quoc Island, Viet Nam. The project builds on the existing scientific understanding of coral reef status in the east Gulf of Thailand, complemented with local community knowledge. It also seeks to clarify the influence of anthropogenic causes of marine pollution and fishing practices towards defining a more integrative approach to the management of marine resources that crosses national boundaries. The research involves assessment of coral reef status and health from field surveys and community knowledge, water quality from field sampling and oceanographic and land-use influences from the literature.

## Field Surveys

Coral reef communities were investigated (in Thailand and Cambodia) using line intercept transects (English et al., 1997). Coral reefs in the study are fringing reefs extending from the shoreline to a few metres below the sea surface, with reef structure not distinctly separated between reef flat and reef slope. Transects were placed parallel to the shoreline at a depth of approximately 6 m. All coral colonies within transects were counted and identified to genus level.

Disease and compromised health indicators were used as a proxy to determine the health of reefs (Raymundo et al., 2008). Disease infected colonies within a related belt transect were counted to determine disease prevalence. Fish were identified to at least genus level and counted along the transect within 1 m of the transect line.

Water quality samples were collected using Nansen bottles at three different depths (surface, mid-water and bottom) and mixed. Nutrient samples were preserved in ice for later laboratory analysis (Table 1).

Community surveys were conducted using a semi-structured interview technique. Participants included were fishers (active and retired), fish wholesalers, who were often women, and tourist operators who have transitioned their livelihoods or gain income from fishing and tourism.

## Results

Field surveys show that coral reef benthic habitat in the study site is diverse, with varying structural complexity and is partly impacted by sediment loads. Oceanographic information indicates plumes from the Mekong delta travel south along the Viet Nam coast (South China Sea), around the Ca Mau peninsula and move northwest into the eastern gulf. Field testing of water quality from rivers, streams and population centres indicate high levels of ammonia and contribution to sediment loads, among other things, resulting in degraded water quality in some areas.

The biodiversity survey data, fish catch records

Water quality parameter	Method of analysis	Remark
Physical parameter		
- Temperature	Thermometer	In situ
- Transparency	Secchi disc	In situ
- Salinity	Refractometer	In situ
- Suspended solid	Filtrate by Whatman GF/C	Laboratory
Chemical parameter		
- Nitrite (NO <sub>2</sub> <sup>-</sup> )	Atomic absorption spectrometry	Laboratory
- Nitrate (NO <sub>3</sub> <sup>-</sup> )	Atomic absorption spectrometry	Laboratory
- Ammonia (NH <sub>4</sub> )	Atomic absorption spectrometry	Laboratory
- Phosphate (PO <sub>4</sub> <sup>3-</sup> )	Atomic absorption spectrometry	Laboratory
- Dissolved oxygen (DO)	Titration	Laboratory
- pH	pH meter	Laboratory

**Table 1.** Water quality parameters and method of analysis.

and community surveys indicate potential threats to reef fish populations. Current fishing activities are removing top predators from the system. Local fishers reported halving of fish catch in the last five years, although fish size is perceived to remain relatively constant. Tipping points for the resilience and survival of targeted fish species is currently unknown.

Marine currents and environments do not recognise political boundaries and present a challenge for the development and implementation of co-ordinated and effective management measures across the three countries. The effectiveness of establishing MPAs in the recently declared Koh Rong Marine Park, Cambodia and Koh Chang Marine Park in Thailand to protect key commercial species to reach breeding size is evident from the data. Future development of a transnational IUCN Man and Biosphere Reserve for the coral reefs in the east Gulf of Thailand is essential to the provision of sustainable biodiversity protection and on-going food security.

## Future Work

The data for Thailand and Cambodia have been collected and analysed, but not fully interpreted. A final round of data collection of community perspectives is currently being conducted. The major difficulty that the project has faced is in obtaining safe field logistical support for diving activities in Cambodia. Adverse weather conditions have limited diving opportunities to obtain water samples for in-country analysis. Final reporting to stakeholders awaits final data collection and analyses.

## Project Publications

Carter, R. W., O'Rourke, V., Livingstone, T., McKenzie,

T., Lyell, M., Brown, J., ... Roiko, A. (2013). Strategic guidelines for sustainable tourism on the Khmer coast: report to the Ministry of Tourism, Royal Government of Cambodia. Sippy Downs: University of the Sunshine Coast.

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## Acknowledgements

Field assistance provided by Kasetsart University and the Cambodian Ministry of Tourism and the Provincial Governments of Koh Kong, Preah Sihanoukville, Kep and Kampot are gratefully acknowledged.

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Raymundo, L. J., Couch, C. S., & Harvell, C. D. (Eds.). (2008). *Coral disease handbook: Guidelines for assessment, monitoring & management*. St Lucia: Coral Reef Targeted Research and Capacity Building for Management Program.

### ARCP2013-09CMY-CARTER

#### PROJECT TITLE

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

#### COUNTRIES INVOLVED

Australia, Cambodia, Thailand, Viet Nam

#### PROJECT DURATION

Year 2 of a two-year project

#### APN FUNDING

US\$ 60,000

#### PROJECT LEADER

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ARCP2013-10CMY-YOO

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

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**Abstract:** The project examines issues related to the implementation of a seasonal climate forecast-based Early Warning System for fire and haze in Southeast Asia. This works builds on current fire danger rating systems available in the region by providing forecasts with a longer lead time; providing a timescale that is more relevant and useable for decision makers. Once this project is realised, one of the major outcomes will be a thorough assessment of global and regional forecast skills for fire-inducing drought conditions. The needs of resource managers in Southeast Asia will be assessed and used to develop a prototype Early Warning System for fire and haze in the region.

**KEYWORDS:** *fire danger, seasonal forecasts, statistical downscaling, dynamical downscaling, seasonal drought, early warning system*

## Introduction

Smoke haze from forest fires is one of 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 longer lead time EWSs.

The project builds upon current fire danger rating systems by providing forecasts at a longer lead time, thus providing timescales that are more relevant and useable for decision makers. The immediate objectives of the

project are to:

- Assess forecast skill over fire-prone areas in Southeast Asia and the extent to which the skill can be improved by applying various downscaling techniques; and
- Develop new fire management decision triggers based on seasonal forecasts. The project will also implement these new seasonal forecast-based fire management decision triggers and work towards developing a prototype fire danger early warning system for Southeast Asia.

This project is strongly aligned with APN's institutional agenda to strengthen science-policy linkages and represents a directed scientific effort towards helping

solve a regional policy-relevant problem. This is evident in the ASEAN Regional Haze Action Plan early warning systems as a corner stone of fire management policy. Furthermore, the project supports APN's goal of regional cooperation by involving organisations in six APN Member Countries to address one of Southeast Asia's most significant global change problems.

## Methodology

This two-year project consists of three parts; namely: (1) forecast skill assessment of current and downscaled products supplied by the APEC Climate Center (APCC); (2) development of a prototype fire danger EWS; and (3) training to mainstream seasonal climate forecasts into standard fire management operating procedures.

The forecast assessment is being conducted for global climate forecasts using standard verification procedures recommended by the World Meteorological Agency (WMO). The coarse resolution of global forecasts does not allow predictive information to be applied at the spatial or temporal scales that are relevant for fire management. Hence, a critical methodology is downscaling of global forecasts, both in terms of time and space, to fit the needs of fire managers in the region. We are exploring two main types of downscaling techniques: dynamical and statistical. Based on these downscaled forecasts, drought and forest fire indices will be constructed at relevant

spatio-temporal scales. One of the main research objectives is to determine the lead time at which forecasts can be made and the benefits of downscaling over fire-prone regions.

In the coming year, fieldwork and interviews with resource managers will be conducted to determine their practices and needs. Based on the stakeholder interviews, we will formulate guidelines on integrating advance climate information into the standard operating procedures of fire management agencies. Furthermore, a training workshop will be held to increase stakeholders' understanding of seasonal forecasts based on global models and of statistical and dynamical downscaling techniques and their strengths and limitations. The workshop will also be an opportunity to demonstrate the prototype EWS to fire and land managers and receive their feedback before prototype refinement.

## Results and Discussion

Thus far, we have conducted a preliminary assessment of global forecast skill over fire-prone regions in Southeast Asia. Our analysis shows reasonable skill for surface temperature, but somewhat lower skill for rainfall (Figure 1). The extent to which skill for both of these critical variables (Field & Shen, 2008) can be improved using downscaling techniques is now under investigation. As suggested by Field and Shen (2008), 3-month total precipitation was determined to be

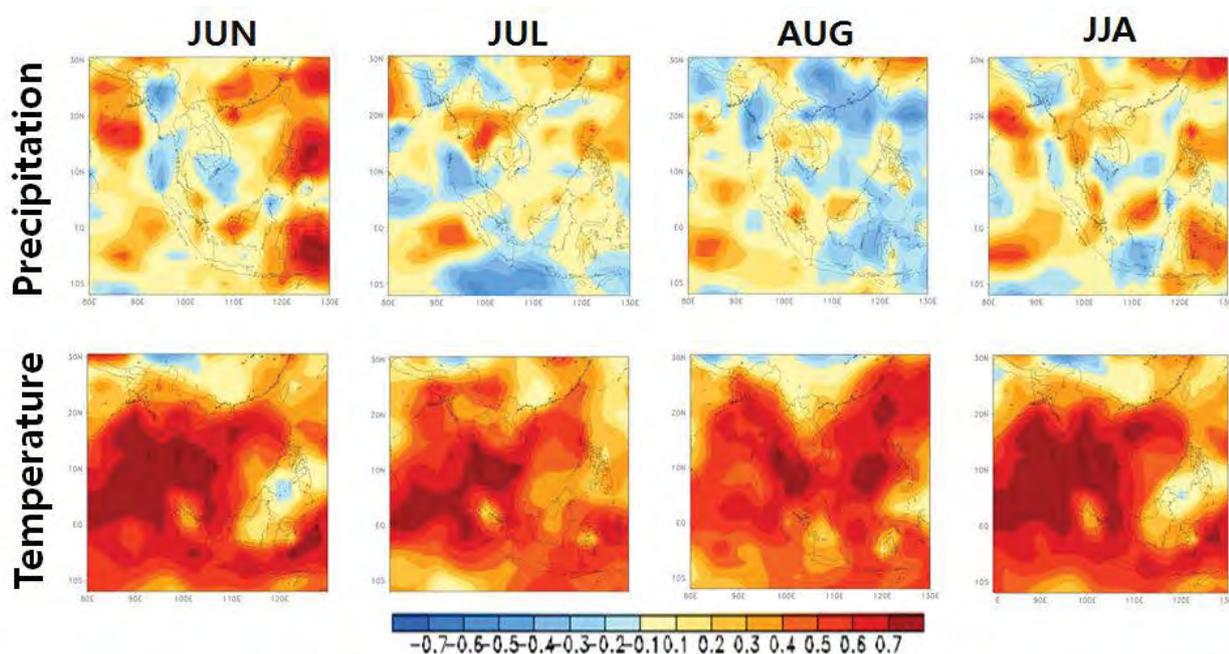


Figure 1. Temporal Correlation Coefficient (TCC) for precipitation and temperature from ACP/MME forecasts.

the best predictor for predicting severe biomass burning carbon emissions in equatorial Southeast Asia. The statistical downscaling method underestimated the 3-month total precipitation and showed limitations in representing yearly variations. Furthermore, the downscaling method was somewhat successful in mimicking the yearly variations but it still showed limitations in predicting values below the threshold value for the years 1999, 2001 and 2005.

During the second phase of the project, surveys and interviews with resource managers in Southeast Asia will be conducted in order to assess the information needs required for developing a prototype EWS. In order to construct the prototype, in the coming months the research team will analyse the precipitation threshold levels for the study region, i.e., if the amount of precipitation dips below the threshold level, this predicts an increased risk for severe burning, carbon emissions, and transboundary haze. A workshop being planned in 2014 will focus on providing essential training to resource managers in Southeast Asia to make the best use of seasonal climate information and the EWS for decision-making.

## Project Publications

Scientific manuscripts for journal publication will be prepared during the next year of the project when more results have been obtained. Policy briefs and operational guidelines will also be prepared for distribution among Southeast Asian government agencies responsible for fire prevention and management.

## Acknowledgements

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

## References

Field, R. D., & Shen, S. S. P. (2008). Predictability of carbon emissions from biomass burning in Indonesia from 1997 to 2006. *Journal of Geophysical Research: Biogeosciences*, 113(G4), n/a–n/a. doi:10.1029/2008JG000694

### ARCP2013-10CMY-YOO

#### PROJECT TITLE

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

#### COUNTRIES INVOLVED

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

#### PROJECT DURATION

Year 2 of a two-year project

#### APN FUNDING

US\$ 73,000

#### PROJECT LEADER

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ARCP2013-11CMY-YABE

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

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## Introduction and Background

The GEOSS Asian Water Cycle Initiative (AWCI) is a regional collaborative framework of 18 countries in Asia that has been implementing convergence and integration of data from earth observation satellites, fields, and model cases at Asian major river basins; and researching on the impact assessment and adaptation measures for climate change using these data. To further accelerate the coordinated and integrated efforts, the “GEOSS Water Cycle Integrator (WCI)” is proposed to develop a holistic coordination capability of the following functions in cooperation with various partners:

- Observation integration
- Science and model integration
- Data integration & analysis
- Cross-socio benefit Areas and Community of Practices
- Management system integration
- Sustained education framework

With its achievements in development of some of the above functions in the water cycle arena, GEOSS AWCI is an essential component in WCI development and the present project contributes to such efforts.

## HIGHLIGHTS

- » Pilot case of a workbench in Cambodia.
- » 6th GEOSS Asia-Pacific Symposium.
- » AWCI training course on improved bias correction and downscaling techniques for climate change assessment including drought indices.

## Objectives

The major activity of this project is to support the development of 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. In order to establish the workbench function properly, this project provides a platform for researchers, data experts and representatives of government organisations from Asian countries to meet, discuss, exchange ideas and arrive at agreements on necessary steps to achieve the required functions. A further aim is to utilise the established workbench functions to initiate the implementation of comprehensive decision making support tools for IWRM practices into operational sectors.

### Outcomes to Date

The pilot case of a workbench has been completed in Cambodia under cooperation among stakeholders, space agencies and science communities on water, climate and agriculture. The resulting integrated system provides online information on near-real time spatial precipitation, soil moisture as well as rice production to local communities. The process of developing the Water-Climate-Agriculture Workbench was initiated at a stakeholder meeting consisting of also the University of Tokyo research team and the JAXA team (a SAFE project), which resulted in the recognition of a holistic approach to the water-climate-agriculture issues in the country (Figure 1). Climate change impacts on the river Mekong and Tonle Sap Lake regime was identified as an important factor driving the variability of water resources for agriculture and extreme events resulting into the flood and drought disasters.

Subsequently, a system for real-time dissemination of aerial precipitation data was developed using *in situ* measurement from newly installed telemetry stations to

correct the JAXA GSMaP spatial precipitation product available on a near-real time basis and disseminating corrected spatial precipitation data through the online DIAS platform. Furthermore, part of the workbench includes a soil moisture monitoring system developed by collaborative efforts of JAXA and UT using AMSR-E (nationwide area) and ALOS PALSAR (local area) satellite data.

Comprehensive studies and preparation of workbench development has been initiated further in some countries, in particular Pakistan (the Indus river basin) and Indonesia (the Musi and Citarum river basins). In addition, the DIAS (<http://www.editoria.u-tokyo.ac.jp/projects/dias/?locale=en>) has been steadily expanding its data archives including data essential for the research into climate change impacts on water nexus that also include *in situ* data from the selected basins of AWCI countries.

Simultaneously, new on-line tools have been developed to ease the accessing, processing and analysis of the model output (<http://dias.tkl.iis.u-tokyo.ac.jp/model-eval/stable/index.html>). Methodologies for assessment of climate change impacts on water regime in AWCI basins

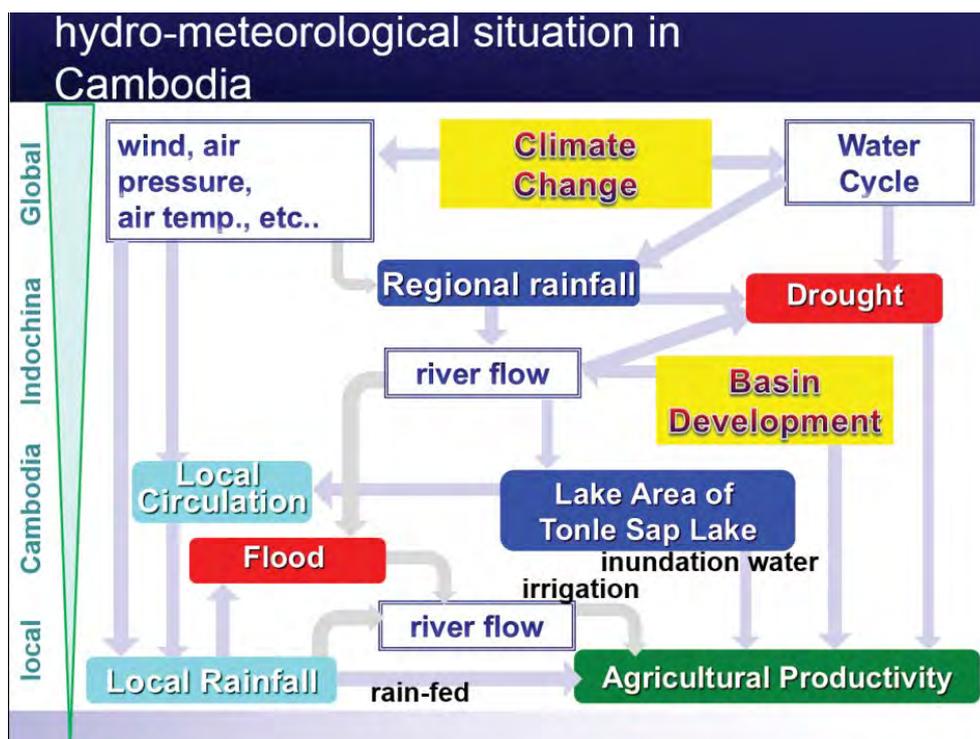


Figure 1. Holistic view of water-climate agriculture problems in Cambodia.

(developed under previous APN-supported AWCI projects) have been improved, in particular the GCM precipitation bias correction.

In addition, this project supported several AWCI-related meeting events and one training course by inviting AWCI country representatives to these events. The first event was the 6th GEOSS Asia-Pacific Symposium in Ahmedabad, India, from 25-27 February 2013, in which an AWCI session was held especially to finalise the phase two implementation plan.

Furthermore, the AWCI training course improved bias correction and downscaling techniques for climate change assessment including drought indices. Held in Tokyo, Japan, on 18-20 June 2013 and organised by the University of Tokyo, it explained the improved techniques including GCM selection, model output (precipitation) bias correction, downscaling of the corrected output at the basin scale and generation of drought indices and drought assessment.

Finally, the first GEOSS Joint Asia-Africa Water Cycle Symposium was held in Tokyo, Japan, from 25-27 November 2013, co-organised by the University of Tokyo and the Group on Earth Observations (GEO) (Figure 3: Group photo of the first GEOSS Joint Asia-Africa Water Cycle Symposium, in Tokyo, Japan, from 25-26 November 2013). The symposium's aim was to build upon the commonalities of approach by both

the AWCI and the Africa Water Cycle Coordination Initiative (AfWCCI) towards addressing integrated water resource management in the context of climate change. The symposium shared accomplishments and lessons learned from the past development and execution of implementation plans for river basin management, especially from the AWCI to the AfWCCI.

## Acknowledgements

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

## References

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- Tsujimoto, K., & Koike, T. (2012). Requisite conditions for post-monsoon rainfall in Cambodia by looking through 2009 rainfall data. *Journal of Hydroscience and Hydraulic Engineering*, 30(1), 1-14.

### ARCP2013-11CMY-YABE

#### 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

Year 2 of a two-year project

#### APN FUNDING

US\$ 90,000

#### PROJECT LEADER

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ARCP2013-12CMY-BURNETT

# Phosphorus Dynamics in Tonle Sap Lake, Cambodia

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**ABSTRACT:** The project investigates the relationship between Mekong river hydrology and the dissolved and particulate phosphorus cycle of the Tonle Sap Lake, which is the largest and most productive lake in Southeast Asia. As phosphorus - considered a key limiting nutrient - controls the primary production of the lake, geochemical measurements and phosphorous modelling are being used to determine sources of phosphorous and their relationship to surface hydrology in both the Tonle Sap River and Lake. We are particularly interested in evaluating the role of groundwater in the phosphorous cycle. The overarching objectives are to assess and model nutrient and productivity impacts in response to climate change, dam construction and other development activities in the Mekong River basin that will affect river flow.

**KEYWORDS:** *Mekong River, Tonle Sap Lake, phosphorus, radon, groundwater, SD modelling*

## Introduction

Tonle Sap, the largest freshwater lake in Southeast Asia (Figure 1), is a flood-pulse system hosting one of the most productive inland fisheries in the world and accounting for more than 75% of Cambodia's inland fish catch and approximately 60% of the country's protein needs. Accelerating development of dams and diversion projects in the Lower Mekong Basin 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 the lake. Particular attention is being paid to the possible influence of groundwater as a nutrient source in this system.

The sources and mechanisms of nutrient supply to the Tonle Sap, 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. The present research should help clarify these points.

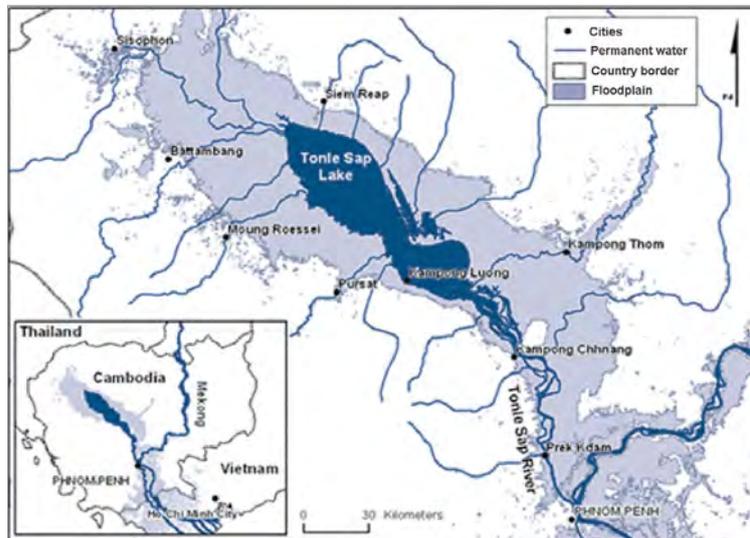
### Methodology

Sampling trips, both on the Mekong River and the Tonle Sap, are being conducted to characterise the amount and form of P being delivered to the lake. In 2013, two sampling trips on the Tonle Sap lake and one trip on the Tonle Sap and Mekong rivers, were completed. During these surveys, the research team made continuous measurements of radon levels, conductivity, temperature, GPS coordinates and water depth. Discrete water samples were collected at regular intervals (approx. every 5-10 km) for P speciation studies.

### Results and Discussion

#### Phosphorus species

Phosphorus is an essential plant nutrient found in different forms in natural waters: dissolved inorganic phosphorus (DIP), dissolved organic phosphorus (DOP) and particulate phosphorus (PP). The sum of DIP and DOP is termed total dissolved phosphorus (TDP), and the sum of all phosphorus components combine to provide total phosphorus (TP). The overall distribution of the phosphorus species shows that DIP is the most important portion of TP, with PP the 2nd highest in the river, and DOP higher in the lake (Figure 2).

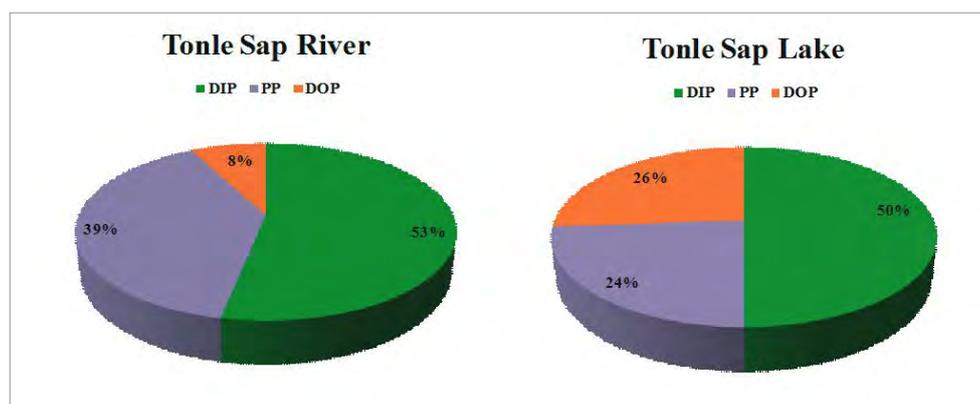


**Figure 1.** Map of the Tonle Sap Lake, Cambodia. Dark colour represents the permanent lake; light colour shows the extent of the floodplain.

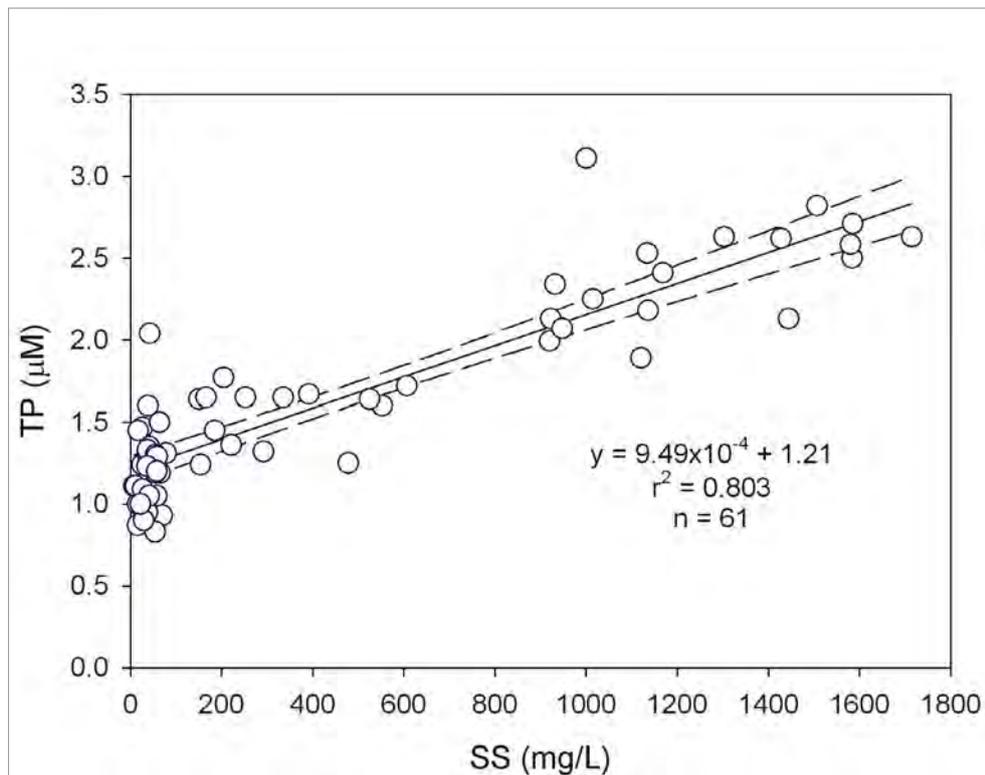
DIP is the most biologically available form of P and, therefore, considered the most important form. High TP concentrations generally are associated with runoff events, which carry a substantial proportion of suspended sediment to which is attached. The results from the Tonle Sap Lake show that, as suspended sediment concentrations increase, concentrations of TP also increase (Figure 3). Yields of P can, therefore, vary considerably from month to month in natural waters, depending upon discharge, sediment re-suspension, etc.

#### Modelling

Phosphorous modelling is being undertaken to investigate the response of the lake’s P cycle to changes in P loads under different development scenarios for the Mekong Basin, including a high



**Figure 2.** Distribution of phosphorus fractions from the Tonle Sap river and lake waters.



**Figure 3.** Relationship between total phosphorus (TP) and suspended sediment (SS) in the Tonle Sap lake.

development scenario as well as current conditions. The dynamic characteristics of the lake and the deficiency of data call for careful design of the P model structure, which was developed based on System Dynamics (SD) methodology. SD modelling predicts future states by

showing feedback mechanisms among the system components rather than forecasting future states using time series data. The time series data now being collected is expected to produce results of high quality with the SD model.

#### ARCP2013-12CMY-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

Year 2 of a two-year project

##### APN FUNDING

US\$ 74,000

##### PROJECT LEADERS

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ARCP2013-13CMY-SASE

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

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## Background and Objectives

In East Asia, the deposition level of sulphur (S) is high and hence the cumulative load of S is also high. Since S deposit on ecosystems may be retained in soil and/or cycled in the soil-plant system, manifestation of its effect may be delayed (e.g. Mitchell and Likens 2011; Kobayashi et al. 2013). Moreover, several rivers/lakes for monitoring an inland aquatic environment in East Asian countries showed a pH-declining trend with  $\text{SO}_4^{2-}$ -increasing trend (EANET 2011). The effect of S deposition on terrestrial ecosystems is currently an important issue in East Asia that requires investigation. Scientists from the community of the Acid Deposition Monitoring Network in East Asia (EANET) investigate the dynamics of S derived from atmospheric deposition in forest catchments in Niigata, Japan; Nakhon Ratchasima, Thailand; and Sabah and Sarawak, Malaysia. In order to determine S dynamics in the forest ecosystems, analysis of S isotopic ratio is applied for rainwater, soil water and stream water in addition to flux measurements.

## Progress of Field Surveys

Study sites were established in four forest catchments in Japan, Thailand and Malaysia, as shown in Table 1. In this report, seasonal changes in S isotopic ratio at the

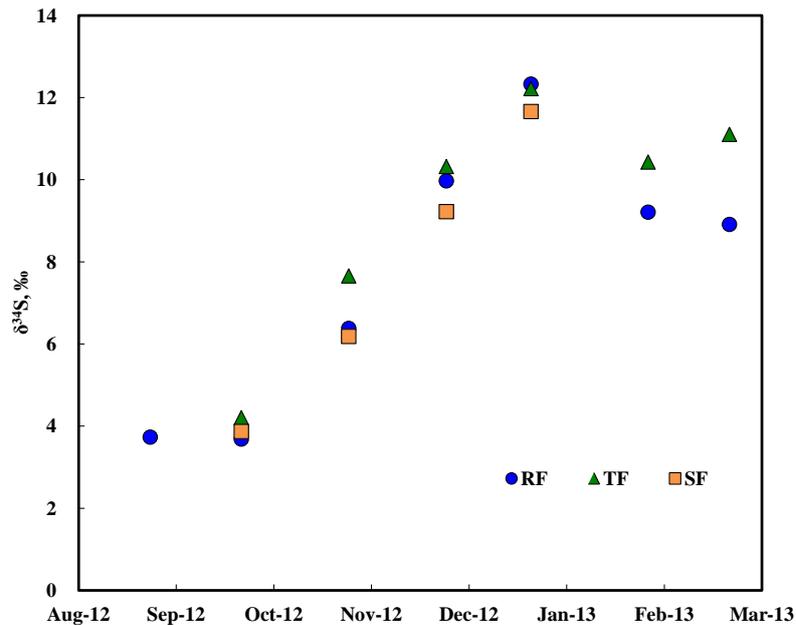
Kajikawa site in Japan will mainly be introduced.

At the Kajikawa site, rainwater (RF, rainfall outside forest canopy; TF, throughfall; SF, stemflow), soil solution and stream water were collected monthly. The  $\text{SO}_4^{2-}$  were precipitated as  $\text{BaSO}_4$  using  $\text{BaCl}_2$ . The S isotopic ratio in the powdered  $\text{BaSO}_4$  was analysed by using an Elemental analyser (EA) - Mass Spectrometer (MS). The S isotopic ratio of rainwaters, soil solution and stream water was measured to determine the origin of S (atmospheric, biological or geological origin) and to discuss the retention time of S in the ecosystems. S isotopic ratio is expressed as:

$$\delta^{34}\text{S} (\%) = \left\{ \left( \frac{{}^{34}\text{S}/{}^{32}\text{S}}{\text{sample}} \right) / \left( \frac{{}^{34}\text{S}/{}^{32}\text{S}}{\text{CDT}} \right) - 1 \right\} \times 1000$$

Where  $\left( \frac{{}^{34}\text{S}/{}^{32}\text{S}}{\text{sample}} \right)$  and  $\left( \frac{{}^{34}\text{S}/{}^{32}\text{S}}{\text{CDT}} \right)$  were isotopic ratios of sample and Canyon Diablo troilite (standard substance), respectively.

The seasonal and vertical variations of S isotopic ratio of the water samples at the Kajikawa site are shown in Figure 1. The  $\delta^{34}\text{S}$  of rainwater from RF, TF and SF increased from summer to winter substantially, peaked in December, and then slightly decreased. The variation may reflect changes of S sources, as suggested by Ohizumi et al. (2001). On the other hand, the  $\delta^{34}\text{S}$  values of soil solutions and stream waters were very stable (approximately 9%) throughout the period. This may



**Figure 1.** Seasonal variation of S isotopic ratio in rainfall outside forest canopy (RF), throughfall (TF) and stemflow (SF) in Kajikawa site, Japan.

suggest that S deposited onto the forest floor did not directly flow into the stream. The deposited S may be retained/cycled in the ecosystem and then released to soil solutions and stream waters with a specific value of the isotopic ratio. The  $\delta^{34}\text{S}$  values of soil solutions/stream waters were high and low in summer and winter, respectively, compared with those in rainwaters. Since the  $\delta^{34}\text{S}$  values of  $\text{SO}_4^{2-}$  may increase by biological fractionation in general, not only biological fractionation but also geochemical processes including adsorption/desorption of  $\text{SO}_4^{2-}$  in soil and other natural geological sources should be taken into consideration. Further discussion is necessary after accumulation of one-year data.

### Project Workshop in Malaysia

One of the major planned activities for the project, “APN Workshop on Sulphur Dynamics in East Asian Forests” was held from 24-25 June 2013 in Selangor, Malaysia, to share outcomes/progress of the project with relevant agencies in Malaysia (Figure 2).

The workshop was organised by ACAP in cooperation with UPM. About 40 scientists and experts attended, namely the project members, researchers in relevant study fields, and experts from the EANET relevant organisations, including the Malaysian Meteorological Department (MMD), Department of



**Figure 2.** APN Workshop on Sulphur Dynamics in East Asian Forests, 24-25 June 2013.

Chemistry (DOC), and Universiti Putra Malaysia (UPM).

The presentations in the workshop included the latest scientific knowledge on catchment-scale analysis in the EANET countries and new trials in the project, such as S isotopic analysis and use of rehabilitated forests for acid deposition studies. The workshop provided information as a basis for understanding possible mechanisms of acid deposition impacts on forest ecosystems and considering future direction of EANET monitoring and other relevant studies.

### Acknowledgements

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## ARCP2013-13CMY-SASE

### PROJECT TITLE

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

### COUNTRIES INVOLVED

Japan, Malaysia, Thailand

### PROJECT DURATION

Year 2 of a two-year project

### APN FUNDING

US\$ 44,000

### PROJECT LEADER

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ARCP2013-14NMY-MIYATA

# Towards CarboAsia: Integration and Synthesis of Ecosystem Flux Data in Tropics/Subtropics and Croplands in Asia by Activating Regional Tower-based Observation Networks

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## Objectives and Outline of the Project

Eddy covariance terrestrial ecosystem flux measurements should be enhanced as an essential component of the Integrated Global Carbon Observing system (IGCO) (Ciais, *et al.*, 2010). Integration of standardised flux data from a variety of biome types is also essential for validating modelling and remote sensing to upscale carbon budgets. AsiaFlux, the flux monitoring tower network for carbon and water cycles in terrestrial ecosystems in Asia, is implementing its strategic plan has accomplished two important forward-looking projects in the past. One

is the earlier APN-funded project (2005-07-NMY/2006-01-CMY) on advancing standardisation of flux observations, which resulted in the launch of the other successful foresight project, CarboEastAsia between China, Japan and the Republic of Korea, in which key methodologies for data integration and syntheses were gleaned and a database mostly for forest ecosystems in mid-latitudes established. The next step, 'Toward CarboAsia' (the carbon budget assessment covering all Asian terrestrial ecosystems) is essential to fill the critical data gaps in tropical/subtropical forests and croplands in Asia. More than 90 sites are registered with AsiaFlux but the available multi-year datasets from tropical/subtropical forests and croplands are quite limited. These data are crucial for the integrated assessment of the Asian carbon budget and its role in a global context. By utilising the framework of AsiaFlux, we will have workshops and training courses to encourage and activate tower-based flux observation networks in South and Southeast Asia, thereby promoting data integration and syntheses of carbon and water cycles in tropical/subtropical forest and croplands in Asia. A synthesis will be undertaken by the project participants in close collaboration with investigators on terrestrial biosphere modelling and satellite remote sensing. The current project will make a major contribution to the report by AsiaFlux on 'the

### HIGHLIGHTS

- » At the International Joint Conference of 11th AsiaFlux International Workshop, 3rd HESSS and 14th Annual Meeting of KSAFM held from 21-24 August 2013 in Seoul, Korea, a special session entitled "Linking Regional Flux Network" was held and CarboAsia was launched.
- » We reviewed the current status of flux monitoring sites in Asia and confirmed the implementation plan of the project during the AsiaFlux Steering Committee Meeting.



**Figure 1.** A group photo of the joint Conference.

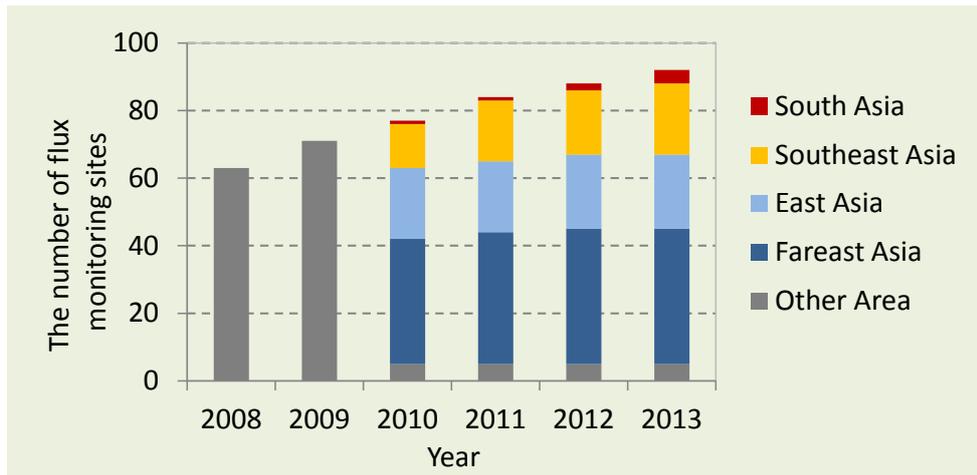
Asian Carbon Budget and Implications for the Global Carbon Cycle’.

## Progress to Date

APN sponsored the International Joint Conference of 11<sup>th</sup> AsiaFlux International Workshop, 3<sup>rd</sup> HESSS (Hydrology delivers Earth System Science to Society), and 14<sup>th</sup> Annual Meeting of KSAFM (Korean Society of Agricultural and Forest Meteorology) from 21-24 August 2013 at Seoul National University (SNU), Seoul, Republic of Korea. More than 200 scientists and students from 24 countries contributed to 120 oral and 60 poster presentations (Figure 1).

During the conference opening, the project held a session entitled “Linking Regional Flux Networks.” In this session, eight national and regional flux networks, including FLUXNET (the global network) and AsiaFlux reported their activities and recent progress. FLUXNET stressed the importance of synthesising global data and encouraged linking networks. AsiaFlux reported that it has 92 flux monitoring sites (Figure 2), and number of the monitoring sites

in Asia has been increasing, especially in South and Southeast Asia (Figure 3). The 97 site-year dataset has already been submitted to the AsiaFlux Database from 27 monitoring sites (Figure 4), and submitting site information and further datasets are encouraged. ChinaFLUX (China) has expanded from an original 8 to the current 45 sites, and is focusing on coupled cycling of carbon, water and nitrogen as well as the national scale budget. In India, the National Remote Sensing Centre is showing strong leadership in promoting national-level studies. JapanFlux (Japan) is active in studies on disturbance, tropical forest, rice paddy, soil respiration network, and data-model fusion. KoFlux (Republic of Korea) is preparing a ten-year dataset of 3 tower sites and is incorporating a new data assimilation and synthetic analysis – CarbonTracker-Asia. Malaysia, Taiwan, Thailand, Viet Nam, Philippines and OzFlux (Australia and New Zealand) also reported their respective activities. Some difficulties in managing the national networks were reported by several national networks. Capacity development supported by AsiaFlux is still important to encourage and link the regional networks in Asia.



**Figure 2.** The number of AsiaFlux monitoring sites from 2008 to 2013 (no geographic classification for 2008 and 2009).

As part of our capacity development activities, the project organised a two-day training course on flux measurement prior to the main conference and a young scientists meeting during the conference. About 50 young scientists and students from 13 countries participated in the training courses provided by the LI-COR Biosciences and SNU groups. The young scientists meeting had more than 60 young scientists from 19 countries (Kang, 2013).

The AsiaFlux Science Steering Committee Meeting was held during the joint conference. The meeting was conducted to review and discuss the implementation plan of the project, and it was confirmed that AsiaFlux will have its next workshop at the International Rice Research Institute (IRRI) in August 2014. The workshop will provide an excellent opportunity to promote data integration and synthesis of cropland sites in Asia, especially of rice fields, because IRRI is a focal point of studies on rice and rice fields and has an active flux study site in its campus (Alberto *et al*, 2012). At the time of writing, the project is also at the final stage of preparing for a training activity and seminar on methane flux and the carbon cycle in Mymensingh, Bangladesh, scheduled in late February 2014. At the time of

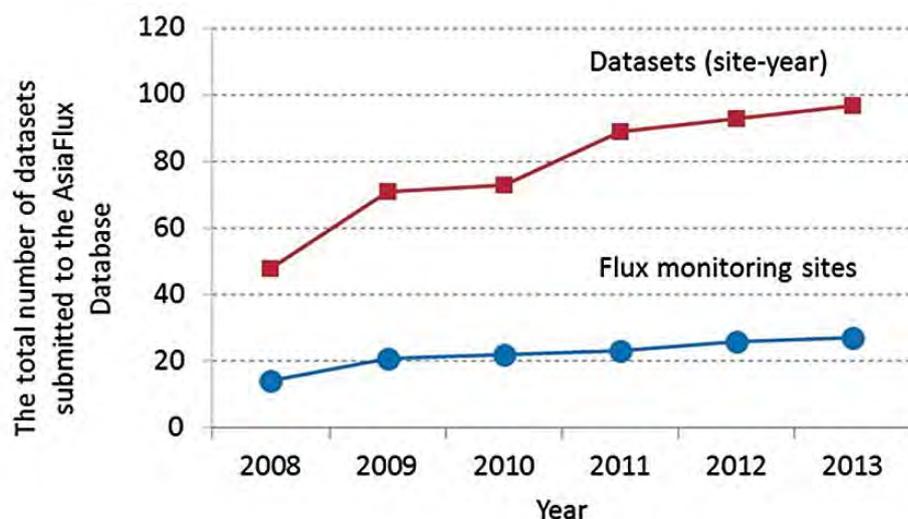
writing, the project also plans to collaborate with another APN-funded project (ARCP2012-01CMY-Patra/Canadell/ARCP2013-01CMY-Patra/Canadell) by inviting one of the co-leaders to present a keynote lecture on the necessity of flux measurement of greenhouse gases in South and Southeast Asia.

## Project Publications

AsiaFlux (2013). Proceedings of the International Joint Conference of 11th AsiaFlux International Workshop, 3rd HESSS, and 14th Annual Meeting of KSAFM, 21-24 August 2013, Seoul, Korea, 174p.

## Acknowledgements

We acknowledge Dr. Minseok Kang, Seoul National University (SNU), and Ms Sawako Tanaka, AsiaFlux Tsukuba Office in National Institute for Environmental Studies, for assistance in preparing the manuscript, and Ms. Boeun Choi, SNU, for designing the map of the flux monitoring sites (Figure 2). We also express our gratitude for Dr. Yoshikazu Ohtani, the leader of the previous APN Project (2005-07-NMY/2006-01-CMY), for establishing the foundation of the current project.



**Figure 3.** Total number of datasets submitted to the AsiaFlux Database and the number of flux monitoring sites that submitted datasets.

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## ARCP2013-14NMY-MIYATA

### PROJECT TITLE

**Toward Carbon Asia: Integration and Synthesis of Ecosystem Flux Data in Tropics/Subtropics and Croplands in Asia by Activating Regional Tower-based Observation Networks**

### COUNTRIES INVOLVED

Bangladesh, China, India, Indonesia, Japan, Malaysia, Philippines, Republic of Korea, Thailand, Viet Nam

### PROJECT DURATION

Year 1 of a three-year project

### APN FUNDING

US\$ 135,000

### PROJECT LEADER

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ARCP2013-15NMY-MANTON

# Coordinated Regional Climate Downscaling Experiment (CORDEX) in Monsoon Asia

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## Introduction

The Coordinated Regional Climate Downscaling Experiment (CORDEX) is a project of the World Climate Research Programme (WCRP) aimed at providing regional climate change projections to support impact and adaptation studies (<http://wcrp-cordex.ipsl.jussieu.fr/>). The CORDEX strategy includes the generation of ensembles of output from dynamical and statistical models forced by the global climate models (GCMs) of the Coupled Model Intercomparison Project Phase 5 (<http://cmip-pcmdi.llnl.gov/cmip5/>), which is also organised by WCRP. The strategy of CORDEX involves the division of the world into domains that are large enough to contain the important geographical features influencing the climate of a region but small enough to allow century-long integrations of regional climate models at a resolution of around 25 km. For the Asian region, it is planned to have three domains covering South Asia, South East Asia and East Asia; there is another domain for the Australian region in the southern hemisphere.

While the three Asian domains of CORDEX have some distinct geographical features, there are many commonalities in climate, ecology and human activity that suggest that the analysis and application of downscaling should be carried out in a collaborative manner across monsoon Asia. The present APN project therefore aims to promote cooperation

between the climate downscaling communities and the vulnerability, impact and adaptation communities across the region. The project involves a series of three workshops to be held in 2013, 2014 and 2015 in South Asia, Southeast Asia and East Asia.

## South Asia Workshop

The first workshop was held from 27-30 August 2013 in Kathmandu, Nepal, and involved 70 experts from 16 countries. The meeting was hosted by the International Centre for Integrated Mountain Development (ICIMOD) in collaboration with the Indian Institute of Tropical Meteorology (IITM), the Chinese Academy of Sciences (CAS), the Monsoon Asia Integrated Regional Study (MAIRS) and the WCRP. The

### HIGHLIGHTS

- » Workshop in Kathmandu brings together climate downscaling and applications communities with a focus on the Himalayas – Tibetan Plateau (HTP) region.
- » Scarcity of systematic observations in HTP region provides challenges for model development, evaluation and application.
- » Mechanism for data sharing for CORDEX South Asia agreed.
- » Effective links established across downscaling communities of monsoon Asia.

workshop built on the outcomes of a CORDEX South Asia Training Workshop held at IITM in Pune, India from 17-20 October 2012.

The first two days of the meeting focused on presentations and discussion of current research on downscaling in the Himalayas – Tibetan Plateau (HTP) region, with an emphasis on the application of down-scaled products to water management issues. The scarcity of systematic climate observations over the HTP, owing to the mountainous and isolated terrain, poses a major challenge for model development and evaluation. It is therefore essential for the uncertainties of downscaled products to be understood by all stakeholders. The IITM offered to host a data portal for CORDEX South Asia through which key variables from regional climate models could be accessed by potential users.

The meeting also discussed the application of downscaled products. The range of applications discussed included water management, agriculture, ecosystem management and human health. It was seen that the nature of downscaled product needs to be aligned with the application. In particular, the cascade of uncertainties from the global climate model through downscaling to the application model should be quantified. These uncertainties can be represented by the use of ensembles of model output.

## Other Activities

The South Asia workshop provided a forum for key people from the three Asian domains to meet informally to discuss future collaboration. This project is closely linked with the APN projects on “Building Asian

Climate Change Scenarios by Multi-regional Climate Models Ensemble” (ARCP2009-16NMY-Wang/ARCP2010-04CMY-Wang/ARCP2011-01CMY-Wang) and on “Development of an Integrated Climate Change Impact Assessment Tool for Urban Policy Makers (UrbanCLIM)” (ARCP2012-10NMY-Li/ARCP2013-05CMY-Li), and their work was discussed at the Kathmandu meeting.

A very important link was made in Kathmandu with the APN project on “Southeast Asia Regional Climate Downscaling Project (SEACLID)” (ARCP2013-17NMY-Tangang). An outcome of discussions in Kathmandu was for this project to be represented at their workshop in Jakarta, Indonesia from 18-19 November 2013. It was agreed that the two projects would collaborate on the organisation of future meetings and downscaling activities.

This project was also well represented at the International Conference on Regional Climate – CORDEX 2013 held in Brussels, Belgium from 4-7 November 2013. A side meeting was hosted on CORDEX Asia on 8 November 2013 at which a number of key issues were discussed, including refinement of the domain and resolution for East Asia CORDEX integrations, data archive and access, model evaluation, and the coordination of future workshops.

## Acknowledgements

The workshop in Kathmandu was hosted by ICIMOD and supported by the APN, CAS, IITM, MAIRS and WCRP. All these contributions are greatly appreciated.

### ARCP2013-15NMY-MANTON

#### PROJECT TITLE

**Coordinated Regional Climate Downscaling Experiment (CORDEX) in Monsoon Asia**

#### COUNTRIES INVOLVED

Australia, China, India, Nepal, Republic of Korea

#### PROJECT DURATION

Year 1 of a three-year project

#### APN FUNDING

US\$ 135,000

#### PROJECT LEADER

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ARCP2013-16NMY-LI

# Assessing Spatiotemporal Variability of NPP, NEP and Carbon Sinks of Global Grassland Ecosystems in Response to Climate Change from 1911-2011

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## Introduction

The project addresses existing gaps in the field of global land-use and climate change research, which runs from September 2013 to September 2016. The total funding required from APN is \$108,000 in 36 months. The focus of the project is to build and enhance scientific capacity in three developing countries and to explore the quantifying method on assessing spatiotemporal variabilities of net primary production (NPP), net ecosystem production (NEP) and carbon sinks of the global grassland ecosystem in response to climate change and human activity during 1911-2011. This is a new attempt at integrating natural and social sciences in assessing changes of land use and climate change studies and it aims to overcome critical gaps in knowledge of how to enhance and manage the global grassland ecosystem, which includes management of grassland production, biomass, NPP, NEP and carbon sinks and environmental goals, in the face of climate change in the period 1911-2011.

## Activities Undertaken and Results to Date

The project has conducted an assessment of the variations of distribution, extent and NPP of global natural vegetation in response to climate change in the period 1911-2000. It has also tried to provide a feasible method

for global change research in regions where historical data collected/observed were difficult to obtain.

Variations of spatiotemporal distributions of global potential natural vegetation (PNV) from 1911 to 2000 were analyzed with the comprehensive sequential classification system (CSCS), and NPP of different ecosystems was evaluated with the synthetic model to determine the effect of climate change on the terrestrial ecosystems. The results showed that constantly rising global temperature and altered precipitation patterns have exerted strong influence on spatiotemporal distribution and productivities of terrestrial ecosystems, especially at the mid/high latitude. Ecosystems in temperate zones expanded and the areas of global deserts decreased as a consequence of climate variations. Cold desert was observed as the area that has the highest decrease of vegetation (18.79%), while the maximum vegetation increase (10.31%) was recorded on savanna. In addition, the area of tundra and alpine steppe reduced significantly (5.43%) and were forced to head northward due to significant ascending temperature at mid/high latitude. In accordance, the global terrestrial ecosystems productivities increased by 2.09%, most of which was attributed to savanna (6.04%), tropical forest (0.99%) and temperate forest (5.49%), whereas the biggest NPP losses was found in cold desert (27.33%). NPP increase also occurred at latitudinal distribution. On a global scale, NPP showed a significant



**Figure 1.** Meeting of project collaborators in Nanjing, China, 9-12 November 2013.

positive correlation with precipitation in comparison to mean annual temperature and biological temperature.

The project has also tried to provide better understanding of the role of grassland ecosystems in the global carbon cycle and to clarify the effects of climate change on grassland ecosystems in different regions.

Grasslands NPP and their spatio-temporal variations in four regions with abundant grassland resources, namely China, North America, Europe and Australia, were quantitatively evaluated and compared based on the modified Zhou Guangsheng model (Zhou & Zhang, 1995). The correlations between NPP of each grassland type and climate factors were also evaluated to reflect the response of grassland ecosystems to climate change from 1981 to 2010. The results showed that, in these four regions, all mean annual temperature increased during the past 30 years. In addition to that, the only decreasing trend of mean annual precipitation was observed in North America. The maximum grasslands NPP with  $4225.30 \pm 215.43$  Tg DW yr<sup>-1</sup> was found in North America, where the largest area of grassland ecosystems

lies, while the minimum grasslands NPP with  $928.95 \pm 24.68$  Tg DW yr<sup>-1</sup> occurred in Europe with the least grasslands area.

With regards to the grasslands NPP variations, an increasing trend was found in China and Australia, whereas a decreasing trend was observed in Europe and North America in the period 1981-2010. Additionally, grasslands NPP significantly showed positive correlation with the MAP in these four regions, especially in arid and semi-arid places. However, great differences presented in the correlations between grasslands NPP and MAT. Each grassland type in Europe showed positive correlations with MAT, while negative correlations presented in all grassland types in Australia. In conclusion, in the period 1981-2010, the role that climate change played on grasslands NPP variations was significant in the four regions and different grassland types reacted distinctively to these changes.

## Publications

Gang, C., Zhou, W., Li, J., Chen, Y., Mu, S., Ren, J., ... Groisman, P. Y. (2013). Assessing the Spatiotemporal

Variation in Distribution, Extent and NPP of Terrestrial Ecosystems in Response to Climate Change from 1911 to 2000. PLoS ONE, 8(11), e80394. doi:10.1371/journal.pone.0080394

## Acknowledgements

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### ARCP2013-16NMY-LI

#### PROJECT TITLE

**Assessing Spatiotemporal Variability of NPP, NEP and Carbon Sinks of Global Grassland Ecosystems in response to Climate Change in 1911-2011**

#### COUNTRIES INVOLVED

Australia, China, Mongolia, Uzbekistan, USA

#### PROJECT DURATION

Year 1 of a three-year project

#### APN FUNDING

US\$ 120,000

#### PROJECT LEADER

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ARCP2013-17NMY-TANGANG

# Southeast Asia Regional Climate Downscaling Project (SEACLID)

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## Project Summary

The Southeast Asia Regional Climate Downscaling (SEACLID) project aims to develop multiple downscaled Climate Change Scenarios for the Southeast Asia region based on the latest IPCC Representative Concentration Pathway (RCP) Emissions. These downscaled data products are crucially important for climate change impact assessments at the local and regional scales. Due to the multiple General Circulation Models (GCMs) and RCPs requirement for such assessments, regional climate downscaling can be a very resource-expensive exercise. In the spirit of regional collaboration, scientists from seven countries within the Southeast Asia region (i.e. Indonesia, Malaysia, Viet Nam, Thailand, Philippines, Cambodia and Lao PDR) initiated this project. Indeed, this activity is similar to the regional CORDEX and hence this project was later incorporated into CORDEX and has been renamed as SEACLID/CORDEX Southeast Asia (or CORDEX-SEA). In addition to the original SEACLID country members, a number of countries have joined the project as collaborators. These include Australia, UK, Republic of Korea, and Hong Kong SAR. The project officially started in October 2013 and will continue for a three-year period. The inception workshop was held

from 18-19 November 2013 in Jakarta and hosted by the Indonesian Agency for Meteorology, Climatology and Geophysics (BMKG). Currently, the group is completing the RegCM4 sensitivity experiments for the best physics options. The results of these experiments will be presented and discussed at the second workshop scheduled in June 2014 in Bangkok. Actual climate downscaling work will commence after the second workshop.

## Introduction

The Southeast Asia Region is at high risk of the potential impacts of climate change. According to the fourth assessment report of the Intergovernmental Panel on Climate Change (IPCC), a globally warmer world is likely to have regional adverse effects on agriculture, marine and coastal ecosystems, water security, forest and biodiversity, and human health. However, within the region, evaluation of the assessment of climate change impacts is yet to be carried out comprehensively. One important basic requirement of such an assessment is the availability of high-resolution regional climate change scenarios. The Southeast Asia Regional Climate Downscaling (SEACLID) was formulated to improve understanding of regional climate change and generate

climate change scenarios in the region. SEACLID original country members include Malaysia, Indonesia, Philippines, Viet Nam, Thailand, Cambodia and Lao PDR.

SEACLID has also been incorporated into the World Climate Research Programme (WCRP)'s Coordinated Regional Climate Downscaling Experiment (CORDEX) and renamed SEACLID/CORDEX Southeast Asia (CORDEX-SEA). SEACLID/CORDEX-SEA aims to downscale a number of CMIP5 GCMs for Southeast Asia through a task-sharing basis among the institutions and countries involved. A data portal will be created for effective data products dissemination to users in which APN and CORDEX data policy will be practiced. Additionally, SEACLID/CORDEX-SEA is a platform for capacity building and training for regional climate modeling, enhancement of scientific understanding of regional climate and increasing publications both in scientific journals and for policy makers.

## Work Undertaken

The first workshop of the SEACLID)/CORDEX Southeast Asia (or SEACLID/

CORDEX-SEA was successfully held from November 18-19, 2013 in Jakarta, Indonesia and hosted by the Indonesian Agency for Meteorology, Climatology and Geophysics (BMKG). The main objective of this workshop was to formulate an agreement among SEACLID member countries and potential collaborators on how to implement SEACLID/CORDEX-SEA activities. The workshop was attended by participants from Indonesia, Malaysia, Thailand, Viet Nam, Philippines, Singapore, UK, Australia, Republic of Korea and Hong Kong. The workshop was officiated by Dr. Widada Sulisty, Deputy Director General for Climatology of BMKG, where he acknowledged the need for scientists from within the region to work together and build capacity in regional climate downscaling. He also praised the establishment of SEACLID/CORDEX-SEA.

Dr. Michel Rixen of CORDEX, who addressed the participants via Skype, provided an overview of WCRP and CORDEX activities. A total of seventeen presentations were made, covering aspects of regional modeling activities within the SEACLID/CORDEX SEA region and the results of RegCM4 sensitivity experiment for the best physics



**Figure 1.** Dr. Michel Rixen of WCRP addresses participants via Skype during the opening session.

Country	No of GCMs	RCM	RCP4.5	RCP8.5
Indonesia	1	RegCM4	✓	✓
Malaysia	3	RegCM4	✓	✓
Viet Nam	1	RegCM4	✓	✓
The Philippines	1	RegCM4	✓	✓
Thailand	1	RegCM4	✓	✓
Australia	3	CCAM	✓	✓
UK	1	PRECIS2	✓	✓
South Korea	1	WRF	✓	✓
Hong Kong SAR	1	WRF	✓	✓

**Table 1.** Pledged commitments by countries involved in SEACLID/CORDEX-SEA.



**Figure 2.** Group photograph of the workshop participants.

options over the SEACLID/CORDEX-SEA domain. In addition, a discussion was held on various issues related to implementation of SEACLID/CORDEX-SEA.

The workshop has achieved its objective in which an agreement was reached where thirteen GCMs (Table 1) would be downscaled to a resolution of 25 km on the SEACLID/CORDEX-SEA domain. Currently, the sensitivity experiment is ongoing and is expected to be completed in the next few months, before the second workshop in June 2014, which will be hosted by Thailand. Actual downscaling will commence subsequently after the second workshop.

**ARCP2013-17NMY-TANGANG**

**PROJECT TITLE**

**Southeast Asia Regional Climate Downscaling Project (SEACLID)**

**COUNTRIES INVOLVED**

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

**PROJECT DURATION**

Year 1 of a three-year project

**APN FUNDING**

US\$ 135,000

**PROJECT LEADER**

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ARCP2013-18NMY-PRABHAKAR

# Scaling up Risk Insurance in the Asia-Pacific Region: Issues and Way Forward

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Natural and man-made hazards have historically undermined the developmental gains across the world and the Asia-Pacific region is no exception. The Asia-Pacific region is one of the most vulnerable regions to a range of primary hydro-meteorological natural hazards such as storms, floods, and droughts. The data from The International Disaster Database (EM-DAT) suggest that the number of hydro-meteorological natural disasters has been increasing at an average annual rate of 217% over the past 40 years in the Asia-Pacific region (Centre for Research on the Epidemiology of Disasters, 2012). As a result, an increase in the number of catastrophic natural disasters and related losses was also reported by Munich Re (2010), according to which both insured and uninsured losses have been increasing over the years (Figure 1).

Climate change has brought an additional dimension to disaster risk in the Asia-Pacific region as it is projected to exacerbate the intensity and magnitude of various

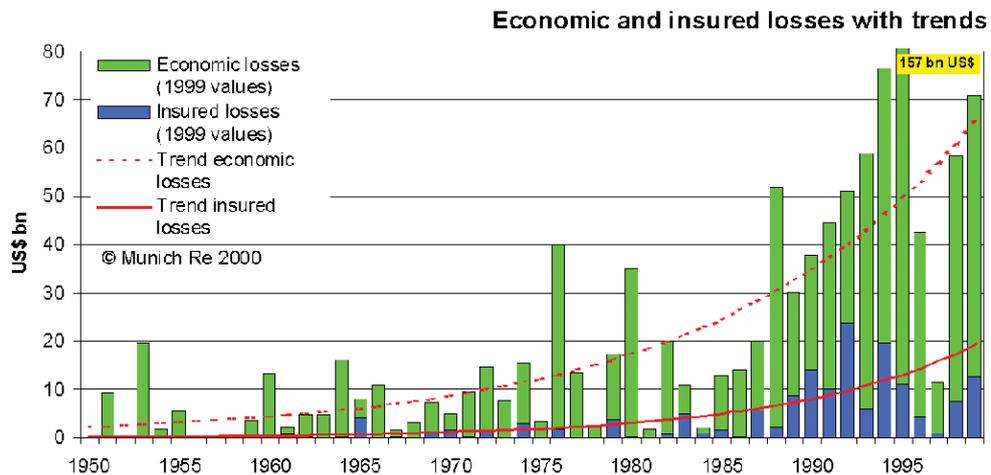
natural hazards such as storms, high-intensity rainfall events, heat waves, floods and droughts. Especially, the projections suggest high probability for an increasing trend in the high-intensity and low probability events (IPCC, 2007; Kunreuther and Michel-Kerjan, 2007). These increased catastrophic risks will further undermine the developmental gains already made in the Asia-Pacific region.

Hence, in order to address additional risks brought by the impact of climate change, there is a need to review and reframe the current risk reduction strategies especially in terms of development and utilisation of risk-spreading instruments within the Asia-Pacific region. Though risk insurance can moderate the impacts of climatic hazards in rural and urban contexts, and several risk insurance initiatives have been implemented at grassroots level over the years for reducing the vulnerability of communities to disasters, the penetration of risk insurance

## HIGHLIGHTS

- » Risk insurance can provide an effective means of catastrophic risk reduction and climate change adaptation in developing countries.
- » Case studies from within and outside the Asia-Pacific region provide valuable lessons, which could be used for promoting risk insurance for future climate regimes.
- » Issues such as high basis risk, lack of qualified historical data for designing and pricing risk insurance, limited knowledge and awareness in designing and utility of insurance, high premium prices, limited reinsurance availability and lack of enabling policies, are the key bottlenecks that limit the spread of risk insurance in the region.
- » This project aims to assess the benefits accrued through community-level risk insurance experiences in the region, evaluate barriers limiting its penetration, and identify interventions for greater risk insurance penetration leading to climate change adaptation and disaster risk reduction.

**Figure 1.** Trends in overall and insured losses due to catastrophic events since 1950.



in the developing Asia-Pacific is poor compared to many developed countries in the region. The limiting factors are poor globalisation of insurance benefits, high insurance costs, poor access and availability of qualified location-specific weather data, poor structural risk mitigation, lack of enabling policies, imperfect information, and technical complexity. The United Nations Framework Convention on Climate Change (UNFCCC) and Hyogo Framework for Action (HFA) are seeking for a global framework for promoting risk insurance but with little clarity on efficacy in addressing issues at the community level.

The poor spread of insurance remains a concern for the Asia-Pacific region especially in the non-health catastrophic risk insurance sector, which is attributed to the following factors:

- **High premium costs:** High residual risks, lack of optimum number of insurers, low competition and low number of insured population all lead to higher premium costs than what they could be in the Asia-Pacific region.
- **Low affordability:** Affordability relates to both the high cost of insurance and the low willingness to subscribe to insurance services which is, in turn, a function of lack of risk awareness.
- **High residual risks:** Residual risks are the risks uncovered by other structural and regulatory risk

mitigation mechanisms, which are poorly developed in the region.

- **Policy environment:** Though risk insurance is a “market instrument” (i.e., its dynamics are determined or governed by the principles of an open market), government policies and regulatory guidelines act as precursors for flourishing of the sector and ensure the effectiveness of the instrument.
- **Poor presence of insurers and reinsurers:** All the above factors act as disincentives for the proliferation of insurers and reinsurers.

It can be seen that most of the above factors are interlinked and provides an example of the “chicken and egg” dilemma. In order to promote risk insurance in the Asia-Pacific region, there is a need to overcome these limitations.

Quantifying risk insurance benefits will help various stakeholders to recognise the value of insurance in risk mitigation and hence will pave the way to greater acceptance of risk insurance as a risk management tool. Surprising enough, there are only few studies that bring out climate change adaptation and disaster risk reduction benefits of risk insurance though insurance has been widely regarded as an effective risk mitigation tool. This project, therefore, aims to assess the benefits accrued through community level risk insurance experiences in the region, evaluate barriers limiting its penetration, and identify

interventions for greater risk insurance penetration leading to climate change adaptation and disaster risk reduction. The specific objectives of the project are as follows:

- To identify technical, socio-economic, institutional and policy barriers limiting penetration of risk insurance: What insurance alternatives can be designed for locations with poor weather data?
- To assess climate change adaptation and disaster risk reduction benefits and costs accrued through risk insurance initiatives: What benefits of risk insurance help it to scale up?
- To identify enabling environments to scale up risk insurance: What policy and institutional processes can help scale up risk insurance?
- To sensitise policy makers and other stakeholders on scaling up risk insurance

This research identifies solutions to issues like poor availability or access to available weather information, identifying alternative innovative risk insurance products where weather information is not available, and exchanging research outcomes through various international and regional policy forums. This research is consistent with the climate change, agriculture and food security (CCAFS) project of the Consultative Group (CG)-alliance as it investigates index-based crop insurance, which plays an important role in climate-related risk reduction in agriculture sector.

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### ARCP2013-18NMY-PRABHAKAR

#### PROJECT TITLE

**Assessing Community Risk Insurance Initiatives and Identifying Enabling Policy and Institutional Factors for Maximizing Climate Change Adaptation and Disaster Risk Reduction Benefits of Risk Insurance**

#### COUNTRIES INVOLVED

Bangladesh, India, Japan, Malaysia, Philippines, Viet Nam

#### PROJECT DURATION

Year 1 of a two-year project

#### APN FUNDING

US\$ 80,000

#### PROJECT LEADER

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ARCP2013-19NMY-GOMBOEV

# Boreal and Tropical Forest and Forest-Steppes in East Asia: A Comparative Study on Climate Impacts and Adaptation

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## Introduction

The project has identified the following two main goals:

- Estimation of the carbon budget in key areas of different forest ecosystems (boreal and tropical forests and forest-steppe) in the countries of East Asia (Republic of Buryatia in Russia, Mongolia and China), and comparative analysis of their contribution to the mitigation of global climate change.
- Development of an adaptation strategy for these forest ecosystems to climate change, based on analysis of the carbon budget and estimation of “cost-benefit” from sustainable forest management, and the development of recommendations for their implementation in a variety of regional programmes of studied countries.

The project team intends to achieve the first goal by investigating how global warming affects forests; and how forests, in turn, affect climate. The work will be performed through a comparative analysis of response of different forest ecosystems to global climate change and economic activity. The most climate-dependent vegetation types (forest plots) will be revealed.

An inventory of sources and sinks of greenhouse gases in key areas will be done to estimate balance or accumulation of greenhouse gases (CO<sub>2</sub>, CH<sub>4</sub>, N<sub>2</sub>O) in different forest ecosystems. Results will show the main reservoirs (pools) of carbon and the factors (logging, fires, forest pests, etc.) that contribute the most to climate change. Furthermore, different assessment methods for calculations will be used, depending on the availability of the necessary information for calculation (i.e., methods based on the use of forest inventory materials in areas where data is unavailable, through remote sensing techniques).

The second goal will be achieved by learning how to adopt forest management practices that increase the contribution of forests in climate change mitigation. To develop a strategy for forest adaptation under changing climatic conditions, as well as recommendations in implementing forest management plans, the team considered a set of measures, which are as follows:

- Forest conservation
- Use of effective practices for sustainable forest management aimed at increasing carbon stocks and greenhouse gas emission reductions

Investigating ecosystem services and the human population interplay is vital in determining the cost and benefits of sustainable forest management. The main



**Figure 1.** First workshop attended by scientists from Russia, Mongolia and China.

method of assessing cost and benefits of adaptation includes computing for the direct use value, indirect use value, option value, bequest value and existence value of the ecosystem. The total economic value of ecosystem services is derived taking into consideration direct loss of production and loss of income from the effects of climate change.

In this project, each object of analysis (ecosystem services, the population, the forest sector of the economy) constitutes a single algorithm which will be used in: (1) determining the current indicators and their possible changes as a result of the implementation of existing plans for socio-economic development of the region; (2) describing the observed and potential impacts of climate change on the types of threats; (3) evaluating the types of threats and the aggregate potential harm to the development; and (4) identifying possible adaptation measures.

The total value from the ecosystem services (calculated by countries) will be compared with the gross national product of the area and, on the basis of these calculations, the effectiveness of sustainable forest management and climate change adaptation measures can be gauged.

### Activities Undertaken

In accordance with the project timeline, the first workshop was held in the Baikal Institute of Nature Management of Russian Academy of Sciences (BINM), in Ulan-Ude, Russian Federation, 25-28 December 2013 (Figures 1).

The workshop was attended by scientists from the project's participating countries (Russia, Mongolia and

China). The workshop informed participants about the objectives, main activities and expected results of the project. Participants presented their reports which included:

- Problems related to climate change and its influence on the forest;
- Adaptation policies and measures to climate change;
- Experience in projects, programmes related to climate change, reforestation, nature reserve development; and
- Future strategy and objectives of the participating countries.

Finally, the workshop discussed future cooperation and planned activities within the scope of the project, focusing on main issues for the next year as follows:

- Comparative analysis of the reaction of different forest ecosystems (boreal and tropical forests, forest-steppes) to global climate change and economic activities.
- Evaluation of sensitivity and vulnerability of the studied ecosystems to climate change.
- Identifying the most dependent ecosystems on climatic variability, and vulnerable plant species and forest areas.
- Implementation of the inventory of emission sources from anthropogenic and natural factors and removal (sink) of carbon in key areas of the forest and forest-steppe ecosystems in Asia-Pacific.
- Calculations of absorption and emission of carbon in different ecosystems (short- and long-term).

- Comparative assessment of carbon budget of studied forests in selected case study sites.
- Implementation of a communications and networking plan among team members (through the use of the project website, database, email distribution list, etc.).

## Project Publications

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## Acknowledgements

The authors thank the Asia-Pacific Network for Global Change Research (APN) and the National Science Foundation (NSF) for financial support.

## HIGHLIGHTS

- » Comparative assessment of the contribution of different forest biomes (boreal, tropical, forest-steppe) of annual percentage rate (APR) in Russia (Selenga river basin area in Buryatia), Mongolia (Selenga river basin area) and China (Yellow river delta area) to mitigate global climate change and the development of measures (strategies) to reduce emissions and increase carbon sequestration by forests, based on: (1) a review and analysis of the literature; (2) the study of institutional barriers and market imperfections in the studied countries; and (3) the collection of materials and information.
- » Assessment of forest conditions, trends in biodiversity change, deforestation and forest degradation, and the forecast effects of climate change.
- » Evaluation of the carbon budget of the reference countries and identification of problem fields.
- » Research capabilities of the participating countries in using effective practice and experience on sustainable forest management aimed at reducing emissions from deforestation and forest degradation, conservation and increase (accumulation) of carbon stocks.
- » Working out mechanisms of an equitable distribution of costs and benefits (valuation of carbon and the ecosystem services) on measures to mitigate the effects of climate change will in turn develop common approaches and methods to assess carbon budgets, costs and benefits of adaptation measures, and recommendations for the effective use of the adaptive capacity of the studied areas.

## ARCP2013-19NMY-GOMBOEV

### PROJECT TITLE

**Boreal and Tropical Forest and Forest-Steppes in East Asia: A Comparative Study on Climate Impacts and Adaptation**

### COUNTRIES INVOLVED

China, Mongolia, Russian Federation

### PROJECT DURATION

Year 1 of a two-year project

### APN FUNDING

US\$ 90,000

### PROJECT LEADER

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ARCP2013-20NMY-SHRESTHA

# Climate Change and Runoff Scenarios in South Asia: An Analysis of Observed Data

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**ABSTRACT:** Climate change has significant impacts on the water resource of Himalayan region affecting more than 1.4 billion people downstream. The Hindu-Kush Himalaya (HKH) makes the largest and highest mountain chain over the earth and contains the third largest ice reserves after the Polar Regions. The project aims to understand the climate variability and its change in the region with particular focus on water resources and its consequences to people and society. Observed hydro-meteorological data and dynamically-downscaled IPCC climate scenarios will be used for runoff simulation, and development of future water scenarios will be carried out using distributed/physical-based hydrological models. Snow statistics will be calculated from MODIS daily product using MODIS Snow Tool and MODIS Re-projection Tool (MRT). In this study, three countries namely Nepal, Pakistan and Bangladesh are involved to assess the spatial nature of the problem. The project is still ongoing and, to date, climatic analyses have been undertaken. Community-based adaptation strategies will be developed based on the model outcomes, which will facilitate the countries' informed decision-making processes.

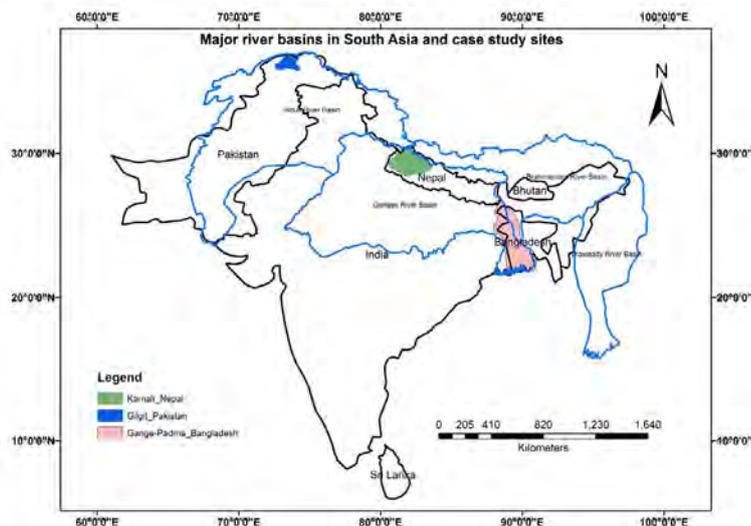
**KEYWORDS:** *South Asia, climate modelling, runoff scenario, water-based adaptation*

## Introduction

The Asia-Pacific region is a hotspot for climate change and extremes because of its significant regional monsoon climate, interaction with the global climate system and greater economic activity in recent decades (Manton et. al, 2011). Among the regions of the world, South Asia

includes the most massive geographical features like the Himalayas and the Tibetan Plateau and is considered to be very sensitive to climate variability and climate change-related extreme events. This region depends heavily on precipitation from the regional monsoon system as well as water derived from the snow and glacier melts in the Himalayas – both of these are affected by climate

**Figure 1.** Map of South Asia showing case study sites in Nepal, Pakistan and Bangladesh.



change (Muhammed, 2003). The majority of precipitation studies of Southern Asia have excluded the Himalayan belt due to the region’s extreme and complex topography and lack of adequate rain-gauge data (Shrestha, 2000). High Himalaya range is literally the “abode of snow” with glacier ice covering roughly 17% of the mountain area while seasonal snow covers every year an additional area ranging from 30-40%. The melt water from the extensive snow cover and glaciers in the Himalayas drains into the perennial Himalayan river systems; therefore, it is critical for the 1.4 billion of people inhabiting the mountain slopes and plains in the south.

The objective of the project is to develop a runoff scenario under various

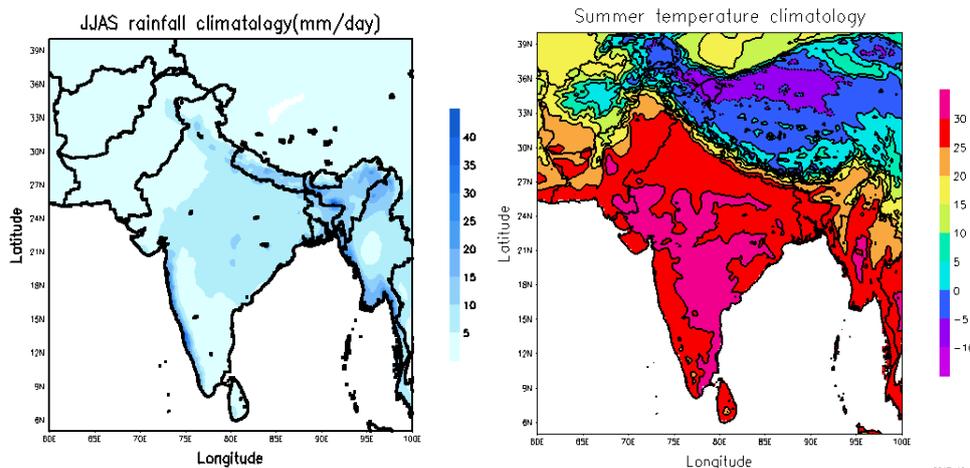
climate scenarios and develop water-based adaptation strategies for South Asia. Mapping of snow statistics and climate change are other key components of the project.

**Study Area**

Karnali river basin in Nepal, Gilgit river basin in Pakistan and Gange-Padma river basin in Bangladesh have been taken as the case study sites from the South Asia as shown in Figure 1.

**Progress of the Project**

An inception workshop was organised from 23-24 November 2013 in Kathmandu where project collaborators

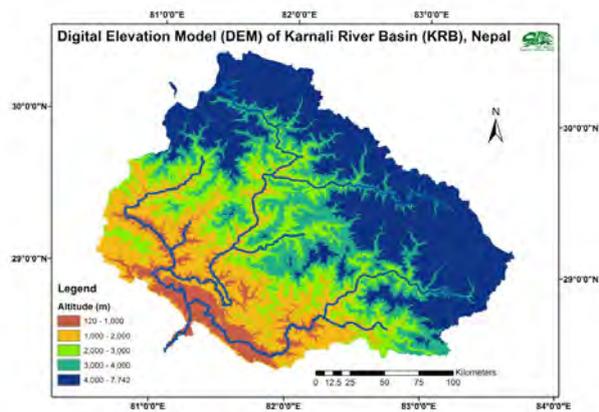


**Figure 2.** Climatology of summer monsoon rainfall (left) and average temperature for March-April (right) for South Asia.

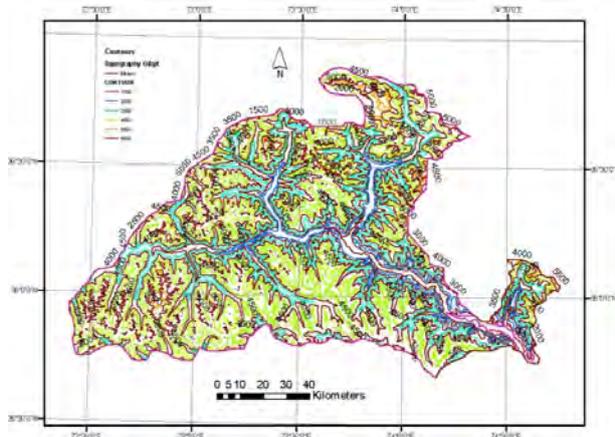
and other relevant stakeholders from Nepal and participating countries were invited. In the workshop, the research plan was shared among project team members and feedback was collected.

Two approaches for hydrologic modelling namely, Soil and Water Assessment Tools (SWAT) and Snowmelt Runoff Modelling (SRM) coupling with the University of British Columbia (UBC) hydrologic model have been suggested. In order to have more effective and sustainable project results, the national policies and programmes such as National Adaptation Programme of Action (NAPA), Climate Change Policies, and Water Resource Strategies have been reviewed and streamlined in developing the adaptation strategies.

Data needs and source assessment was also undertaken among the project collaborators. Hands-on training with GrADS, MODIS-MRT and SWAT modelling was organised during the inception workshop so that all collaborating countries were familiar with the process.



**Figure 3.** Topography and river system of Karnali river basin in west Nepal.



**Figure 4.** Topography and river system in Gilgit river basin in Pakistan.

## Preliminary Results

Observed meteorological and hydrological data were obtained from the respective national meteorological and hydrological services (NMHS) for the climate and hydrology analysis of the case study sites. In the HKH region, the network of stations is inadequate to carry out a detailed study of climate. Therefore, in addition to the available stations data, other data sets like Aphrodite data (resolution of  $0.25^{\circ} \times 0.25^{\circ}$ ) was also used to assess the past climate of the region.

The rainfall and temperature data were analysed for South Asia using Aphrodite data. The precipitation data is available for the period 1961-2004, whereas the temperature data are for the period 1961-2007.

Two typical periods were chosen for presenting examples: the rainiest monsoon (June-Sept) for precipitation and the hottest period (March-May) for temperature. The Aphrodite data set is able to depict the observed distribution of temperature and precipitation. However, more data validation needs to be performed so that the data sets can be used with confidence in data sparse regions in future research. Some of the findings and analyses in the selected river basins are presented below.

### Nepal

**Karnali basin:** Kamali is the third largest river of Nepal and the largest basin in terms of area in Nepal. It drains western Nepal with the Bheri and Seti rivers as major tributaries (Figure 3). The drainage area of Karnali River is 44,000 sq. km of which around 95% lies in Nepal and its altitude ranges from 120 m to 7,742 m. The average temperature trend of the basin shows a rising trend of  $0.04^{\circ}\text{C}/\text{year}$ . However, there is a significant spatial variation with increase of warmer trend toward the higher elevation towards the north. Precipitation in this basin does not show any significant trend.

### Pakistan

**Gilgit Basin:** This basin comprises the major rivers Ghizar, Yasin, Ishkuman and Hunza River and joins the Indus River near Jaglot. The drainage area of the Gilgit river basin at Gilgit is  $14,082 \text{ km}^2$  with Afghanistan and China to the north (Figure 4). The upper reaches of the basin are mostly glaciated and covered with permanent snow. Temperature at Gilgit station ranges from  $-13.75^{\circ}\text{C}$  to  $19.4^{\circ}\text{C}$ . Though the number of



**Figure 5.** Participants of the workshop.

stations in the area is considerably small, most of the area shows increasing trend in average annual temperature with the value of 0.035°C per year at Gilgit. The average annual precipitation at the Gilgit station is 137 mm and it shows an increasing trend of 0.26 mm per year. However, the increasing trend in precipitation is not as significant as the temperature trend. The mean annual runoff is about 8926 million m<sup>3</sup> for 29 years of records (1963 to 1972 and 1980 to 1998). The river flow in summer (June to September) is influenced significantly by snow and glacier melt.

### **Bangladesh**

**Ganges-Padma basin:** The Ganges-Padma river basin is one of the major river systems in the central part of the deltaic river system of Bangladesh with watershed drainage area of 46,300 km<sup>2</sup>. The elevation of the area ranges from zero to 48 m with the upper part of the basin having highest elevation, while the elevation gradually decreases towards the south. The lower part of the study area is almost flat with the range of zero to 5 m (Figure 4).

The amount of annual rainfall is low in the upper part of the study area

and greater along the coastal areas. The historical annual rainfall data indicates an increasing trend in the lower part of the study area (Khulna and Khepupara) while the middle region shows a decreasing trend during the period 1970 to 2008. There is no significant temporal variation of rainfall in the northern region (Rajshahi station). The average temperature in the north (Rajshahi station) ranges from 7°C to 41°C while in the south (Kheupara station) it ranges from 10°C to 36°C. Trend analysis of annual temperature in the basin shows a significant decreasing trend in minimum temperature while no significant trend was observed in maximum temperature. Annually, 343,000 mm<sup>3</sup> of water enters to the Ganges-Padma basin and the flow is mainly concentrated in the wet season (Jul-Oct). Maximum monthly flow is observed during August (97,000 mm<sup>3</sup>).

It is an initial phase report and with the continued support from the collaborators we look forward for fruitful outcomes from this project, which will be effectively used in developing community based adaptation strategies with the intention to facilitate the decision-making processes.

## Acknowledgements

The proponent and the collaborators would like to express their cordial thanks to the Asia-Pacific Network for Global Change Research (APN) for providing the opportunity to undertake this project. Similarly, we would like to express our sincere gratitude to Department of Hydrology and Meteorology (DHM)-Nepal, Pakistan Meteorological Department (PMD)-Pakistan and Bangladesh Meteorological Department (BMD)-Bangladesh for providing the climate data.

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### ARCP2013-20NMY-SHRESTHA

#### PROJECT TITLE

**Runoff Scenario and Water-Based Adaptation Strategies in South Asia**

#### COUNTRIES INVOLVED

Bangladesh, Nepal, Pakistan, USA

#### PROJECT DURATION

Year 1 of a two-year project

#### APN FUNDING

US\$ 82,000

#### PROJECT LEADER

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ARCP2013-21NMY-YAMADA

# Adaptation of Solid Waste Management to Frequent Floods in Vulnerable Mid-Scale Asian Cities

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## Introduction

Pluvial Asian countries are constantly threatened by natural disasters such as typhoons and/or floods. The Asian Development Bank (ADB) has projected that vulnerability to flooding in Asian cities will increase due to urbanisation. An Asia urban population of 410 million is at risk of coastal flooding by 2025 due to the impacts of climate change. Moreover, the number of people at risk of inland flooding will rise to roughly 350 million by 2025. In addition to flood water management and its preventive measures, the inevitable issue faced by urban cities during typhoons and/or flood events is solid waste management. The collapse of solid waste management as a result of natural disasters will directly affect the collapse of normal urban functions of cities. Therefore, a model of resilient and adaptable solid waste management system against flood especially for the cities in the pluvial countries in Southeast Asia is needed.

The primary task of first year is to select the representative vulnerable mid-scale cities in Thailand and Viet Nam to flood. The project aims to select the cities with the similar topographic and socio-economic characteristics in order to make a comparison when proposing a disaster waste management plan. Bangkok will be considered as a benchmark in this study since it has been recently damaged by the massive flood in 2011 and as the city is in urgent need of identifying possible risks and countermeasures for future disaster. By taking Bangkok as one case study, the project team will be able to identify the impact factor of local administration capacity in waste management at the time of flood.

After selecting cities, next objective is to identify issues and factors in establishing a resilient waste management system. This will be done by reviewing the existing literatures, guidelines and manuals. Furthermore, the project team will also coordinate with respective local government units in Thailand and Viet Nam to identify

## HIGHLIGHTS

- » Kick-off meeting with collaborators was held in Bangkok, Thailand on 29 January 2014.
- » Selection of case cities in Thailand and Viet Nam for the case study on disaster waste management was made during the kick-off meeting.
- » First local stakeholders interview session is set to be held in the middle of February, 2014, tentatively in Hue, Viet Nam.

common problems and issues on waste management. As part of the methods of the case study, several interviewing sessions are scheduled during the first six months of the project duration.

Information on the available technology which can be adopted as a disaster waste management technology will be collected and eventually introduced as a catalogue on the APN project website.

The project is planned to hold a kick-off meeting with most of collaborators in Bangkok, Thailand on 29 January 2014. At the meeting, an agreement on the selection of cities and also on the questionnaires to be used for the survey in each case study cities is expected to be completed. For the collaborators to have a clear idea on the major outcome of the

research project, the collaborators will discuss and decide on the most tangible and applicable disaster waste management plan in Southeast Asian cities.

The first interview meeting with the local government unit and other stakeholders is scheduled in the third week of February in Viet Nam. The project team will have a regular meeting with Bangkok Metropolitan Administration (BMA) to polish up the proposed disaster waste management plan to be implemented by the local government. In addition, disaster waste management in Southeast Asia shall be discussed during the experts' meeting on waste management and reduction of greenhouse gas emission scheduled in Summer 2014.

## ARCP2013-21NMY-YAMADA

### PROJECT TITLE

**Adaptation of Solid Waste Management to Frequent Floods in Vulnerable Mid-Scale Asian Cities**

### COUNTRIES INVOLVED

Japan, Thailand, Viet Nam

### PROJECT DURATION

Year 1 of a two-year project

### APN FUNDING

US\$ 74,000

### PROJECT LEADER

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ARCP2013-22NMY-SELLERS

# Mega-Regional Development and Environmental Change in China and India

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## Introduction

Urbanisation in Asia and elsewhere in the developing world represents one of the largest anthropogenic global shifts ever to take place, with major crosscutting implications for land use, biodiversity, greenhouse gas (GHG) emissions and human welfare. Worldwide, the largest proportion of urban growth in the coming decades will occur in China and India. This project examines the increasingly important dynamics of urbanisation beyond the largest urban agglomerations and their immediate peripheries, and the consequences for land use and the environment.

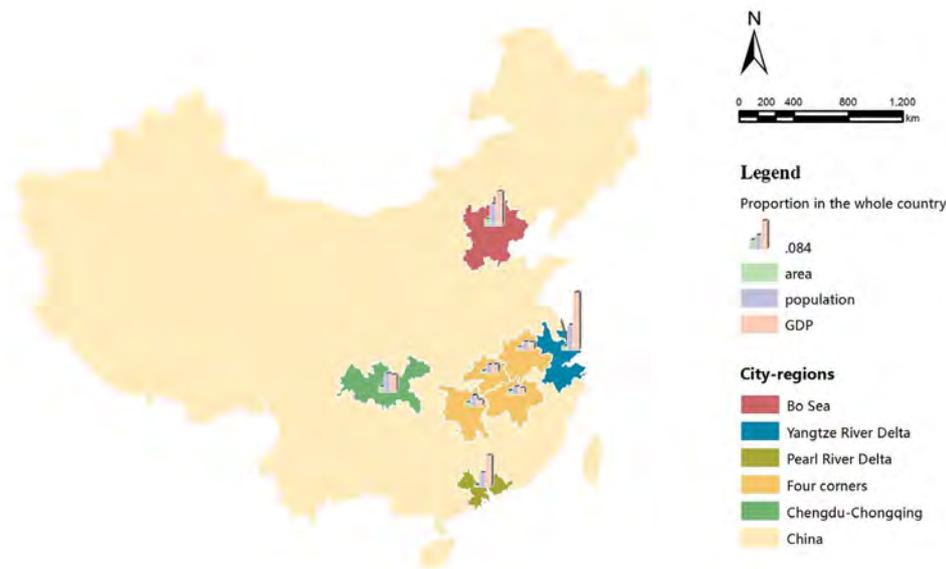
Thus far, research on urban dynamics and their consequences has focused mainly on individual cities and metropolitan areas (e.g., Angel et al., 2005; Schneider & Woodcock, 2008). Throughout the developing world, however, urban growth increasingly clusters in wider

areas beyond the bounds of individual metropolitan regions. Reflective of long-standing trends in developed countries, diffuse or distributed patterns of urbanisation more have emerged across large scale regions or transportation corridors of 100,000 km<sup>2</sup> (Florida et al., 2008; Seto et al., 2012). Policy choices in domains from economic development, planning and infrastructure to migration often shape these dynamics. As regional dynamics beyond the largest urban centres play out in areas of institutional fragmentation and limited governmental capacities, an array of new challenges for policy-making and governance has emerged. Dynamics at this wider regional scale are especially critical to the cumulative environmental consequences from urbanisation, such as land degradation, increasing GHG emissions and loss of biodiversity.

Mega-regional development is common to both India and China, but major national institutional, economic and social differences shape its dynamics. Chinese local governments possess institutional instruments and resources to shape urban growth that Indian local governments usually lack, but that can also undermine the sustainability of developmental trajectories. China has also recently introduced cooperative planning among governments at the inter-urban scale of mega-regions (Figure 1) that so far has no parallel in India. National differences in an array of legal rules and planning practices, as well as other related policies such as residency requirements, further affect the course of urbanisation. An earlier APN project undertaken by the same team, including a comparative study of urban form in ten cities of each country, showed that the dynamics of peri-urban land expansion and urban form have diverged systematically between the two countries (Ramachandra et al.,

## HIGHLIGHTS

- » First comparative analysis of large-scale regional dynamics of urbanisation in the two largest developing countries.
- » Matched transnational comparison illuminates the consequences from national institutions and policies for local and regional dynamics of urbanisation and environmental change.
- » Analysis employs remote sensing and geographic information system (GIS) analysis at micro and macro scales.
- » The project assesses the consequences of urban dynamics for land use and environmental change, and makes recommendations for policy.



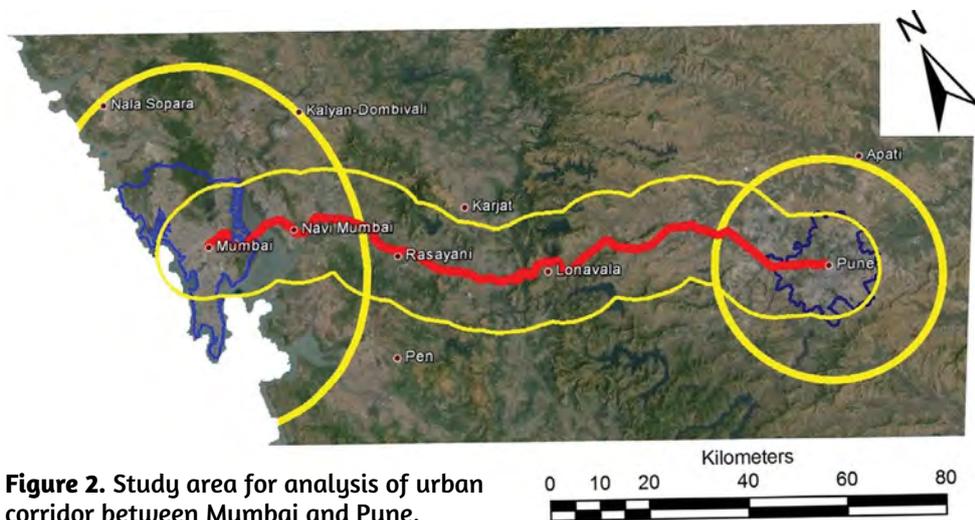
**Figure 1.** Officially defined mega-regions in China.

2012; Sellers et al., 2013a, 2013b).

This project employs remote sensing images and GIS to examine mega-regional dynamics and their consequences at both the macroscale and microscale in four emerging Chinese and Indian regions. The study will examine several interrelated topics such as: (1) large-scale regional dynamics of urban development; (2) policy, economic and institutional sources of variations in trajectories of mega-regional development; (3) the effects of these variations on regional environmental change; and (4) based on projections of future developmental trajectories and their consequences, future policies to address the dynamics and the environmental

consequences from regional trajectories of urban development. A nested research design will combine region-wide spatio-temporal analysis of urban form and land-use change with matched cases of urbanising corridors and micro-level analysis of particular localities or districts within each mega-region.

Groundwork for the project has begun prior to its commencement in early 2014 (Aithal et al., 2013; Ramachandra et al., 2013). Project activities will run until early 2016. Analyses will focus on the patterns of urbanisation from 1990 to the present in mega-regions emerging around Chennai, Bangalore and Mangalore in South India, around Mumbai and Pune in Central India, in the Pearl River

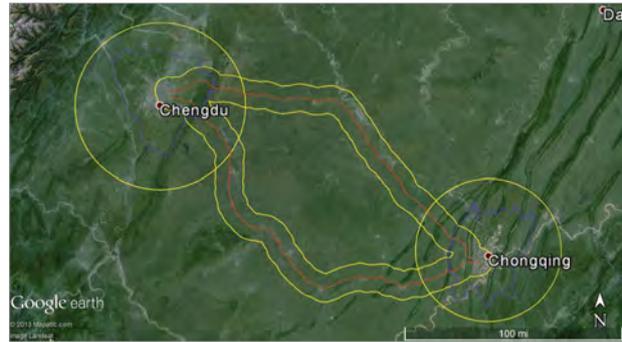


Delta of China, and around Chengdu and Chongqing in Western China. Standardised protocols for defining boundaries and analysing remote sensing and other data will incorporate identical definitions of boundaries and image processing procedures in each country. This will enable side by side comparison of mega-regional dynamics in such matched contexts as the urbanising corridors between large cities of each country (Figures 2 and 3).

At least four or five papers are scheduled to be published from the project. A volume is planned that will synthesise analyses and findings from this project and the previous one.

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**Figure 3.** Study area for analysis of urban corridor between Chengdu and Chongqing.

## ARCP2013-22NMY-SELLERS

### PROJECT TITLE

**Mega-Regional Development and Environmental Change in China and India**

### COUNTRIES INVOLVED

China, India, USA

### PROJECT DURATION

Year 1 of a two-year project

### APN FUNDING

US\$ 68,500

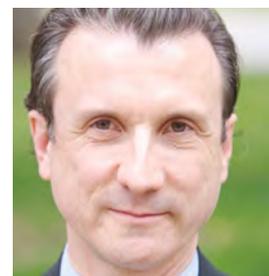
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ARCP2013-23NMY-STHIANNOPKAO

# Developing Scientific and Management Tools to Address Impacts of Changing Climate and Land Use Patterns on Water Quality in East Asia's River Basins

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## Introduction

This project aims to address the question, "What effects are climate change and land use pattern change having on the ecology and the water quality in East Asia's river basins?" Models showing interactions among climate, hydrology, land use, water quality, and ecosystems will be constructed for both the temperate climate of ROK and the tropical climate of Southeast Asia. Specifically, the expected impact of climate change related to extreme events on loadings of nutrients and microorganisms will be determined. This entails a hydrologic/water quality model combined with a climate change model. General Circulation Model (GCM) products will be downscaled to be applicable to a hydrologic model. A Soil and Water Assessment Tool (SWAT) model will simulate hydrologic processes and the resulting water quality. A conceptual

ecology model will be incorporated to assess effects on ecosystems. All prediction models will be integrated for reasons of user friendliness and implemented in the 2nd year of the project. Comparison of results obtained will be made via geographic information system (GIS) maps. Validation of predicted with actual results will be conducted using both our current water quality monitoring data and primary data collected independently by local water quality agencies. In order to share the knowledge generated through this project, a series of workshops will be held in each country with local institutes involved in river basin management. Furthermore, knowledge on the changing climate and land use pattern impacts on water quality and ecosystems at a river basin scale in East Asia will also be generated. Finally, this project will provide scientific baseline information that can be translated into practical knowledge, among these

## HIGHLIGHTS

- » Knowledge on effects of changing climate and land use patterns on water quality in three East Asia's river basins will be produced and transferred to Southeast Asian participants.
- » Models showing interactions among climate, hydrology, land use, water quality, and ecosystems will be constructed for both the temperate climate of the Republic of Korea (ROK) and the tropical climate of Southeast Asia.
- » Developed scientific tools will be tested and implemented by the policy makers who participated.

the tools for assessing and managing risks associated with changes in water quality under rapidly changing climate and land use patterns.

### Expected Outcomes

1. A model at the basin level which addresses interconnection among climate, land use, hydrology, water quality and ecosystems will be developed for and implemented by local institutions.
2. Knowledge that is relevant to and usable on prediction and management of loadings of nutrients and microorganisms with changing climate and land use patterns will be produced.
3. A database will be built for future study on the impact of climate and land use change in East Asia.
4. Outreach components of this study will allow us to educate middle and high school students with knowledge gained during this study. Furthermore, we will contact local farming associations to provide advice on effective agricultural management practices.
5. This project will be sustainable by involving both scientists and policy makers for the entirety of the study. In addition, Dong-A University, ROK, will continue supporting this project as one of the university's outreach programs. The Gwangju Institute of Science and Technology (GIST), on the other hand, will provide funds for our members in the ROK to be trained through an internship.

### Progress to Date

Since the receipt of the project funds, the following research activities have been conducted:

1. Data collection for modelling work for three study sites, namely the Lower Mekong River Basin, the Chao Phraya River Basin and the Yongsang River Basin is being conducted by project members from Lao PDR, Thailand and ROK, respectively.
2. Project website is being developed.
3. Field survey schedule in the Chao Phraya River Basin of Thailand was concluded.
4. Participation of graduate students in the project as a capacity building activity

Since January 2, 2014, the following research activities are or being implemented:

1. Modelling work for assessing water quality and water quantity of the Chao Phraya River Basin in Thailand.
2. Preparations for the workshop in July or August 2014.
3. Field survey in the Chao Phraya River Basin of Thailand was conducted on 7-8 February 2014. First sampling activities in this site is set to start around March or April 2014.

### Acknowledgements

This project is fully funded by the Asia-Pacific Network for Global Change Research (APN).

#### ARCP2013-23NMY-STHIANNOPKAO

##### PROJECT TITLE

Developing Scientific and Management Tools to Address Impacts of Changing Climate and Land Use Patterns on Water Quality in East Asia's River Basins

##### COUNTRIES INVOLVED

Indonesia, Lao PDR, Philippines, Republic of Korea, USA, Thailand

##### PROJECT DURATION

Year 1 of a two-year project

##### APN FUNDING

US\$ 80,000

##### PROJECT LEADER

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ARCP2013-24NSY-FIDELMAN

# Supporting Governance Institutions for Adaptive Capacity to Environmental Change

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**ABSTRACT:** The capacity of societies to adapt to environmental change can be constrained by conservative and reactive governance institutions. Many pressing environmental change problems such as climate change, biodiversity loss, and coastal development are also governance problems. The complex nature of environmental change requires governance institutions that facilitate adaptive capacity, enabling societies to respond and adapt to environmental change and its impacts. This article reports the rationale for understanding adaptive capacity to environmental change through an institutional lens. The project seeks to (1) investigate the potential of existing governance institutions to facilitate adaptation to environmental change in the context of coastal Cambodia, Viet Nam and Australia, and (2) support the design, reform and implementation of institutional arrangements to respond to current and future impacts of such change.

**KEYWORDS:** *governance institutions, adaptive capacity, environmental change, coastal environments, Cambodia, Viet Nam, Australia*

## Introduction

Governance institutions are defined as “...formal and informal rules, rule-making systems, and actor networks at all levels of human society (from local to global) that are set up to steer societies towards preventing, mitigating, and adapting to global and local environmental change” (Biermann et al., 2009). The capacity of societies to adapt to environmental change can be constrained by conservative and reactive governance institutions. Many

pressing environmental change problems such as climate change, biodiversity loss, and coastal development are also governance problems. In this regard, governance institutions are critical determinants of both ecological, social and economic problems and their solution (Young, 2003). Understanding how governance institutions may better support adaptation to environmental change has direct and important implications for solving these problems.

The role of institutions in determining a system’s

ability to adapt to environmental change has been investigated by Adger et al. (2011), Agrawal (2008), Eaking and Lemos (2006), Engle (2011), Engle and Lemos (2010), Gupta et al. (2010), Lebel et al. (2006), and Ostrom (2010), among others. The complex nature of environmental change calls for responsive and flexible institutions that facilitate adaptive capacity, enabling social and political actors (e.g., individuals, groups, community, resource users, government and non-government organisations) to adapt to environmental change. This includes enabling actors to design new institutions and change existing ones in response to environmental change and its impacts (Gupta et al., 2010).

While it has been recognised that governance institutions play a critical role in determining a system's ability to adapt (Agrawal, 2008; Eaking & Lemos, 2006; Engle, 2011; Engle & Lemos, 2010; Gupta et al., 2010; Lebel et al., 2006), there is still relatively limited efforts to assess the characteristics of institutions to stimulate society to adapt to environmental change (e.g., Engle, 2011; Engle & Lemos, 2010; Gupta et al., 2010).

This project seeks to: (1) investigate the potential of existing institutions, at different governance levels (from local to national) and facilitate adaptation

to environmental change in the context of coastal Cambodia, Viet Nam and Australia; and (2) support the design and implementation of institutional arrangements to respond to current and future impacts of such change. Ultimately, it aims to foster ongoing cooperation, exchange of expertise, and capacity development in Cambodia, Viet Nam and Australia, and improve the capacity of social and political actors (stakeholders) in these countries to respond and adapt to environmental change.

The project draws on research to assess the adaptive capacity fostered by governance institutions (e.g., Engle, 2011; Engle & Lemos, 2010; Gupta et al., 2010). It uses a case study approach (Yin, 2003) and multiple sources of data including documents, focus groups, interviews and surveys. The project focuses on Thua Thien-Hue Province (Viet Nam), Koh Kong, Sihanoukville, Kep and Kampong Provinces (Cambodia) and the state of Queensland (Australia). These focus areas were selected based on current and past projects undertaken by the proponent organisation (University of the Sunshine Coast – USC) and collaborative links between USC and partner organisations in the region. Furthermore, the selected areas are subjected to environment change of similar nature, including climate change, threats to biodiversity, and pressure over ecosystems and natural resources, which has prompted responses from different actors (Armitage, Marschke, & Truong Van, 2011; Fidelman, Leitch, & Nelson, 2013; Marschke & Kim, 2003; Truong Van, Armitage, & Marschke, 2010). Lastly, comparing environmental governance institutions in Southeast Asia countries with those in Australia broadens the analysis across different social and political contexts, and allows contrasting the extent to which developing and developed countries differ in terms of governance institutions.

The project started in January 2014 with an inception meeting followed by desktop review of governance institutions and the first phase of data collection.

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## HIGHLIGHTS

- » Governance institutions play key role in determining a system's ability to adapt.
- » Environmental change calls for governance institutions that facilitate adaptive capacity.
- » This project investigates how existing institutions in Cambodia, Viet Nam and Australia facilitate adaptive capacity.



**Figure 1.** Coastal fisheries in Viet Nam (photo courtesy of Prof. Bill Carter).

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## ARCP2013-24NSY-FIDELMAN

### PROJECT TITLE

**Supporting Governance Institutions for Adaptive Capacity to Environmental Change**

### COUNTRIES INVOLVED

Australia, Cambodia, Thailand, Viet Nam

### PROJECT DURATION

One-year project

### APN FUNDING

US\$ 46,000

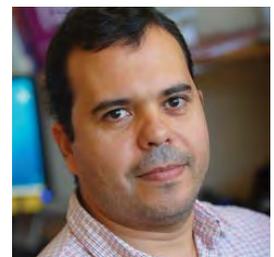
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ARCP2013-25NSY-SHAHID

# Vulnerability and Adaptation to Climate Change in Groundwater-dependent Irrigation Systems in Asian Countries

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## Overview of the Project

Groundwater-based irrigation plays a pivotal role in agro-based economy, food security and people's livelihood in many Asian countries. Despite huge significance, groundwater irrigation is heading for a crisis. Rapid expansion of groundwater-based irrigated agriculture to feed the growing population and inappropriate irrigation practices have caused lowering of groundwater table, decrease in yield, increase of pumping cost, and consequently increase of crop production cost which in turn seriously affect the livelihood of farmers in many Asian countries. Climate change may pose another major threat to already stressed groundwater-based irrigation system. A number of studies carried out in recent years show that increased temperature and changing pattern of rainfall

will significantly affect the irrigation-based economy in many Asian countries if adequate countermeasures are not adopted. The major objective of the proposed collaborative research is to foster regional cooperation to improve knowledge on impacts of climate change and unsustainable human interventions on groundwater-dependent irrigation system for formulating adaptation policies in order to achieve sustainability and improve the livelihood of the people.

## Work Completed

An investigation is carried out to map the region of groundwater overexploitation and understand the climate change impacts on groundwater-based irrigation in Northwest Bangladesh with an aim to improve

### HIGHLIGHTS

- » Groundwater-based irrigation plays a crucial role in food security and poverty alleviation in many Asian countries like Bangladesh, India, Pakistan and China.
- » Ever increasing withdrawal of groundwater for irrigation has caused lowering of groundwater table, increase of pumping cost, and consequently, increase of crop production cost which in turn has seriously affected the livelihood of farmers.
- » Rising temperature and changing pattern of precipitation due to climate change may pose a serious threat to already stressed groundwater-dependent irrigation system.
- » It is very important to understand the influences of climate change on groundwater-based irrigation system to identify the possible adaptation measures to sustain the future growth and development of groundwater-dependent irrigation.

understanding for sustainable groundwater-based irrigation management. Groundwater contributes about 90% of the total water use in Northwest Bangladesh. Favourable geological conditions, absence of surface water due to huge withdrawal of water in the upstream and high occurrence of droughts due to unreliable rainfall are the causes of high dependency on groundwater in Northwest Bangladesh (Shahid, 2008). The national water policy of Bangladesh government also encouraged groundwater development for irrigation. Ever increasing withdrawal of groundwater has caused the groundwater level falls to the extent of not getting fully replenished in the recharge season. Consequently, the groundwater-based irrigation system in the area has reached to a critical phase as the phreatic water level has dropped below the suction lift of shallow wells in many places (Shahid and Hazarika, 2010). The problem is becoming progressively more acute with the growth of population and extension of agriculture.

Long-term climate information for the time period 1961-2010, groundwater table fluctuation data at 69 monitoring wells for the time period of 1998-2002 and the lithological information of the wells are collected for the study. The water balance model by the Food and Agriculture Organization (FAO) is used to understand the status of groundwater in irrigated area.

## Results and Discussion

The obtained map of groundwater status in Northwest Bangladesh is shown in Figure 1. The result shows that groundwater abstraction exceeded the recharge in eight sub-districts out of twenty-six sub-districts situated in Northeast part of the study area.

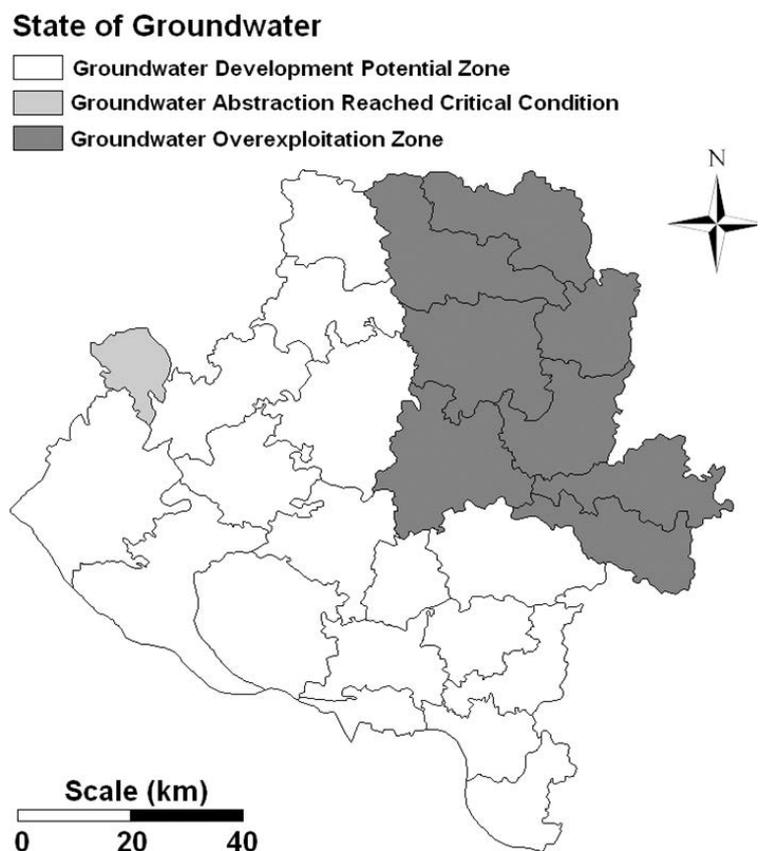
Downscaling of climate models predict an average increase of temperature 1.4°C in 2050 and 2.4°C in 2100. In case of rainfall, the models show an annual increase of rainfall with stronger increase during the summer monsoon.

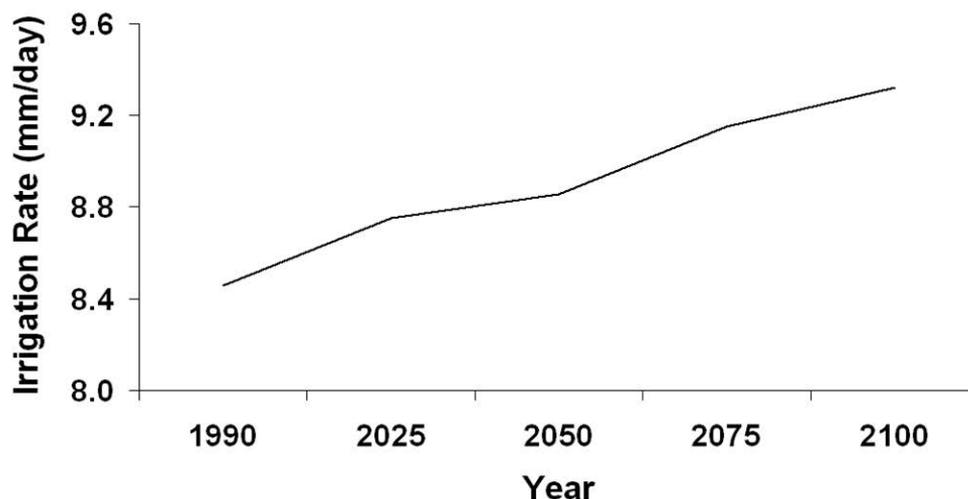
The study shows that though the soil moisture will decrease and daily evapotranspiration will increase due to higher temperature, there will be no major change in the required water for total irrigation due to the shortening of crop growing length and increase of precipitation. However, the climate change will increase the irrigation rate or daily use of water for irrigation. In base years, an average of 1,057 mm water is used for irrigation for the time period of 125 days. In 2100, an average of 1,044 mm water will be used for irrigation in 112 days. Consequently, the irrigation rate will be increased as shown in Figure 2.

Higher per day abstraction to meet the irrigation water requirements due to climate change during the peak dry season may cause further declination of groundwater level which will certainly aggravate the situation of groundwater-based irrigation system, particularly if proper adaptation measures are not undertaken.

The work completed so far is the

**Figure 1.** Groundwater over-exploitation zone in Northwest Bangladesh.





**Figure 2.** Projected change in average irrigation rate.

background survey in a benchmark area. Similar background survey is ongoing in two other benchmark areas in Pakistan and China, respectively.

### Project Publications

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### Acknowledgements

We are grateful to Universiti Teknologi Malaysia (UTM) for co-funding the project as well as for providing necessary support to conduct the project. We are also grateful to SPARRSO (Bangladesh) for providing research support.

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## ARCP2013-25NSY-SHAHID

### PROJECT TITLE

**Vulnerability and Adaptation to Climate Change in Groundwater-dependent Irrigation System in Asian Countries**

### COUNTRIES INVOLVED

Bangladesh, China, India, Indonesia, Malaysia

### PROJECT DURATION

One-year project

### APN FUNDING

US\$ 40,000

### PROJECT LEADER

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ARCP2013-26NSY-PATANKAR

# Characterising Public and Private Adaptation to Climate Risks and Implications for Long-Term Adaptive Capacity in Asian Megacities

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## Introduction

Coastal cities in the Asia-Pacific region are acutely vulnerable to the risks of heavy precipitation, sea-level rise, cyclones and coastal erosion. In recent years, cities like Mumbai, Bangkok and Manila have witnessed unprecedented floods resulting in massive losses of life and property, heavy damages to built infrastructure, economic losses and disruption of economic and social services. A sizable number of people in these megacities are also poor and more vulnerable to the impacts of weather events. Yet they do not have adequate insurance or social security cover to protect them from the losses inflicted by floods. In light of this, it is critical for the coastal cities to assess these vulnerabilities and devise suitable adaptation strategies to cope with future risks.

The frequent weather events have compelled the civic administration to undertake short- to medium-term adaptation measures. However, the effectiveness of such measures and their contribution to long-term city resilience needs to be evaluated. The city residents have also taken steps at the micro level to protect themselves from weather events, in particular, flash floods associated with heavy precipitation. However, there are recurrent impacts and recurrent costs of adaptation. There is, thus, a need to characterise adaptation undertaken by both public and private stakeholders, understand the costs, their burden on the stakeholders and effectiveness in enhancing adaptive capacity of the cities in the long-term.

## HIGHLIGHTS

- » Improving understanding of human dimension to climate change through the design and implementation of public and private adaptation interventions at the local level.
- » Identification of policy implications for long-term city resilience and adaptation strategies and providing inputs in integrating them with long-term development plans.

This project proposes to characterise public and private adaptation in Mumbai (India), Bangkok (Thailand) and Manila (Philippines) in response to heavy precipitation events and bring out policy implications for long-term adaptive capacity.

Literature on adaptation to climate risks mainly focuses on public provision of adaptation measures which primarily deal with improvements in public infrastructure goods and services to enhance the coping capacity. There is as yet limited focus on private adaptation measures and their costs and benefits, in particular adaptation as a recurring activity with recurring expenditure. There are further questions related to private adaptation such as the cross-linkages between public and private adaptation, private actors providing public adaptation goods and the mechanisms through which private stakeholders can participate in effective adaptation that would enhance coping capacity in the long term. There

is thus a need to carry out more studies devoted to this aspect of adaptation policies and practices. The proposed project aims to focus on these aspects for the three Asian cities.

The project will include jointly-developed methodology to characterise and document public and private adaptation undertaken in response to heavy precipitation events in the three cities. Characterisation shall include identifying adaptation measures undertaken by government authorities and private sector including households and commercial sector, costs involved therein, short- and long-term benefits of these measures and their effectiveness in enhancing adaptive capacity in the long term. The comparison across three cities will further bring out policy implications for long-term city resilience and adaptive capacity. The project teams will work closely with the city administration to

ensure that the findings will help in implementing effective measures for the future.

The project will lead to better characterisation and documentation of public and private adaptation measures and their costs and benefits. In addition to this, there will be identification of policy implications for long-term city resilience and adaptation strategies and providing inputs in integrating them with long-term development plans. The project findings will improve the understanding of human dimension to climate change by understanding the design and implementation of public and private adaptation interventions at the local level. Findings of the study will help in identifying and addressing gaps in assessment related to adaptation measures done in the past. It will further strengthen the interface of policy-making processes and society with the research community.

## ARCP2013-26NSY-PATANKAR

### PROJECT TITLE

**Characterizing Public and Private Adaptation to Climate and Implications for Long-Term Adaptive Capacity in Asian Megacities**

### COUNTRIES INVOLVED

India, Philippines, Thailand

### PROJECT DURATION

One-year project

### APN FUNDING

US\$ 34,000

### PROJECT LEADER

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ARCP2013-27NSY-LIU

# The Indian Ocean Zonal Dipole Mode Simulated in CMIP5 Multi-Model Ensemble

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## Introduction

This project examines the impact of global warming on this ocean-atmosphere coupled event using the CMIP5 output. In this project, the Indian Ocean air-sea feedback strength of current climate and of the future climate under the latest RCP will be examined using the CMIP5 and the observational data. The scientists from China, U. S., Malaysia, Indonesia, Maldives, Pakistan and Thailand are going to work together for the project.

## Result from CMIP5 Model Outputs

As the significant interannual variability in tropical Indian Ocean region, the Indian Ocean Dipole (IOD) is known as a basin-scale ocean-atmosphere coupled mode (Saji, Goswami, Vinayachandran, & Yamagata, 1999; Webster, Moore, Loschnigg, & Leben, 1999) with great impacts on climate variability in Africa, South Asia, East Asia, and other remote regions (e.g. Ashok, Guan, Saji, & Yamagata, 2004; Behera et al., 2005; England, Ummenhofer, & Santoso, 2006; Saji & Yamagata, 2003a,

2003b; Wang, Li, & Zhou, 2006; Yu, Xiang, Liu, & Liu, 2005). Previous studies illustrate that both positive and negative dynamical and thermodynamic feedback mechanisms (Bjerknes, 1966, 1969; Li, Wang, Chang, & Zhang, 2003; Webster, Moore, Loschnigg, & Leben, 1999; Xie & Philander, 1994), which include the Bjerknes feedback, are responsible for the evolution of IOD events. A large number of studies have been performed to assess and evaluate the performance of simulated IOD events in coupled general circulation models (CGCM) (e.g. Cai, Hendon, & Meyers, 2005; Luo, Masson, Behera, & Yamagata, 2007; Saji, Xie, & Yamagata, 2006; Song, Vecchi, & Rosati, 2007; Zhong, Hendon, & Alves, 2005).

In this study, an evaluation of the performance of 21 WCRP CMIP5 models in IOD simulation will be conducted by examining the dynamical and thermodynamic air-sea coupling processes. Based on the IOD amplitude, the 21 coupled models are classified into strong, moderate and weak IOD simulation groups.

To study the cause of the diversity in the model IOD intensity, the first activity is to examine the Bjerknes feedback. This dynamic ocean-atmosphere feedback consists of the following three key processes: 1) how strongly the

## HIGHLIGHTS

- » The overall CMIP5 performance in the IOD simulation does not show remarkable improvements compared to CMIP3.
- » Compared to CMIP3, the CMIP5 ensemble produces a more realistic positive wind-evaporation-SST feedback during the IOD developing phase.
- » The El Niño-Southern Oscillation (ENSO) and IOD amplitudes are closely related in CMIP5 models.

atmospheric low-level wind responds to one unit SSTA forcing ( $R(u, T)$ ); 2) how strongly the ocean thermocline depth responds to one unit surface wind forcing ( $R(d20, D)$ ); and 3) how strongly the ocean subsurface temperature responds to one unit thermocline depth variation ( $R(Te, D)$ ). These three dynamical feedback processes are examined and the respective coupling coefficients are estimated in all the 21 models. The overall strength of the Bjerknes dynamic feedback is determined by the product of the three coupling coefficients and the mean upwelling velocity. The comparison of the strong and weak composites shows that the former attains a much greater Bjerknes feedback intensity than the latter (Figure 1).

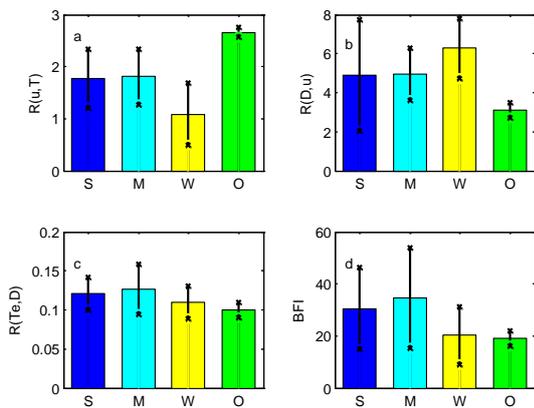
The next activity is to examine the thermodynamic air-sea coupling strength for all the 21 models. Two thermodynamic air-sea feedback processes, WES feedback ( $R(LHT, T)$ ) and the cloud-radiation-SST feedback ( $R(SWR, T)$ ), are examined. While observations show positive feedbacks among the wind, evaporation (or surface latent heat flux) and SST during the IOD developing phase, about a half of the CMIP5 models failed to capture this thermodynamic air-sea feedback (Figure 2). As a strong negative

feedback process, the cloud-radiation-SST feedback may slow down the IOD development. Most of the CMIP5 models successfully simulated this negative feedback process, even though the feedback intensity varies among the models. The averaged negative feedback coefficient is greater (smaller) in the strong (weak) composite than observation, implying a stronger (weaker) thermodynamic damping.

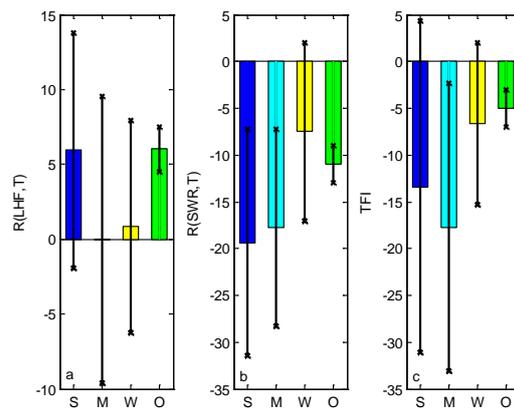
The CMIP5 ensemble produces a more realistic positive WES feedback during the IOD developing phase, while it produces a worse Bjerknes dynamic feedback than CMIP3. A preliminary analysis on the relationship between ENSO and IOD suggested that the IOD amplitude is proportional to the ENSO variance; if a model generates a strong ENSO, it is likely that this model also simulates a strong IOD (Figure 3).

### General Progress

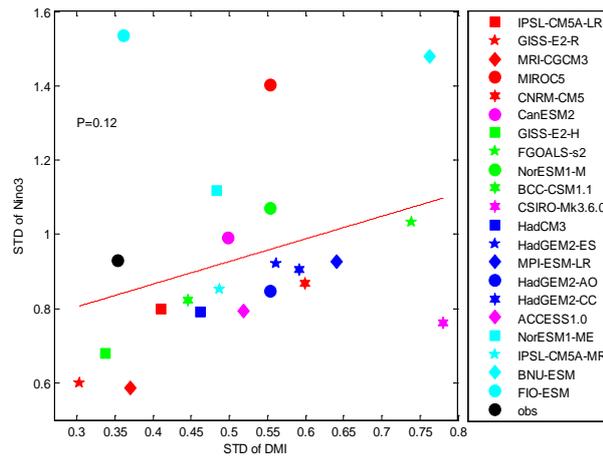
Following the proposed schedule, the project has conducted the data collection, preliminary data analysis based on CMIP5 model outputs and the project meeting with the collaborating researchers. Currently, CMIP5 outputs from RCP4.5 experiment are still being



**Figure 1.**  $R(u, T)$  (unit:  $m s^{-1} K^{-1}$ ),  $R(D, u)$  (unit:  $m$  per  $m s^{-1}$ ),  $R(Te, D)$  (unit:  $K m^{-1}$ ) and BFI (unit:  $W m^{-2} K^{-1}$ ) in JAS season for the strong (denoted by ‘S’), moderate (denoted by ‘M’), and weak (denoted by ‘W’) composites and from the observational data (denoted by ‘O’). Error bars indicate the strength spread among different groups.



**Figure 2.**  $R(LHF, T)$ ,  $R(SWR, T)$  and TFI (unit:  $W m^{-2} K^{-1}$ ) averaged during JAS season for the strong, moderate and weak composites (denoted as ‘S’, ‘M’ and ‘W’ respectively) and from the observation (denoted as ‘O’). Error bars indicate the strength spread among different groups.



**Figure 3.** Scatter diagram revealing relationships between IOD strength and ENSO strength, defined by STD of each index, for the observation and each of the CMIP5 coupled models.

downloaded and it is expected to be completed around April-May based on the current downloading speed.

### Project Publications

Liu, L., Xie, S.-P., Zheng, X.-T., Li, T., Du, Y., Huang, G., & Yu, W.-D. (2013). Indian Ocean variability in the CMIP5 multi-model ensemble: the zonal dipole mode. *Climate Dynamics*, 1–16. doi:10.1007/s00382-013-2000-9

### Acknowledgements

We acknowledge the World Climate Research Programme's Working Group on Coupled Modelling, which is responsible for CMIP, and we thank the climate modelling groups for producing and making available their model output. For CMIP, the U.S. Department of Energy's Program for Climate Model Diagnosis and Intercomparison provides coordinating support and led development of software infrastructure in partnership with the Global Organization for Earth System Science Portals. We wish to thank L. X. Xu and L. Feng for data preparation. This work was supported by Chinese National Basic Research Program grants: 2010CB950304, 2012CB955601 and ARCP2013-27NSY-Liu grants.

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## ARCP2013-27NSY-LIU

### PROJECT TITLE

**The Impact of Global Warming on Ocean-Atmosphere Feedback Strength at Tropical Indian Ocean**

### COUNTRIES INVOLVED

China, Malaysia, Pakistan, Thailand, USA

### PROJECT DURATION

One-year project

### APN FUNDING

US\$ 29,000

### PROJECT LEADER

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# CAPaBLE PROJECTS

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*Scientific capacity development projects funded under*  
**the CAPaBLE Programme**

CBA2013-01CMY-RASUL

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

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## Introduction and Background

Changing weather patterns have increased the vulnerability to hydrological extremes and hence are threatening food production. To ensure sustainable development, an integral approach covering entire components of the water cycle in light of future climate scenarios is a needed. There are 18 Asian countries collaborating in a common platform of the GEOSS Asian Water Cycle Initiative (AWCI) to address water cycle issues ranging from climate change to impact assessments targeting drought, flood and water quality. The present project expands AWCI activities to glacier and snow-fed basins with special attention on drought. The main objectives include:

- Building capacity on temporal and spatial climate projections for snow and glacier areas.
- Improving climate change assessment and downscaling techniques with a special focus on drought.
- Training professionals on the application of the Water and Energy Budget Distributed Hydrological Model with Snow and glacier component (WEB-DHM-S) and other necessary techniques.
- Assessing glacier melt and hydrological regime shift in the light of climate change scenarios.
- Assessing water cycle variability and contribution to development of a drought early warning system.

## Activities Undertaken and Results to Date

The project kicked-off at the 9th AWCI International Coordination Group Meeting in Tokyo, Japan, on 29-30 September 2012, where the objectives, methodology, and implementation steps were introduced and discussed. The participants supported by this project also attended and contributed to the consecutive Asia Pacific Water Forum (APWF) workshop on “Meta-Guidelines for Climate Change Adaptation,” which was organised by the APWF Steering Group on Water and Climate Change and which synthesised key issues and summarised key directions in designing and implementing adaptation strategies with the intention to develop a set of guidelines for policy makers and practitioners.

The main event was the Training Course on Improved Bias Correction and Downscaling Techniques for Climate Change Assessment including Drought Indices, held at the University of Tokyo, Japan, from 18-20 June

### HIGHLIGHTS

- » AWCI Training Course on Improved Bias Correction and Downscaling Techniques for Climate Change Assessment including Drought Indices.
- » Assessment of hydrological regime shift due to climate change in the AWCI countries
- » Climate Change and drought assessment in the Soan Basin.
- » Upper Indus Basin study.

2013. The course explained and taught application techniques and tools including general circulation model (GCM) output selection, model output bias correction, downscaling of corrected output to a basin scale, generation of drought indices, and drought assessment. At the same time, the results obtained during the course set up a basis for a regional analysis of climate change impacts on water resources and are expected to be published in 2014. The course provided lectures with hands-on exercises, during which the participants used the data of their respective country demonstration basins. In total, 22 representatives of 18 AWCI countries and six local participants undertook the training course, six invited experts provided thematic lectures and six trainers of University of Tokyo assisted the participants during the hands-on exercise sessions.

After the event, the participants were asked to complete a questionnaire aimed at participants' perception of the course merits for their future work and their evaluation of the course design and teachers' performance. The answers indicated that the course met expectations of most of the participants and they had learned some new and useful knowledge. However, they felt the time was rather limited to fully grasp all the details and thus further study or cooperation with the methodology authors would be necessary for future applications. The participants also submitted brief technical reports on their work and achievements during the course, which have been summarised in a participant report document. The participant summary report and the full report of the training course are available at the course website (<http://monsoon.t.u-tokyo.ac.jp/AWCI/>

[meetings/Tokyo\\_Jun2013/index.htm](http://monsoon.t.u-tokyo.ac.jp/AWCI/meetings/Tokyo_Jun2013/index.htm)).

The project also supported the first GEOSS Joint Asia-Africa Water Cycle Symposium held in Tokyo, from 25-27 November 2013 (<http://monsoon.t.u-tokyo.ac.jp/AWCI/AAWCS2013>), which was proposed and organised based on the recognition of commonalities of approach by both the AWCI and the GEOSS Africa Water Cycle Coordination Initiative (AfWCCI) towards addressing integrated water resource management in the context of climate change. The event brought together the AWCI and AfWCCI representatives, as well as representatives of governmental sectors, GEO Participating Organizations, official development assistance (ODA) agencies, space agencies and scientific communities, and thus provided an opportunity for a broadened discussion, knowledge and experience-sharing, and exchange of ideas. One of the outcomes of the Symposium is a set of Project Design Matrix (PDM) proposals developed and submitted by AWCI countries and AfWCCI river basin authorities and targeted to ODA agencies. The compilation of PDMs and the full summary report are available at the Symposium website.

In addition, the project has also progressed in the undertaking of research activities. Climate change impact assessment study on drought was carried out in the Soan Basin, Pakistan – an important agriculture area, which is, however, semi-arid and depends on rainfall and rainwater storage ponds. The analysis showed that it is likely that flooding trend will increase in the future. However, it is also likely that drought will intensify in the future. Further analysis has been initiated that includes vegetation growth modelling and assessment of drought



**Figure 1.** Participants at the workshop.

impact on agriculture production. Also, work on development of WEB-DHM-S in the glacierised basins has begun. A pilot study is ongoing in the upper Indus Basin, Pakistan, and first results will be published in the near future.

In the second year of the project, the pilot studies in Pakistan will be concluded and the methodology will be applied in other collaborating countries with glacierised and/or drought-vulnerable basins. More emphasis will also be put on downscaling of climate projections for snow and glacier regions and a training course on application of WEB-DHM and WEB-DHM-S model is planned in the latter part of the project term.

### Project Publications

In preparation is the aforementioned publication on Analysis of Climate Change Impacts on Water Resources in the Asian Basins in the Special Issue of the Science China Earth Sciences Journal focused on Watershed Science, 2014.

### Acknowledgements

The project leader and all collaborators wish to acknowledge the financial and in-kind support of the APN, without which the initiation and implementation of the project would not have been possible. The acknowledgement is extended to all the supporting organisations, in particular the Pakistan Meteorological Department, the University of Tokyo, the Hiroshima University, and the Japan Aerospace Exploration Agency.

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#### CBA2013-01CMY-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

Year 2 of a two-year project

##### APN FUNDING

US\$ 76,000

##### PROJECT LEADER

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**CBA2013-03NMY-D'ARRIGO**

# Atmospheric Circulation Reconstructions over the Earth (ACRE) Southeast Asia (SEA) — Towards New Weather and Climate Baselines for Assessing Weather and Climate Extremes, Impacts and Risks

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## Introduction

The present project will develop capacities to recover, image, digitise, quality control, store, and make freely available both historical instrumental and documentary weather observations, where said data are currently sparse or difficult to recover. Led by an international team of historians, scientists and policy makers, Atmospheric Circulation Reconstructions over the Earth (ACRE) SEA will work with regional National Meteorological Services (NMS), archives and academic institutions to raise awareness of the value of long-term observational data, uncover historical observations, and build a state-of-the art database of this material.

By recovering, cataloguing, imaging and digitising historical weather observations, data in danger of being lost can be built into accessible baselines of data series and weather reconstructions/reanalyses, allowing for vast improvements in current and future projections of weather and climate extremes and risks over time spans not previously possible (Allan et al., 2011).

Dynamical downscaling by the Providing Regional Climates for Impacts Studies (PRECIS) team will use the reanalyses output to provide finer resolution (25-12 km). These improved databases and historical 3D weather reanalyses will build inter-, cross-, and multidisciplinary capacity in SEA, by merging historical documentary and palaeoclimatic evidence with weather observations to produce a more coherent picture of long-term variability.

## The Project

The project has three main foci in the first year, which include: (1) developing an inventory of available data across the region culminating in a project launch; (2) a two-day workshop in Kuala Lumpur; and (3) a Royal Netherlands Meteorological Institute-Badan Meteorologi Klimatologi dan Geofisika (KNMI-BMKG) Digitisasi Data Historis (DiDaH) workshop in Indonesia, in June 2014.

The target workshop participants will discuss the availability and collaborative use of long-term regional weather/climate databases for detailed

## HIGHLIGHTS

- » The official launch of the Atmospheric Circulation Reconstructions over the Earth Southeast Asia (ACRE-SEA) regional focus.
- » A two-day workshop on 27-28 May 2014 at the National University of Malaysia bringing together people working in the fields of climate science, history, historical climatology, and archives.

assessments of observed climate variability and change; future plans to image and digitise published data; create targets for new data recovery and available proxy climate/weather data for intercomparisons; and explore links with regional applications and policy makers.

The second year will run a series of research meetings, archival and data recovery visits to Thailand, Viet Nam, Singapore and Republic of Korea to follow up on the workshop's outcomes, catalogue and recover data, and ensure that new historical weather data feeds seamlessly into ACRE-facilitated reanalyses.

ACRE SEA's partners from the DiDaH project have started a series of visits to regional NMSs to discuss their data and their use of the Southeast Asian Climate Assessment & Dataset (SACA&D) data portal.

Several visits have been made to the Malaysian Meteorological Department

(MMD) to view their pre-1950s daily and sub-daily observations taken at hill station observatories and aerodromes across Malaysia and Singapore. The team are discussing with the MMD the viability of cataloguing and imaging these volumes, and have begun compiling a database of archival records which contain usable data or observational material for the region.

## Publications

D'Arrigo, R., & Ummenhofer, C.C. (2013).

The climate of Myanmar: evidence for effects of the Pacific Decadal Oscillation. *International Journal Climatology*. Manuscript submitted for publication.

Williamson, F. (in press). History and climate science: A collaborative relationship for the twenty-first century, *Procedia - Social and Behavioural Sciences*.

## CBA2013-03NMY-D'ARRIGO

### PROJECT TITLE

ACRE SE Asia — Towards New Weather and Climate Baselines for Assessing Weather and Climate Extremes, Impacts and Risks over Southeast Asia

### COUNTRIES INVOLVED

China, Indonesia, Japan, Malaysia, New Zealand, Philippines, Singapore, USA, Viet Nam

### PROJECT DURATION

Year 1 of a two-year project

### APN FUNDING

US\$ 36,000

### PROJECT LEADER

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CBA2013-04NSY-WCRP

# International Conference on Regional Climate — CORDEX 2013: Towards Improved Knowledge Serving Society

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The **International Conference on Regional Climate — CORDEX 2013**, held in Brussels, Belgium from 4-7 November, was jointly organised by the World Climate Research Programme (WCRP), the European Commission (EC) and the Intergovernmental Panel on Climate Change (IPCC), and was attended by over 500 participants from 97 countries. About 90 participants were supported financially to attend the conference. Participation via web streaming and Twitter Questions and Answers provided an opportunity for the community at large to attend the conference remotely and to interact with the audience.

The main objective of the conference was to bring together the international community of regional climate scientists and stakeholders with a particular emphasis on the production, assessment and use of regional climate information and the CORDEX initiative. This landmark event provided a forum for addressing the following key challenges:

- Assessment and improvement of regional dynamical and statistical downscaling techniques;
- Development of regional climate change projections with associated uncertainties;
- Provision of reliable and actionable regional climate information;

- Use of regional climate information in vulnerability, impacts, adaptation studies; and
- Dissemination of regional climate knowledge to policy makers and a wide range of stakeholders and decision makers.

The first day of the conference featured two important events: (1) High Level Session with the participation of the European Commissioners for Research and Innovation and for Climate Action, where the Intergovernmental Panel on Climate Change (IPCC) presented key findings from the IPCC Working Group I Contribution to the Fifth Assessment Report *Climate Change 2013: The Physical Science Basis*; and (2) Stakeholder Dialogue session focusing on how science-based regional climate information can best serve the needs of regional policy and decision makers, which was intended to provide the global to regional socio-economic and policy context within which WCRP regional climate research activities and programmes operate.

The second segment of the conference, during the following three days, was organised around the key scientific outcomes from Phase I of the Coordinated Regional Climate Downscaling Experiment (CORDEX) project, encompassing results from all participating regions worldwide. This segment was designed to deliver on the

## HIGHLIGHTS

- » Jointly organised between the WCRP, the EC and the IPCC.
- » Attendance of more than 500 participants from 97 countries.
- » CORDEX component featured key findings from IPCC WG I fifth assessment report and scientific results from CORDEX – Phase I.
- » Conference conclusions will form the basis for CORDEX – Phase II experimental design
- » Good opportunity for early career scientists from the Asian-Pacific to meet with their peers and the wider CORDEX network.

current status and needs of regional climate science and modelling; to strengthen collaboration and synergies between the various CORDEX regional activities; and, in collaboration with other regional climate research initiatives, to outline the future priorities for regional climate science, with due consideration of the UN Global Framework for Climate Services (GFCS), Future Earth (FE) and science-based assessments such as those of the IPCC. The segment also featured a dedicated Early Career Scientist event to strengthen the CORDEX networking and collaborations in regional climate science.

The relevance of CORDEX on the climate change agenda and the expected contribution to impacts, vulnerability and adaptation applications in areas such as water availability, agriculture and food security, health, and disaster risk reduction was illustrated by the breadth and depth of oral and poster presentations delivered by the participants. In particular, the following four main conclusions were drawn:

### **1. Dialogue and Co-Exploration with End-Users**

Participants recognised the need for a paradigm shift in which regional climate science operates by placing end-users expectations and needs at the heart of the development of regional climate information through a change in perspective on the analysis and exploitation of climate model outputs, leading to new science-policy approaches. For example, co-development and co-exploration amongst climate scientists and practitioners and stakeholders would ensure the appropriate tailoring of climate information at relevant spatial and temporal footprints with more effective two-way communication leveraging regional and local know-how. The need for capacity building and innovative information and knowledge transfer would provide the necessary instruments for effective delivery of climate services contributing to the World Meteorological Organization (WMO)-led GFCS and the Future Earth initiative.

### **2. Added Value of Regional Climate Information**

Presentations and discussions have highlighted the need to assess the potential of regional climate information to add value to the decision-making process, as compared to global climate simulations. In numerous cases, mean biases of Global Climate Models (GCMs) and Regional Climate Models

(RCMs) are still of similar magnitude. Added value is best illustrated in higher order statistical analysis at the regional and local topographic and process level but much remains to be done to improve the physics of regional models, to demonstrate the robustness of results and to ensure the systematic skill enhancement of downscaling exercises. High-resolution observational data sets and archiving infrastructures such as the Earth System Grid Federation (ESGF) will be instrumental in supporting necessary model development and evaluation, and in gaining confidence in regional climate projections.

### **3. Uncertainty**

Uncertainty cascading, whereby imperfect regional climate knowledge is transferred into the application arena for vulnerability, impacts and adaptation (VIA) studies was recognised as a key challenge faced by the CORDEX joint science decision-making undertaking. Regional climate downscaling relies on approximate information and a number of necessary assumptions (lateral boundary conditions, future forcing, model physics, etc.) impacting results, and their relative contributions to uncertainty ought to be understood. The use of multiple RCMs or multiple downscaling methods appears to increase uncertainty, especially at smaller scales and there is a need to develop robust methods to characterise and communicate uncertainty to the various end-users and stakeholders. Better uncertainty characterisation would also help set priorities for improving downscaling. Multi-model ensembles of dynamical and statistical downscaled products require further innovative post-processing approaches to distil, fuse and possibly reconcile imperfect, and sometimes contradictory, information.

### **4. Future Simulation Framework (CORDEX-II)**

The uptake of CORDEX data for regional climate analysis and VIA applications has been encouraging and widespread, including in the developing countries. A critical mass of multi-model multi-method experiments is needed to capture the uncertainty for robust decision-making and policy challenges. The growing range of practical applications will also require more complex models towards a better representation of the Earth System through Regional Earth System Models (RESMs). In addition, as the resolution of global models increases, it is recognised that regional

downscaling tools should also aim at increasingly finer scales to provide added value and useful information for VIA applications. This may require revisiting the CORDEX domains and developing a clear science-based procedure for their selection. Furthermore, end-to-end pilot studies over selected sub-regions are needed to provide test-beds to explore a range of critical issues, such as:

- Development of targeted as well as transferable analysis metrics to quantify where and when high resolution downscaling gives added value;
- Process-based analysis of models, in part through targeted regional experiments;
- Assessment of regional feedbacks (e.g. soil-atmosphere interactions);
- Intercomparison of different methods (e.g. dynamical vs. statistical downscaling);
- Detailed uncertainty analysis;
- Co-exploration of regional and local scale information for VIA application; and
- Development and exploitation of high resolution observation datasets to support all of the above.

Such pilot studies can also provide frameworks of interactions with other WCRP programs, most noticeably Global Energy and Water Cycle Experiment (GEWEX) and Climate Variability and Predictability (CLIVAR).

### Summary and Conclusion

The CORDEX-I experiment has been undoubtedly a successful framework to federate regional downscaling initiatives around a common experimental design through regional ownership and application. The aforementioned points illustrate the

need to now adapt this framework to enhance the dialogue with end users so as to meet the growing demand for tailored regional climate information and in particular towards updated regional climate assessments and truly operational regional climate services. These challenges will require underlying model developments, infrastructures and tools supporting the provision, assessment, processing, distillation, dissemination and informed use of regional climate information, and necessary training and capacity building efforts, especially in the developing world.

Further information about CORDEX 2013 can be viewed by visiting <http://cordex2013.wcrp-climate.org>.

### Acknowledgements

The conference was jointly organised by the WCRP, the EC and the IPCC who express their sincere gratitude to the co-sponsors of the conference namely APN, EUMESAT, ESA, SMHI and EGU. The organisers would also like to acknowledge Springer and IPS for their contribution which supported the participation of 90 students, early career scientists and people from developing countries. Nineteen of those were supported through the Scientific Capacity Building/Enhancement for Sustainable Development in Developing Countries (CAPaBLE) programme of the APN. This remarkable event offered a great opportunity for scientists from the Asia-Pacific region to meet with their peers and to network with the wider CORDEX community.

#### CBA2013-04NSY-WCRP

##### PROJECT TITLE

**International Conference on Regional Climate CORDEX 2013**

##### COUNTRIES INVOLVED

All APN Member Countries

##### PROJECT DURATION

One-year project

##### APN FUNDING

US\$ 50,000

##### PROJECT LEADER

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CBA2013-05NSY-SUTRISNO

# The Implementation of Multi-sensor Remote Sensing Technology for Sustainable Disaster Management

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## Project Summary

Spawned by the need to rapidly collect vital information for disaster management, technology innovations have often developed to track and monitor progress in critical response and recovery operations, such as remote sensing. New remote sensing technology was introduced to Asia-Pacific early career scientists in a workshop entitled “The Implementation of Multi Sensors Remote Sensing Technology for Sustainable Disaster Management” held in Discovery Kartika Plaza Hotel Bali, 20-21 October 2013 in conjunction with the 34th Asian Conference on Remote Sensing. The workshop lectures consisted of new synthetic aperture rada (SAR) sensor for disaster and global change issues and unmanned aerial vehicles (UAVs) as part of sensing for hazard monitoring and impact management.

## Introduction

The Asia-Pacific region is vulnerable to many catastrophes, caused by nature or human-induced factors. Typhoon Haiyan that hit the Philippines recently, earthquakes and tsunamis in Japan and Indonesia, and flooding in China are some examples. Spawned by the need to rapidly collect vital information for disaster management, technology innovations such as remote sensing have often helped emergency responders to

assess the impact of large disasters more efficiently and rapidly, and to track and monitor progress in critical response and recovery operations. In the past decades, this technology has been used extensively to monitor and explain the extent of impacts caused by earthquakes, tsunamis, hurricanes, floods and wildfires. Through high-resolution optical imagery that may be taken by satellites, surveying aircraft and/or UAVs and active sensors (e.g., SAR), remote sensing technologies have demonstrated significant effectiveness in quantifying post-disaster damage, monitoring recovery and reconstruction progress after significant disasters. Related to these issues, the Scientific Capacity Building/Enhancement for Sustainable Development in Developing Countries (CAPaBLE) programme of the Asia-Pacific Network for Global Change Research (APN) supported a workshop on “The Implementation of Multi-sensor Remote Sensing Technology for Sustainable Disaster Management,” which took place in the Discovery Kartika Plaza Hotel, Bali, Indonesia, 20-21 October 2013, as a side event of the 34th Asian Conference on Remote Sensing. The objectives of the workshop were to:

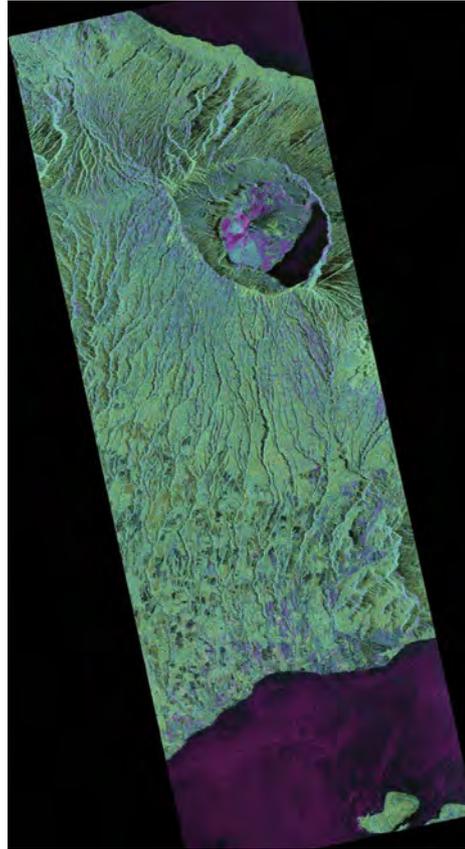
1. Enhance the scientific and technical capabilities of early career scientists in the Asia-Pacific on remote sensing technology for disaster management;
2. Raise awareness to protect and restore the health and integrity of the earth’s ecosystems within the

- region;
3. Alert youth to global change issues that cause catastrophes within the Asia-Pacific region; and
  4. Provide recommendations to relevant decision makers on internationally-based “state-of-the-art knowledge” on remote sensing.

## Work Undertaken and Results

Twenty-five young and early career scientists from developing countries, along with other ACRS participants learned new technology and developments on remote sensing from leading scientists in the field. The APN-funded participants were from Bangladesh, China, Hong Kong, India, Malaysia, Viet Nam, Thailand, Philippines, Lao PDR, Singapore and Indonesia. During the workshop, the participants:

1. Learned the upcoming Japanese earth observation satellite called Advanced Land Observing Satellite-2 (ALOS-2) that will carry an L-band Synthetic Aperture Radar (SAR) named “PALSAR-2.” This satellite and the imageries taken from the sensor are very powerful tools for monitoring disasters. The new imagery will acquire a lot of information about global and climate change not only during disasters but also with respect to environmental issues. The lecturer introduced examples of disasters from earthquakes, volcanoes, floods, and landslides analysed via the new sensor.
2. Learned the new data acquisition tool for obtaining high resolution imagery and its implementation for disaster management. The lecturer introduced UAVs as part of sensing for hazards monitoring, disaster monitoring and response planning with the use of 3D models and how the new



**Figure 1.** Profile of Mount Batur, PALSAR-2 after many significant eruptions, Restec 2013.

information can be obtained using UAV technology.

3. Visited Mount Batur and Mount Batur Museum to learn about volcano eruption and its impacts. Figure 1 indicates the recent condition of Mount Batur from ALOS-2 image and the pattern of the eruption as part of quantifying post-disaster and monitoring recovery.

The APN-funded participants acquired knowledge regarding new satellite development, were imparted with knowledge on how to choose an image for certain disaster responses, and acquired knowledge on how new high resolution imagery from UAV is important for disaster monitoring including the backstage process in processing images, georeferencing, digital terrain model (DTM) generation, etc. They said the workshops gave them a different perspective on how to manage and improve their research capabilities using new high resolution imagery technology.



**Figure 2.**  
Participants of the workshop.

### Acknowledgements

The authors acknowledge contributions from APN as the main sponsor and all committee members of the 2013 ACRS Conference. The authors also thank all international experts and speakers who participated in the workshop and all APN-funded participants who shared their experiences of implementing remote sensing technologies in their own countries and their plans to explore the new remote sensing technology.

**CBA2013-05NSY-SUTRISNO**

**PROJECT TITLE**

**The Implementation of Multi Sensors Remote Sensing Technology for Sustainable Disaster Management**

**COUNTRIES INVOLVED**

Indonesia, Japan, Singapore

**PROJECT DURATION**

One-year project

**APN FUNDING**

US\$ 38,000

**PROJECT LEADER**

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CBA2013-06NSY-SHRESTHA

# Enhancing Groundwater Management Capacity in Asian Cities through the Development and Application of Groundwater Sustainability Index in the Context of Global Change

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## Introduction

Increase resilience to climate change impacts in the water sector is important for sustainable development in the Asia-Pacific region. Options to adapt to intensifying water scarcity, especially in the prolonged dry season recently observed, include the need for groundwater in recent years. However, groundwater resources are not always well managed by users and policy makers, which can cause overdraft or contamination of groundwater resources. Maintaining the sustainability of groundwater resources through better management contributes not only to sound access to water but also to increased resilience to potential climate change impacts in the water sector. The main objective of the project is to enhance the understanding of policy makers and relevant stakeholders (e.g., water users) in selected Asian cities on groundwater sustainability and develop their capacity to assess the status of their groundwater resources and manage them through customisation and application of a “groundwater sustainability infrastructure index.”

The project aims to achieve its objective through an e-conference and regional workshops, and communications among policy makers, scientists and local stakeholders (water users). It

is expected that at the end of the project, members from each collaborating country can assess the sustainability of groundwater use not only in the selected city but also in other cities of their respective countries leading to better groundwater development and management.

The project is targeted to be implemented in nine cities: Bangkok, Bandung, Bharatpur, Ho Chi Min City, Hyderabad, Lahore, Tokyo, Vientiane and Yangon.

## Objectives

The following are the objectives of the project:

1. To apply and customise a groundwater sustainability index, which can assess the extent of use and development of groundwater resources in

## HIGHLIGHTS

- » Conceptual frameworks of “Groundwater Sustainability Infrastructure Index” and “Driver-Pressure-State-Impact-Response” have been prepared and nine case study cities selected for application. Bangkok, Bandung, Bharatpur, Ho Chi Minh City, Hyderabad, Lahore, Tokyo, Vientiane and Yangon.
- » An e-Conference, which identified a suitable set of indicators for the frameworks was held.
- » The project website was set up for communication among project members and participants as well as wider dissemination of project activities and findings.

selected cities.

2. To develop the understanding and capacity among groundwater managers and stakeholders to assess groundwater sustainability by involving them in index customisation for application in their respective cities.

## Work Undertaken

During the first few months of project implementation, the following activities have been accomplished:

### E-Conferences

An e-conferencing mechanism has been set up to ensure continuous networking and consultation with the project members and collaborators. This provides an online platform for continuous sharing of information on project objectives, methodologies, schedules and drafts of the “groundwater sustainability index.” At this stage, guidelines on data requirements and the application framework have been shared among all

project members and collaborators in order that they can provide lists of data and data sources in advance of the regional workshop.

The primary objectives of e-conferences are to:

- identify quantifiable indicators for respective city and developing rating criteria for indicators based on quantitative values.
- collect comprehensive background information about the status of groundwater environment in selected cities.
- determine whether indicators for groundwater sustainability infrastructure index (GSII) provided in the guidelines were enough for the mentioned nine respective cities
- determine whether indicators for Driver-Pressure-State-Impact-Response (DPSIR) provided in the guidelines are sufficient for the nine cities
- prepare a general framework and city-specific groundwater sustainability index which will be reviewed and assessed during the first regional workshop in Bangkok.

Project Activities	Remarks
Initial communications, electronic consultation and communication, initiating process to hire research assistants	Part-time research assistants have been appointed for each city.
Website page development	<a href="http://apngw.ait.ac.th/">http://apngw.ait.ac.th/</a>
Electronic discussions on framework of GSI and DSII for workshop and case study	Literature review, developing project methodology, framework, etc.
Collecting data and conducting case studies	Data collection is underway.
Regional Workshop I to discuss conceptual framework and finalise methodologies for case studies based on the framework	January 16-17, 2014
Perform analyses based on GSI to assess groundwater use & development	Underway
Regional Workshop II to synthesise case study results and disseminate outputs/reports of application of groundwater sustainability index	May 29-30, 2014 (tentative)
Synthesis report of all cities	To be completed as planned in the contract
Two international peer-review journal on groundwater use sustainability	To be published as anticipated according to the contract.

### **Project Website**

The project website, [www.apngw.ait.ac.th](http://www.apngw.ait.ac.th), has been developed and is being managed and updated by AIT. The core idea behind setting up the website is to provide an online forum among stakeholders that can serve as a venue for discussion. The website will be used for sharing and uploading materials on the methodology of developing groundwater sustainability index, database of groundwater development and management of each city, and application framework of groundwater sustainability. The website will contain all project-related materials and another useful information and links related to groundwater management.

### **Initiation of Case Studies**

A common framework of the “groundwater sustainability index” has been adopted by all nine cities for the preparation of a case study. Data collection is still ongoing and the sources being explored include government agencies, organisations from the water and energy sectors, and scientific publications.

### **Progress Summary**

A summary of progress is presented in Table 1 for the first phase showing completed and remaining activities with remarks.

### **Upcoming Publications**

During the period of the project, at least three types of publication are planned:

- Background paper on groundwater resource conditions in selected Asian cities
- Workshop Proceedings (Combined proceedings of workshop I and workshop II)
- Two international peer-reviewed journal publications on groundwater use sustainability in Asian cities

### **Acknowledgements**

We would like to express our gratitude to the Asia-Pacific Network for Global Change Research (APN) for supporting and funding the project. We would also like to thank the Institute for Global Environmental Strategies (IGES) and the International Research Centre for River Basin Environment (ICRE) for providing technical assistance. Our sincere thanks to all project members and collaborators who, despite their busy schedules, agreed to spend time and share information for this project.

## **CBA2013-06NSY-SHRESTHA**

### **PROJECT TITLE**

**Enhancing the groundwater management capacity in Asian cities through the development and application of groundwater sustainability index in the context of global change**

### **COUNTRIES INVOLVED**

Indonesia, Japan, Thailand, Viet Nam

### **PROJECT DURATION**

One-year project

### **APN FUNDING**

US\$ 42,000

### **PROJECT LEADER**

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CBA2013-07NSY-DAHAL

# Policy Brief Writeshop for Early Career Researchers: An Approach to Promote Greater Science-Policy Interfacing in South Asia

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## Introduction

South Asia is one of the least experienced regions for research and development in the world. While younger generations are penchant towards research, research undertaken tends to have negligible policy impact. Researchers are unable to express their findings in styles suitable for policy makers. The present project intends to narrow the gap between science and policy by building capacity of early career South Asian researchers from different disciplines. It will accomplish this objective by utilising the knowledge and experience of experts who will serve as mentors to participants. This project also aims to publish peer-reviewed policy briefs on the policy-science interface in global change research in South Asia through the network formed via the project. The policy briefs will be tailored to the policy-making sector and be less technical and scientific in nature. It would also facilitate the review of relevance and feasibility of countries' policies and synthesising them accordingly. Therefore,

intensive training by policy research experts and policy practitioners, and writing fellowship to publish policy briefs on policy science interface will be career milestones for young researchers.

## Project Activities

A steering committee has been formed to provide necessary guidance and recommendations for writeshop participants, and design the curriculum for the entire writeshop. The committee consists of experts in policy research from the Asia-Pacific region. An open announcement was circulated in December 2013 for application to the policy brief "writeshop," which will be held in Kathmandu, Nepal on the last week of February 2014. After the completion of the writeshop, selected participants will be invited to finalise their manuscripts, which will be published and distributed among the policy community.

## HIGHLIGHTS

- » Project is mainly focused on capacity building of early career researchers in writing policy briefs from their research.
- » Young researchers from South Asia will be trained in writing policy briefs for policy makers of their country in an understandable language and format.
- » Selected policy briefs from young researchers will be published which will help policy makers in South Asia to incorporate original scientific research into policy decisions.



**Figure 1.** View of Kathmandu, Nepal's capital region.

## Expected outcomes

The following outcomes are expected from the project:

1. Early career researchers from South Asia will be equipped with knowledge on writing policy briefs from their research findings;
2. Peer-reviewed policy briefs in South Asia will be published through the network that will be formed through the project.
3. A strong network will be formed among youth and experts in the field of global change research. The experts will serve as mentors before and after the workshop via different modes of communication.

### CBA2013-07NSY-DAHAL

#### PROJECT TITLE

**Policy Brief Writeshop for Researchers: An Approach to Promote Greater Science-Policy Interfacing in South Asia**

#### COUNTRIES INVOLVED

Australia, Nepal, Thailand, USA

#### PROJECT DURATION

One-year project

#### APN FUNDING

US\$ 36,000

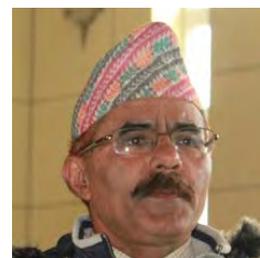
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CBA2013-08NSY-SOLAS

# The Sixth Surface Ocean-Lower Atmosphere Study (SOLAS) Summer School

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The Surface Ocean-Lower Atmosphere Study (SOLAS) International Summer School is a biennial, two-week program designed to immerse early career scientists in SOLAS sciences and provide them with the skills necessary for their future scientific careers. SOLAS is an international initiative aiming to understand the biogeochemical-physical interactions/feedbacks between the ocean and atmosphere. SOLAS serves as an excellent training that adequately prepares future scientists to contribute to the understanding of global change and its significant environmental and societal challenges.

Following the previous, highly successful summer schools held in France, the program moved east, "Far East" in 2013, and was held in Xiamen, Fujian Province, P.R. China from 23<sup>rd</sup> August to 2<sup>nd</sup> September. It was co-chaired by Dr. Véronique Garçon of CNES/LEGOS and Dr. Minhan Dai of Xiamen University. Sixty-nine students from 24 different countries (27 of whom came from APN member countries) attended the summer school along with 15 world-leading scientists.

As with previous schools, the 6<sup>th</sup> SOLAS Summer School can be divided into three sections. The first week consisted primarily of plenary lectures covering a diverse range of topics. These included an introduction to SOLAS, carbon and iron cycles in the ocean, greenhouse/trace gases and their relationship to climate change, atmospheric chemistry and modelling, air-water gas exchange, ocean physics and coastal processes, remote sensing and time series observations, marine ecology, aerosols, marine genomics, macronutrients, solar radiation, and biogeochemical modelling over long time scales. In addition to these, special sessions were also arranged that covered ethics in science, scientists and the press, and the changing Earth.

Poster sessions were also held during the first three days of the program and four winners were selected by

## HIGHLIGHTS

- » SOLAS Summer School is an international capacity building program for early career scientists.
- » Sixty-nine students from 24 countries attended the 6<sup>th</sup> SOLAS Summer School held in Xiamen, Fujian Province, P. R. China.
- » Instructors/lecturers for the Summer School are world renowned in their respective fields
- » The Summer School provides a combination of theoretical and hands-on learning experiences.

the faculty (Shlomit Sharoni, Israel; Hilary Palevsky, USA; Young-shin Kwon, South Korea; Meri Eichner, Germany). Having the poster sessions occur at the start of the school allows the students to learn about each other's research and fosters networking during the remainder of the program.

The second section coincided with the start of the second week when the school became more interactive. Students were divided into small groups (averaging 8-10 members per group) and took part in hands-on practicals that introduced them to techniques regularly employed in the field. Laboratory work focused on atmospheric and carbon cycle modelling, marine molecular ecology, and gas exchange. Students were also given the opportunity to collect, process, and analyse samples taken along the Jiulong River Estuary aboard Xiamen University's research vessel, Ocean II. These results were then presented before the faculty and peers, giving the students a chance to not only interpret their results but to practice their communication skills.

Prior to their arrival in Xiamen, students were advised to prepare a five-minute oral presentation (along with a poster) on their research. After the poster



**Figure 1-2 (L-R).** Students aboard Xiamen University's research vessel; Group photograph of the summer school.

sessions, each student attended a mandatory "Oral and Communications" workshop whereby faculty provided constructive criticisms and guidance on their posters which gave the chance for students to practice and refine their five-minute presentations.

In the final section of the summer school, in addition to lectures on more advanced SOLAS science topics, each student had their oral presentations in plenaries, drawing on the skills and lessons they learnt just a few days earlier. Faculty members and students each voted for their top three during these sessions and winners were announced at the closing ceremony (Faculty selections: Eva Mayol, Spain; Natalie Freeman, USA; Neil Clark, UK; Student selections: Jana Schneider, Germany; Raissa Philibert, South Africa; Shlomit Sharoni, Israel).

Another equally important though less discussed aspect of the Summer School is the varied opportunities for networking it provides, even outside of the classroom. While exploring Xiamen, its surroundings, and culture during free time, students and faculty members alike were subconsciously creating those networks and linkages that are critical to the interdisciplinary and collaborative nature of science today.

Each iteration of the Summer School has been highly successful, as evidenced by the high number of applications received. The 6<sup>th</sup> School is no different with well over 200 applications received for the limited slots. Furthermore, the feedback from the anonymous, post-program evaluations given to faculty members and students was overwhelmingly positive.

### Acknowledgements

We would like to thank the generosity of the numerous sponsors of the 6<sup>th</sup> SOLAS Summer School. Without the support of groups such as the Asia-Pacific Network for Global Change Research, North Pacific Marine Science Organization (PICES), Scientific Committee on Oceanic Research, the State Key Laboratory of Marine Environmental Science (Xiamen University), the National Natural Science Foundation of China, the Natural Environment Research Council, Xiamen University, the State Oceanic Administration of China, the Centre Nationale d'Etudes Spatiales, and Ocean Carbon and Biogeochemistry, this program would not be possible.

## CBA2013-08NSY-SOLAS

### PROJECT TITLE

**Capacity building on Surface Ocean - Lower Atmosphere Study: The SOLAS Summer School**

### COUNTRIES INVOLVED

All APN Member Countries

### PROJECT DURATION

One-year project

### APN FUNDING

US\$ 23,000

### PROJECT LEADER

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CBA2013-09NSY-PASCOE

# Building Capacity for Socio-Ecological Resilience to Coral Bleaching Events in Indonesia, Malaysia and Thailand

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**ABSTRACT:** Severe coral bleaching is expected to affect half the world's coral reefs in any given year by 2030 as a result of climate change. A severe coral bleaching event in 2010 in Southeast Asia provided an opportunity to investigate the economic, social, and ecological impacts of these events and strategies for responding to them. Seven knowledge-exchange workshops involving approximately 170 stakeholders were held in Indonesia, Malaysia, and Thailand in October 2013 to learn more about the impacts of bleaching events and build capacity for responding to future events. The workshops aimed to: (1) raise awareness about the impacts of climate change on reefs and reef-dependent communities; (2) provide scientific input on responses to bleaching based on surveys conducted during the 2010 bleaching event; and (3) facilitate interactions between scientists, decision makers, and reef-dependent tourism operators. Each workshop used a combination of expert presentations, facilitated small-group discussions, and whole group synthesis and voting exercises to understand bleaching-related issues. Pre- and post-workshop evaluations demonstrated that, after the workshops, participants (1) viewed climate change as more damaging to coral reef ecosystems than they previously believed; (2) were more supportive of closing dive sites to divers during bleaching to help reefs survive these events; (3) believed that governments, non-governments, and business stakeholders had similar ideas about how to respond to bleaching events; and (4) felt better able to respond to coral bleaching events.

## Introduction

Climate change provides multiple threats to both coral reefs and the communities that depend on the resource for their livelihood. Foremost of these threats are coral bleaching and acidification (Hoegh-Guldberg et al., 2007), while increased tropical storm severity brought about by climate change has also been found to have substantially degraded coral reefs in some areas (De'ath, Fabricius, Sweatman, & Puotinen, 2012). Coral reef degradation corresponds to a simultaneous loss in the significant ecosystem services they provide as the foundation for a thriving dive tourism industry, extensive fisheries, and a broad range of regulating services. In the Asia-Pacific region, approximately 150 million people derive benefits from coral reefs (Burke, Reytar, Spalding, & Perry, 2011).

Of particular concern to this study are the impacts of coral bleaching and appropriate management responses to bleaching events. At current rates of greenhouse gas emissions, it is projected that half of the world's reefs will experience severe bleaching events in any given year by 2030 (Donner, 2009). A severe coral bleaching event in 2010 in Southeast Asia provided an opportunity to investigate the economic, social, and ecological impacts of these events and strategies for responding to them (Guest et al., 2012; Tan & Heron, 2011) (Figure 1). Broad scale coral bleaching occurs when unusually high sea temperatures cause corals to expel the symbiotic algae that live within their tissues and provide up to 90% of corals' energy requirements. In this compromised state, corals are vulnerable to mortality from starvation, disease, competition from other species, and anthropogenic stressors, such as tourism, fishing, some construction activities and water pollution. Reefs that experience high coral mortality typically take 5-10 years or more to recover from bleaching events and often lose some of their former biological diversity. In some cases,



corals fail to recover and reefs instead become dominated by algae (Bruno & Selig, 2007).

While significant progress has been made over the last decade in understanding and responding to bleaching events (Eakin et al., 2010; Marshall & Schuttenberg, 2006), research identifying actions to increase the resilience of the reef tourism industry to coral bleaching is in its infancy. Existing research has focused on assessing economic losses during bleaching events, with little scientific work examining adaptation strategies for dive operators or the long-term consequences of bleaching for the structure of the dive industry, the broader economy, the well-being of dependent coastal communities, and government policy. This project aimed at working with the dive industry, government, conservation non-government organisations (NGOs), and academic stakeholders to fill this gap in scientific knowledge and build capacity for supporting social and ecological resilience to future bleaching events.

The project was predicated on previous research work conducted in Indonesia, Malaysia, and Thailand during the 2010 bleaching event. Ecological surveys characterized the bleaching event, and quantitative

### HIGHLIGHTS

- » A severe coral bleaching event in 2010 in Southeast Asia provided an opportunity to examine the economic, social and ecological impacts of such an event.
- » A series of multi-stakeholder workshops were held in Indonesia, Malaysia and Thailand in 2013 to report back on and verify the results of a rapid response survey undertaken in 2010 with key reef stakeholders, and to identify key observations, issues and ideas for improving social, economic and ecological resilience in the future.
- » The workshops were attended by marine park managers and other government officials, conservation NGO workers, researchers and a large number of business stakeholders (mainly dive and resort operators).
- » Results of the workshop evaluation survey indicate that the workshops raised participants' awareness on the impacts of climate change on coral reef ecosystems, increased support for some forms of responsive management action, and increased participant confidence in responding to bleaching events.

**Figure 1.** Bleached coral off Phuket, June 2010. (Photo: Heidi Schuttenberg)

socio-economic surveys of 575 divers assessed diver perceptions of the bleaching event, the influence of those perceptions on support for different management actions, and the resulting economic impact (Thomas & Heron, 2011). Concurrently, qualitative interviews were conducted with dive operators to explore their perceptions of the event on their business and the ways they were seeking to adapt their operations. Analysis of these socio-economic data found that the dive industry contributed at least US\$ 1.3 billion a year to the local economies in the three countries, while divers themselves accrued around US\$ 4.5 billion a year in non-market benefits (Pascoe et al., in submission). The loss of non-market economic benefits to the divers during the bleaching event was estimated to be US\$ 100-150 million (Doshi et al., 2012). The qualitative interviews provided valuable insight into the current level of social resilience, and how social resilience may be enhanced.

## Methodology

To better understand the impacts of coral bleaching on dive tourism and to build capacity for supporting the social and ecological resilience of island communities to future bleaching events, seven knowledge-exchange workshops were held in Indonesia, Malaysia, and Thailand in October 2013 (Figure 2). The workshops aimed to:

- Raise awareness about the impacts of climate change on reefs and reef users;
- Provide scientific input on responses to bleaching, based on surveys conducted during the 2010 bleaching event; and,
- Facilitate interactions between scientists,

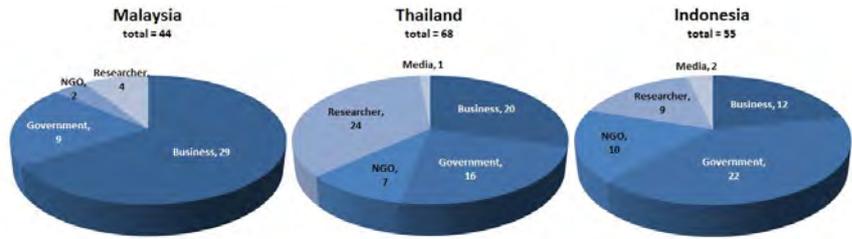
policy makers, and reef-dependent tourism operators.

Workshops were organised and hosted by teams of local and international partners in the locations that were studied during the 2010 bleaching event (Table 1). A total of 167 stakeholders attended the seven workshops. Participation varied by workshop location (Figure 3), and included marine park managers, national and local government officials, conservation NGOs, dive operators, others affected by the bleaching event (e.g. resort operators and fishers), and local schools. Each workshop consisted a morning session that investigated the impacts of the 2010 bleaching event and an afternoon session focused on responsive actions. Both sessions used a combination of expert presentations, facilitated small-group discussions, and whole group synthesis and voting exercises to understand bleaching-related issues. The small group discussions were highly successful in eliciting ideas of how to better respond to future coral bleaching events, taking into account the multiple needs and wants of the different stakeholder groups. The groups also focused on how to build social and economic resilience in their communities as well as how to respond to the immediate need to protect the reefs. In some cases, this was the first of such interaction among stakeholder groups. The results of these discussions are being compiled and will be included in the full project report as well as in scientific papers.

A mixed methods of evaluation was conducted before and after the workshops to understand participant experiences during the workshop, and the workshops' effect on participant awareness of climate change, support for management actions, and confidence in the ability of different stakeholders to work

Country	Organisation
Indonesia	CORAL Indonesia Reef Check Indonesia Balai Kawasan Konservasi Perairan Nasional (BKKPN) Balai Pengelolaan Sumberdaya Pesisir dan Laut (BPSPL)
Malaysia	Faculty of Maritime Studies and Marine Science, Universiti Malaysia Terengganu Reef Check Malaysia
Thailand	Prince of Songkla University WWF-Thailand
Australia	CSIRO Marine and Atmospheric Research School of Economics and Finance, Queensland University of Technology Australian Centre for Tropical and Freshwater Research, James Cook University University of New South Wales
USA	NOAA Coral Reef Watch

**Table 1.** Project partners.



**Figure 2 (left).** Location and dates of the stakeholder workshops undertaken in 2013. The Terengganu symposium was a scientist-only meeting to discuss research issues.  
**Figure 3 (top).** Composition of the participants engaged in the seven multi-stakeholder workshops.

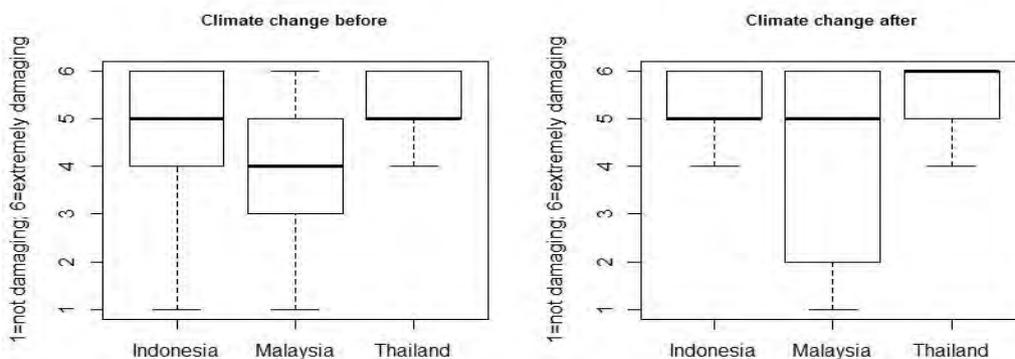
together effectively to respond to bleaching events. Selected participants were interviewed on video before the workshops to gauge their expectations and after the workshops to explore their experiences and knowledge gain. All participants were given a written survey consisting of Likert-scale questions assessing their perceptions of bleaching-related issues (distributed in local languages and English) and were also asked of their perceptions before and after the workshops. Seventy-six percent of the workshop participants completed the survey.

**Results**

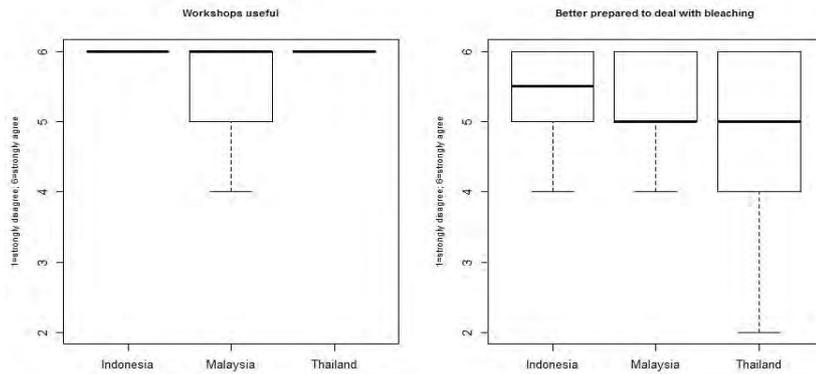
Results of the workshop evaluation survey indicate that the workshops raised participants’ awareness on the impacts of climate change on coral reef ecosystems, increased support for some forms of responsive management action, and increased participant confidence in responding to bleaching events. Participants were asked to rate the extent to which they perceived climate change was damaging to coral reef ecosystems on a 6-point Likert scale before and after the workshop, where 1 signified “not damaging” and 6 indicated “extremely damaging”. Relatively few

individuals believed that climate change was not very damaging before the workshop, and even fewer after (Figure 4).

While the trend was overwhelmingly towards climate change being considered extremely damaging, a number of individuals in the Malaysian workshop indicated that they believed climate change was less damaging after the workshop than before. There are three possible reasons for this. First, given that this outcome is counter to the overall trend in the data, it is possible that these scoring were made in error. Second, the presentation of 2010 data on the impacts of the bleaching event on localised tourism operations indicated that impact levels on business flows and divers satisfactions levels were low. This was verified through the workshops. Consequently, Malaysian businesses may have taken this as an indicator for future impact levels and their worries somewhat alleviated. Third, if they were climate change sceptics, these individuals may have been trying to influence the overall score by reducing their own score in expectation that others would increase their scores following the workshop. Views were collected anonymously and processed after the workshop so there is no way to verify these interpretations. The relationship between



**Figure 4.** Views on the relative threat to coral reefs from climate change before and after the workshops. The dark line depicts the median score, while the box depicts the upper (75%) and lower (25%) quantiles, and the dashed lines the 90 per cent confidence limit.



**Figure 5. Feedback on workshop value.**

the direction and magnitude of the change in belief and the initial belief was examined, but no relationship was observed, suggesting the third possibility is unlikely.

Participants were also asked questions about their perceptions of: (1) the impacts of coral bleaching and climate change on dive tourism and coral reef condition; (2) their support for different management actions; and (3) their confidence in the ability of government, NGO, and industry stakeholders to work together effectively to respond to bleaching events. Two of these questions showed statistically significant differences before and after the workshops. Participants' belief that "closing some areas to tourists during coral bleaching events will help reefs survive" showed a significant increase ( $p=0.036$ ), from a mean rating of 4.33 on the workshop pre-survey to 4.69 on the workshop post-survey (where 1 indicated "strong disagreement" with the statement and 6 indicated "strong agreement"). Similarly, ratings on the statement, "the government, business operators, and NGOs have similar ideas about the best way to respond to bleaching events" increased from 2.74 on average to 3.11 ( $p= 0.003$ ). While this result indicates that there is still some disagreement between the groups, the overall results indicate that common ground was strengthened through the workshops. Overall, most participants found the workshops extremely useful, and felt that it helped to make them better prepared to deal with bleaching events in the future (Figure 5).

## Conclusions

The set of workshops was a first step in bringing the multiple stakeholders affected by coral bleaching together to address a common issue. Marine park managers benefited from a better understanding of the business needs of the local dive and resort operators, while the latter gained an improved understanding

of the processes underlying coral bleaching and the importance of management responses to ensure recovery and resilience. Having scientists, conservation and management groups from different countries interact and share their own management/response plans with the stakeholders and each other was also a key outcome of the workshops. Such a shared understanding is the first step in building social resilience as well as economic and ecological resilience in the region. The workshops also opened communication channels among these different stakeholders – an opportunity that many participants felt was previously absent.

In addition to the measureable impacts of the workshops reported here, workshop partners reported several other potential future outcomes. These include interest by Thai government officials at the workshop in developing a national-level bleaching response plan, interest by stakeholders in further operationalising the existing bleaching response plans in Malaysia and Indonesia, and interest in advancing development of a regional level response plan for Bali, Indonesia.

## Acknowledgements

The authors would like to thank the APN, Australia's CSIRO Wealth from Oceans National Research Flagship, and the U.S. NOAA Coral Reef Conservation Program for their financial support in running the workshops. We would also like to thank The Nature Conservancy for their support during the 2010 bleaching response study, our local partners from government and civil society (Box 1) for their in-kind contributions to hosting the workshops and the workshop participants for their insights and observations. The manuscript contents are solely the opinions of the authors and do not constitute a statement of policy, decision, or position on behalf of NOAA or

the US Government. We would also like to thank Toni Cannard and Ingrid van Puten for comments on an earlier draft of the manuscript.

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## CBA2013-09NSY-PASCOE

### PROJECT TITLE

**Building Capacity for Socio-Ecological Resilience to Coral Bleaching Events in Indonesia, Malaysia and Thailand**

### COUNTRIES INVOLVED

Australia, Indonesia, Malaysia, Thailand, USA

### PROJECT DURATION

One-year project

### APN FUNDING

US\$ 44,000

### PROJECT LEADER

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**CBA2013-10NSY-VISCO**

# Communicating and Operationalising Site-specific Climate Change Adaptation Strategies in Selected Upland Communities in Southeast Asia

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## Introduction

Climate change is, indeed, a real problem. It is not simply based on the scientific projections and forecast in the past but impacts are actually being felt by humanity, particularly in the food and agriculture sector. Two major elements of climate change adaptation are communication and action.

The Philippine Agroforestry Education and Research Network (PAFERN), in collaboration with the two member-countries of the Southeast Asian Network for Agroforestry Education (SEANAFE), namely Indonesia Network for Agroforestry Education (INAFE) and the Viet Nam Network for Agroforestry Education (VNAFE), is currently implementing a project entitled “Communicating and Operationalising Site-Specific Climate Change Adaptation Strategies in Selected Upland Communities in Southeast Asia.” This project aims to: (1) train at least 75 farmer-trainers from the three collaborating countries on the different site-specific and appropriate climate change adaptation strategies that could help address the impacts of climate change in their agricultural production; (2) conduct a forum with the local government units in each of the three collaborating countries to discuss current climate change scenarios in their respective areas, and how climate change could be mainstreamed in their local development programs; and (3) establish a community-based project that showcases workable and appropriate farmer-level climate change adaptation strategies in each of the three collaborating countries.

## Activities Undertaken

### *Setting the Stage for Project Implementation*

The collaborators organised a project team meeting from 15-17 August 2013 in Ho Chi Minh City, Viet Nam. The meeting served as a venue to level-off the details of project implementation, including the expected outputs and deliverables; develop country plans for the component activities of the project; and devise a project team plan and budget allocation for overall project implementation. The meeting was attended by Dr. Bao Huy of Viet Nam Network for Agroforestry Education (VNAFE), Dr. Christine Wulandari of Indonesia Network for Agroforestry Education (INAFE), and Dr. Roberto G. Visco, Ms. Leila D. Landicho and For. Rowena D. Cabahug of PAFERN.

### *Establishing Partnerships with Local Communities*

In the case of the Philippines, PAFERN is collaborating with the Kalinga-Apayao State College in Northern Luzon as its local partner. The state college will involve local government units (particularly the Municipal Agriculture Office, Municipal Environment and Natural Resources Office, and Municipal Planning and Development Office) of five municipalities in the province of Kalinga; namely Pasil, Tabuk, Balbalan, Rizal and Pinokpok. Meanwhile, INAFE is partnering with the Lampung Province Forestry Service Office, West Lampung Forest District Office, Watershed Management Forum of Way

Seputih and Way Sekampung, Community Forestry Program of Lampung Province, Province HKm Forum, and Lampung University. VNAFE is partnering with the Department of Agriculture and Rural Development of Dak Nong Province, Department of Forest Protection, Agriculture and Rural Development Station, Department of Forest Development, District government of Tuy Duc and Kien Duc, Extension Stations of Tuy Duc and Kien Duc, Agriculture and Rural Development, Quang Tam and Dak R'Tih Government Commune, and Tuy Duc Agriculture and Forestry and Rubber State Company.

### ***Building Technical Capabilities of Farmer-Trainers in Climate Change Adaptation***

Training of farmer-trainers on site-specific climate change adaptation strategies will equip the farmers with the knowledge and skills in employing appropriate climate change adaptation strategies in their respective communities. The farmer-trainers will be trained with the hope of re-echoing the capacity and knowledge to other upland farmers via farmer-to-farmer training programs.

The collaborators from Indonesia and Viet Nam have already conducted the Training of Farmer-Trainers. In Indonesia, 25 participants were trained on the following topics: Climate Change Adaptive Strategies on Agricultural and Forestry Sector; Appropriate Nursery and Patterns of Agroforestry on Supporting Climate Change Adaptation Strategies; Agroforestry as Integrated Agriculture Technique: Socio-economic Aspects; Mycorrhiza and Other Root-Development Techniques; and Integrated Pest Management.

The training in Viet Nam was held from 26-28 November 2013 and participated in by 25 members



**Figure 1.** Training of farmer-trainers.

of the M Nong ethnic group in the upland areas of Viet Nam. In the Philippines, the training of farmers is scheduled from 12-15 January 2014 in the Kalinga State College, Tabuk, Kalinga. The training will be attended by 25 farmers from the upland communities of the municipalities of Rizal, Balbalan, Tabuk, Pasil and Pinokpok. Lecture-discussions on the concepts and issues of climate change and a workshop on the impacts of climate change in agricultural production systems as experienced by the upland farmers will be held. Other activities include sharing of farmers' experiences in employing climate change adaptation strategies and action planning for adopting appropriate climate change adaptation strategies.

### ***Towards Mainstreaming Climate Change Adaptation Programs in the Local Government Units***

A forum with local government units is intended to create awareness among the local executives about the concepts and issues of climate change, how the farming sector in their municipalities experience the impacts of climate change, and how local government units could help farmers adapt to the impacts of climate change. Towards the end, this project component aims to mainstream climate change adaptation strategies in local development programs of the local government units. In Viet Nam, a forum with local government units was held on 29 November 2013. This was participated in by the Department of Agriculture and Rural Development of Dak Nong Province, Department of Forest Production of Dak Nong Province, Department of Forest Development of Dak Nong Province, District Government of Tuy Duc and Kien Duc, Extension Stations of Tuy Duc and Kien Duc, Agriculture and Rural Development Station of Tuy Duc and Kien Duc Districts, Protection Forest Station of Tuy Duc District, Quang Tam and Dak R'Tih Government Commune, and Tuy Duc Agriculture and Forestry and Rubber State Company. The forum dwelled on the presentation of the findings of problems of cultivation under climate change in the locality, policies related to climate change mitigation and adaptation, possible solutions to climate change, and identified policy gaps in terms of climate change.

In the Philippines, the forum with local government units will be held on 16 January 2014 at the Kalinga State College, involving the Municipal Agriculture Office, Municipal Environment and Natural Resources Office, and Municipal Planning and Development Office of the local government

units of Pasil, Tabuk, Rizal, Balbalan and Pinokpok in the province of Kalinga. The selected representatives from the Kalinga State College and the University of the Philippines Los Baños-Institute of Agroforestry will also be participating. In Indonesia, the forum is scheduled in December 2013.

### **Showcasing Workable and Appropriate Climate Change Adaptation Strategies**

The third project component is the establishment of a community project showcasing the different site-specific climate change adaptation strategies that could possibly be employed and adopted by other farmers in the village and neighboring villages. An integrated farm with different crops or species, considered an agroforestry system, will be showcased. Different workable climate change adaptation strategies and practices such as organic farming (e.g. composting, vermiculture, and integrated pest management), changing cropping patterns and cropping combinations, and further crop diversification will also be highlighted. Meanwhile, the community project in Viet Nam, which belongs to Commune Quang Tam will be implemented in Bunor Village, Tuy Duc District and Dak Nong Province in the Central Highlands of Viet Nam. This district serves as the home of the ethnic minority group called M Nong, who are practicing



**Figure 2. Members of the Local Government Unit on mainstreaming climate change adaptation strategies in development programs.**

shifting cultivation. The community is engaged in rubber, coffee and cashew plantation, rice production, and annual crops production. The major impacts of climate change include the occurrence of diseases in crops and trees, decreased growth and productivity, and declining non-timber forest tree products and wild animals.

The project aims to improve cultivation systems to include trees and crops, promote shifting cultivation via agroforestry, implement policies on payment for ecosystem services, and build capacities of the local government.

## **CBA2013-10NSY-VISCO**

### **PROJECT TITLE**

**Communicating and Operationalising Site-Specific Climate Change Adaptation Strategies in Selected Vulnerable Upland Communities in Southeast Asia**

### **COUNTRIES INVOLVED**

Indonesia, Philippines, Viet Nam

### **PROJECT DURATION**

One-year project

### **APN FUNDING**

US\$ 36,000

### **PROJECT LEADER**

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CBA2013-11NSY-PAKHARKOVA

# Scale in Earth System Governance: Local Case Studies and Global Sustainability

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**ABSTRACT:** The “Scale in Earth System Governance: Local Case Studies and Global Sustainability” summer school was held at the Siberian Federal University in Krasnoyarsk, Russian Federation, from 15th to 29th July 2013. This capacity building event focused on the issue of scale in environmental governance, with a particular emphasis on the issues of local governance and inter-linkages of local actors and institutions with existing and emerging national and global environmental regimes. In addition to classes on concepts and theories describing scale issues and their implications on environmental policies and management, the school provided rich opportunities for practical application. About half of the school’s length was devoted to case study research work in thematic groups, including extended field work in the beautiful Siberian nature, and interactions with local practitioners.

**KEYWORDS:** *case studies, governance, scale, Siberia*

The “Scale in Earth System Governance: Local Case Studies and Global Sustainability” Summer School, held at the Siberian Federal University in Krasnoyarsk, Russian Federation from 15th to 29th July 2013, addressed challenges of scale in Earth system governance. It served as a means for capacity building, and cross continental network development of early-career researchers from the Asia-Pacific region and Central and Eastern Europe, while undertaking research into local sustainability in the city of Krasnoyarsk and the beautiful nature of the Krasnoyarsk region. Participants came from India, Japan, Nepal, Thailand, Russia, Belarus and Ukraine.

## Thematic Focus

Scale is an important crosscutting theme in Earth

system governance as that is more than a problem of the regulation of the “global commons” through global agreements and conventions. Earth system governance is happening not only at the global level but in a variety of places and at all levels where humans shape their interaction with nature (Biermann et al., 2009) Places, and the Planet Science and Implementation Plan of the Earth System Governance Project Executive Summary In Humans now influence all biological and physical systems of the planet. Almost no species, no land area, no part of the oceans has remained unaffected by the expansion of the human species. The four main global change research programmes, affiliated in the Earth System Science Partnership, see evidence today that the entire earth system now operates ‘well outside the normal state exhibited over the past 500,000 years’, and that

'human activity is generating change that extends well beyond natural variability - in some cases, alarmingly so - and at rates that continue to accelerate'. Given this situation, the Earth System Science Partnership declared an 'urgent need' to develop 'strategies for Earth System management'. Yet, what such strategies might be, how they could be developed, and how effective, efficient and equitable such strategies would be, remain unspecified. It is apparent that the institutions, organizations, and mechanisms by which humans currently govern their relationship with the natural environment and global biochemical systems are not only insufficient, they are also poorly understood. This is the rationale for the Earth System Governance Project, a new long-term research programme developed under the auspices of the International Human Dimensions Programme on Global Environmental Change. This Science Plan elaborates upon the concept of earth system governance and on the central questions, methods and processes of a global research effort in this field. Earth system governance is defined in this project as the interrelated and increasingly integrated system of formal and informal rules, rule-making systems, and actor-networks at all levels of human society (from local to global).

For research, it is important to identify whether certain findings or hypotheses apply on all scales, or are valid merely for one scale, and to what extent do scales influence findings. In sustainable development research, there is a strong emphasis on local level studies but often these studies insufficiently address the interactions and cross-scale dynamics and the "fit" of social (governance) to natural scales. Also, valuable approaches like "resilience" and "social ecological systems" recognise a hierarchical spatial organisation of governance developed on local scale, but they struggle with multi-level governance and favour polycentric governance to explain questions of scale.

In addition to such analytical issues of scale, there is also an important

additional area for research and capacity building. That is, the politics of scale. Actors like individual politicians, agencies, institutions and mechanisms are contesting and framing scales and levels by shifting issues to between scales and levels to positions which they are most influential or powerful. Such contests can be relatively direct, as in debate or argument, or through use of technologies, controlling resource access and other ways of shaping the arenas of interaction.

### **Scale, Scope and Interdisciplinarity**

In terms of geographical scale, the Summer School was special: Although the school looked at local issues, the geographical scope was far beyond what is usually called "local" as the case studies were spread all over the Krasnoyarsk region with its impressive 3,000 km stretch from the Arctic Ocean to Central Asian deserts, and the total area of about half the size of the European Union (EU). Although the furthestmost locations were reached only by means of phone and social networks, some research groups had to travel up to 650 km to reach their case study locations and do a good deal of mountain hiking to perform interviews and get insights into problems at hands.

The thematic scope was rather large too: The case study topics encompassed the whole range of local sustainability issues such as sustainable urban planning, mini-hydropower facilities, sustainable tourism and waste management in nature preserves, human-wildlife conflicts in Southern Siberia, and energy efficiency in housing sector in Krasnoyarsk.

Still uncommon for environmental science research and for solving environmental problems in Russia and elsewhere in former USSR, all the case study research teams explored and applied tools and techniques coming from a broad range of disciplines, trying to achieve a deepened understanding and experience of interdisciplinarity and even of transdisciplinarity, as the

core idea of case study research in the Summer School was co-design of research projects in collaboration with stakeholders involved into a particular environmental issue. The themes of the case study research not only reflected the interests of the recruited group, the host institution, and other organisers, but also that of local stakeholders.

## Organisation and Structure

The summer school was organised jointly by the Siberian Federal University, the Central European University, the Russian State Hydrometeorological University, and the Earth System Governance Project, with the support of the Asia-Pacific Network for Global Change Research, the European Commission's Tempus EC project "Environmental Governance for Environmental Curricula" (EnGo), and the Open Society Institute's (OSI) ReSET programme on "Governance of Global Environmental Change" (ReSET).

The event was comprised of four periods. A four-day introductory period included lectures on theories and research methodology as well as presentations of research designs for the case studies that were undertaken in the following five-day period in the city of Krasnoyarsk, and in the nature reserve

Stolby and nature park Ergaki. The third part of the two days was for analysis of the field data collected and preparation of draft reports which were presented and discussed during the final two days.

The workshop did partly build upon work on sets of case studies developed at a Summer School in July 2012 in Lviv and Vorokhta, Ukraine, and a follow-up workshop in September 2012 in Odessa, Ukraine. Both these events were organised under the umbrella of Tempus EnGo and OSI ReSET projects. The case study materials collected in these earlier events were used for comparisons and discussions of scale issues in similar settings to draw a more comprehensive picture of the problem of scale across global locations. In addition, participants brought case studies and experiences from their own localities and context into the design and implementation of the studies in Siberia.

The diversity of case studies and research experience within and outside the APN region created an interesting synergy — while all the non-Russian APN participants came from social and policy science backgrounds, those coming from Russia, Belarus and Ukraine were natural scientists with deep insights and overall familiarity with local environmental issues and Russia's socio-economic and political setup.

### CBA2013-11NSY-PAKHARKOVA

#### PROJECT TITLE

**Scale in Earth System Governance:  
Local Case Studies and Global  
Sustainability**

#### COUNTRIES INVOLVED

Russian Federation

#### PROJECT DURATION

One-year project

#### APN FUNDING

US\$ 38,000

#### PROJECT LEADER

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CBA2013-12NSY-MAIRS

# Promoting Sustainability Science in Monsoon Asia

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## Introduction and Background

In recent decades, Asia is experiencing rapid economic development and environmental changes induced both by global warming and human activity. The Monsoon Asia Integrated Regional Study (MAIRS), a regional program under the ESSP (Earth System Science Partnership), was formally established in 2006. The main objective of establishing MAIRS is to develop multi-disciplinary studies in the monsoon Asia region to understand the interaction between monsoon climate and human activity which can contribute to the sustainable development of Asian countries. MAIRS is aimed at promoting frontier research in global change sciences, initiating new research projects nationally and internationally, and implementing capacity building activities for young scientists on crosscutting studies.

After several years of development, MAIRS has established four research themes: (1) rapid urbanisation in Asian coastal region; (2) vulnerable ecosystems in Asian drylands; (3) water resource and hazards in high mountain areas; and (4) regional environmental change simulation and projection. MAIRS has developed groups of scientists and projects based on the research themes mentioned, and set up “water, land and air” as the main crosscutting issues in the MAIRS scientific agenda.

The new International Council for Science-International Council of Social Science (ICSU-ICSS) initiative which is called “Future Earth Initiative” was formally

## HIGHLIGHTS

- » Promoting sustainability science in Asia.
- » Showing successful trans-disciplinary studies in Asia.
- » Contribution to Future Earth activity
- » Involvement of more Asian young scientists in transdisciplinary studies.

launched in 2013, and its science agenda emphasises the contribution of scientists towards sustainability of societies by promoting integrated studies across natural and social sciences, various research fields, and different regions. MAIRS set of objectives matches well with that of the Future Earth Initiative by focusing on climate change issues and problems in monsoon Asia. Therefore, the upcoming conference, supported by the Asia-Pacific Network for Global Change Research (APN), serves as an important event contributing to the Future Earth Initiative in the Asian region.

MAIRS has a long history of collaboration with the APN and from the very beginning of MAIRS, its Science Steering Committee (SSC) and International Program Office (IPO) pushed and developed a series of APN proposals. This includes: (1) Regional Climate Modelling Inter-Comparison (RMIP Phase III); (2) Downstream Impact of Glacier Melting in Himalayan Region; (3) Asian Dryland Land Surface Modelling; and (4) Integrated Climate Change Impact Assessment Tool for Urban

Policy Makers (UrbanCLIM). These APN-funded projects became the supporting projects of MAIRS.

The first MAIRS conference will be held from 7-10 April 2014 in Beijing, China. The purpose of the conference is to highlight the latest research on integrated studies and sustainability science dealing with Asian environmental change. In addition, the conference aims to showcase success stories or successful projects/cases of multi-disciplinary studies and recognise how crucial science contributes to sustainable development of Asian countries. Lastly, the conference provides capacity building for young scientists who are interested in global change and sustainability science.

### Participating Countries

- China: This project is led by Dr. Ailikun, China, director, IPO of Monsoon Asia Integrated regional Study (MAIRS), Institute of Atmospheric Physics, Chinese Academy of Sciences, aili@mairs-essp.org
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- India: Prof. Jayaraman: India, National Atmospheric Research Laboratory, director@narl.gov.in, jayaraman@narl.gov.in

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#### MAIRS Conference 2014 Work Plan

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25-26 March 2013	During the 8th MAIRS Science Steering Committee meeting in Guangzhou, China, the structure of the conference, session arrangement and keynote speakers were discussed. The formal announcement of the MAIRS Open Science Conference 2014 was released in May 2013
May 2013	MAIRS conference website was set up, start personal registration and call for sessions. <a href="http://www.mairs2014.org/dct/page/1">http://www.mairs2014.org/dct/page/1</a>
November 2013	All the sessions and conveners were confirmed. Starting submission of abstracts.
November 2013	Start call for support of young scientists. The list of young scientists supported by this APN CAPaBLE project to be decided in February 2014.
February 2014	We will send out invitations and visa documents to all participants, detailed programme to be released 1 month before the conference
7-10 April 2014	MAIRS conference in Beijing Friendship Hotel
June 2014	Final report to APN
Summer to Autumn 2014	Collection of papers for the special issue of MAIRS conference
Summer to Autumn 2015	Publication of MAIRS conference special issue

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## Objectives

The main objective of this APN-funded project is to support Asian young scientists to attend the MAIRS conference from 7-10 April 2014. More than 20 young scientists outside China will be invited to Beijing. Through this project, we will:

- Deliver the latest information on global change research and results to young scientists;
- Promote collaboration between scientists and policy makers in the monsoon Asia region;
- Promote crosscutting (integrated) studies among young scientists and transfer the knowledge and methodology of climate change adaptation science;
- Show the research undertaken by Asian young scientists;
- Improve networking among young scientists and help communication on sustainability science between senior and young scientists.

## Project Publications

A proceedings of the conference will be published, as well as a special issue featuring excellent papers from the conference.

## Acknowledgements

Joint sponsors of the conference: Chinese Academy of Sciences (CAS), China Association of Science and Technology (CAST), National Science Foundation of China (NSFC), World Climate Research Program (WCRP), Research Institute of Humanity and Nature (RIHN), ICSU regional office in Asia and the Pacific (ICSU-ROAP), IGBP/IHDP LOICZ programme.

### CBA2013-12NSY-MAIRS

#### PROJECT TITLE

Promoting Sustainability Science in Monsoon Asia

#### COUNTRIES INVOLVED

Australia, China, India, Japan, Malaysia, Mongolia, USA

#### PROJECT DURATION

One-year project

#### APN FUNDING

US\$ 38,000

#### PROJECT LEADER

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CBA2013-13NSY-VARMA

# Building Capacity for Adaptive Governance through Participatory Modelling: Rural and Urban Flooding in India

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## Introduction

Climate change challenges the continuation of the control and command type of management approaches for natural resources because of the uncertainty associated with this global change problem. There is a gap between available knowledge and the knowledge policy makers seek for making strategic response plans. Though the risks of climate change are known, currently they are more precise in broader ecosystem scale rather than in jurisdictional levels (i.e., national and sub-national levels where policy decisions are made and issues of livelihood and settlements evolve). Besides, the evidences of linkages across environmental processes point out to the complexity out there, which impact assessment models are yet to grasp. Such example is a knowledge gap regarding the coupled impact of increasing temperatures and changing precipitation patterns, which may lead to shifts in the timing of precipitation and runoff, and also in frequency of extreme weather events like extended periods of extreme heat or high intensity precipitation. Extreme weather events are already affecting major river basins to create flooding more frequently though indications of change in the frequency of droughts are ambiguous (Sud et al., forthcoming).

Due to the uncertainty of climate change risks and its impacts in finer resolutions of time and space, localised surprise incidences may increase. Majority of the effort has been going towards information generation and processing for decision-making with a strong

## HIGHLIGHTS

- » An initiative to mainstream principles of adaptive governance into climate change response planning.
- » Project attempts to create a learning process between research-policy and practice for managing flood.
- » Project is attempting to create a network between researchers in local universities of India with scholars of Asia-Pacific region.

emphasis on uncertainty reduction (Sud et al., forthcoming; Werners, 2013). But, policy problems face deeper uncertainties, which cannot be reduced by just gathering more information and are often not statistical in nature. In Upper Brahmaputra Valley within Assam and Bengal plains of India, the ecological regime has shifted, from a fluvial agroecosystem to a sediment-deposited landscape; the problem is no longer of seasonal floods but of a state of landlessness among farmers. But, the continuation of a mix of annual maintenance of earthen embankment and bank protection from the government just reflects the rigidity of governance to transform (Varma & Mishra, 2013). Similarly, the expansion of cities into lake beds and low lying areas like in case of Bangalore in Karnataka State of India reflects ignorance of feedbacks between social and ecological systems, which can increase their vulnerability (Kelkar et al., 2013, Ramchandra and

Mujumdar, 2009). Review on climate adaptation policy and practice for South-Asia suggest the need of integrated approaches factoring complexity of social and ecological linkages (Sud et al., forthcoming) to guide strategic planning. However, integrated assessments often ignore the diversity of worldviews which creates policy problems even more complex (Sendzimir et al., 2010).

### Need for Capacity Building

As the present day world is becoming more complex and the future more uncertain, a need for iterative processes between science-policy and practice arises. Natural resource managers have to be ready to acknowledge feedbacks of their own interventions in social and ecological domains, and create appropriate mechanisms for monitoring and evaluating policy outcomes for facilitating learning for better management. Thus, in the Asia-Pacific Network for Global Change Research (APN)-funded project entitled "Building capacity for adaptive governance through participatory modelling: Rural and urban flooding in India," we plan to build capacity among sub-national policy makers, practitioners, and researchers in India to respond to global change issues by using an adaptive governance approach. The adaptive governance paradigm seeks to learn from diverse knowledge systems and experience, networking among various actors to facilitate social learning of novel solutions and leadership to navigate change in social processes. It recognises systems thinking as a methodology for management and seeks stakeholder participation in every level of policy-making for robust understanding of natural and social risks and feedbacks (Pahl-Wostl, 2009).

Such a paradigm seeks for diagnostic approaches (Ostrom, 2007) and refrains from generic governance blueprints, hence, calls for iterations between policy purposes, social-ecological systems analyses and evaluation of policy outcome (Rijke et al., 2012). However, South Asia lacks capacity to operationalise adaptive governance (Sud et al., forthcoming). A common observation is that, though the policy goals in India have moved towards integration of issues, management institutions still lack capacity to function beyond the realm of their sector boundaries such as water, disaster and agriculture (Mishra et al., 2011) and there is a lack of information on policy outcomes (Sud, et al., forthcoming). Thus, currently there exists competing paradigms across the evolving policy frameworks and the values guiding management

institutions while, an ignorance of the dynamic of social-ecological contexts of resource users. We argue that climate change may aggravate surprises, but the ongoing planning for its response provides a window of opportunity to incorporate diagnostic and iterative mechanisms into policy design.

### Project Activities

The focus of the project is flood management in two varying socio-economic, political and ecological contexts, one in villages of the Lakhimpur district (within the agro-ecological sub-zone of Upper Brahmaputra Valley) of Assam in northeast India and other in Bangalore City of Karnataka in south India. Through lectures and group modelling activities, the program aims to establish the benefits of this adaptive governance approach and train stakeholders for its operationalisation. In December 2013, a curriculum was designed where advisory committee members comprising distinguished scholars from Asia with knowledge of climate change, complexities of natural resource management and experience with contexts, guided the project team. A four-day workshop was held in the last week of January in Guwahati, Assam which was attended by stakeholders ranging from academia, civil society and government institutions in Lakhimpur as well as in the state capital. A similar workshop was held in the month of March in Bangalore. The workshops were intended to establish flood as a governance problem, introduce climate change as a risk and create an understanding of systems thinking and principles of adaptive governance. It included lectures by resource persons with theoretical knowledge and experiences in dealing with social-ecological problems in same and different contexts. There were group activities aligned to the lecture series which helped participants not only to reflect but also express, share and negotiate their mental models (i.e., diagnose problem and decide by learning in an iterative process) of problem contexts. This was then achieved through group modelling exercises using conceptual systems modelling (Vennix, 1996).

The workshops implemented at the sub-national level will allow the project team to understand the barriers and bridges towards shared understanding of flood problems and negotiated solutions in the different contexts. This will be disseminated to stakeholders through a national level workshop in New Delhi in September 2014 which will help the team identify elements for an operational framework for adaptive governance and flood management in India.

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### CBA2013-13NSY-VARMA

#### PROJECT TITLE

**Building Capacity for Adaptive Governance through Participatory Modelling: Rural and Urban Flooding in India**

#### COUNTRIES INVOLVED

Bangladesh, India, Nepal, Singapore, Sri Lanka

#### PROJECT DURATION

One-year project

#### APN FUNDING

US\$ 40,000

#### PROJECT LEADER

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CBA2013-14NSY-MAITY

# Promoting Algaculture in Trapped Waters as Sustainable Aquafarming and Adaptive Climate Mitigation in Inundated Coastal Areas

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## Introduction

The project is envisioned as a capacity building and action research in promoting algaculture in coastal villages of *Sundarbans* in India that are mostly inundated due to rising sea levels. The aim of the project is to introduce algaculture as a sustainable aquafarming for alternative livelihoods and climate-smart community-based adaptive mitigation. Hands-on training on low-cost *in-vivo* aquafarming, management and monitoring of algaculture, harvesting of algal biomass and its commercial usage has been demonstrated in a capacity building module towards technology cooperation for standardisation of agrofarming practice. Carbon mitigation potentials in culture period and cost-benefit analysis over return on investment will be integral to the action research component of the project.

## Objectives

The main objectives of the project are:

- To demonstrate the cultivation technology of commercially-important algae, integrated with fisheries, in inundated coastal areas for sustainable alternative livelihoods;
- To develop community skills in algaculture through promotional capacity building programme to mitigate climate vulnerability with low-cost place-based intervention; and
- To disseminate amongst stakeholders the scientific knowledge with regards to carbon sequestration potential of cultured alga as a strategic way of climate change adaptation and resilience.

## Project Initiation

Under the aegis of APN's CAPaBLE programme on global change research, the South Asian Forum Environment (SAFE) initiated community-based sustainable aquafarming to promote algaculture in June 2013, as an adaptive climate mitigation measure for marginal farmers in three coastal villages of the Sundarbans of eastern India. Through community capacity building, on-field demonstration and scientific interventions, it soon became a multi-stakeholder endeavour of reputed

### HIGHLIGHTS

- » Promotion of Algaculture in inundated coastal areas outreach to 780 marginal farmers encompassing 12 climate vulnerable villages in Indian Sundarbans.
- » Three native algal flora of economic importance has been stabilised for commercial mass culture in areas affected by high salinity ingress and 18 smallholder farmer families have already adopted the same as an alternative livelihood.
- » Two species of *Enteromorpha* shows excellent growth patterns and biomass accumulation indicating significant carbon capture and storage potentials in a stressed habitat.
- » Members of scientific community and other stakeholders take serious notes on the algal farming practice, endorsing it as a significant climate smart initiative and commit scale-up actions.
- » Community members unanimously accept and adopt the aquafarming technology showing positive attitude change.



organisations like School of Oceanography and Marine Science, Jadavpur University, National Bank for Agriculture and Rural Development (NABARD), Indian Institute of Technology (IIT), Central Inland Fisheries Research Institute (CIFRI), Department of Science and Technology (DST), Government of India and rural local administration as well. Participatory planning or setting up experimental designs, selection of demonstration sites and identification of beneficiaries brewed during in-house brainstorming at SAFE and CIFRI was duly shared with the community members during village awareness camps held in Sundarbans and final implementation blueprint was made ready for execution by end of July. During project initiation, Dr. R. Gopichandran, Director of DST of the Government of India, commented, “It is important to publish a working manual on algaculture in inundated areas after the successful completion of this intervention and I appreciate the generous support of APN and endeavours of SAFE for such commendable climate adaptive initiative.”

### Grounding and Structural Interventions

In the month of July 2013, the project monitoring team comprising of researchers, scholars and scientists, with the research team of SAFE, identified three locations in Sundarbans for grounding project interventions, one each in outer estuarine (Jhorkhali near Saatjelia village), mid-estuarine (Kumirmari village) and inner estuarine (Sagar village), and three

cultivation techniques in each site were initialised, namely U-Lock, Fishbone and Free-Float model. Ecological survey and habitat evaluation was conducted in all three sites following standard methods. Natural habitats of local algal flora that are economically important were identified from field and seed stocking were made in freshwater ponds at Jhorkhali village near Saatjelia. On completion of the earthwork, algal seeds were inoculated to cultivation beds in all three types of models. The first harvest was reaped in mid-November, 2013. Dr. Sanjay Deshmukh, Chairman, Board of Studies in Life Sciences of Mumbai University, India, and Dr. Kawser Ahmed, Chairman of the Department of Marine Biology and Climate Change of Dhaka University, Bangladesh, visited the area of intervention and expressed their concerns in scaling up the activity to other areas.

### Community Outreach

The first community awareness campaign was launched in August wherein general concepts and working knowledge on aquafarming and algaculture were shared with the community members in Kumirmari, Jhorkhali, Saatjelia and Sagar villages. This was followed by two more awareness camps in October with a target to include more women participants, who are potential beneficiaries. Capacity building workshops were conducted in August, October and November at all three project sites and the workshops covered various topics such as identification of the algal species, pond preparation, and

**Figures 1-3. Project orientation and series of trainings on algaculture conducted at the village-level.**

**Figures 4-5 (L-R).** Measuring biomass of harvest; SAFE Chair, Dr. Dipayan Dey, presenting at scientific workshop in Jadaupur University, Kolkata.



cultivation management. The use of pH papers, simple sacchi discs, and measuring temperature and tidal levels were also included as important components of the training workshops. Beneficiaries were also taught about harvesting, measuring the growth rates in terms of daily growth rate (DGR) percentage from filament length and weight. Mr. Kartik Sardar, a tribal farmer exclaimed and said, "I have often seen these alga growing in the wilderness, but never knew that they can be so useful for we, the poor." Mrs. Bimala Gorui, a community woman expressed with relief, "...Now I can even feed my cattle in odd days with this (alga). I am really thankful for this insight." It is expected that in the times to come, the locals would be more involved in commercial production of the flora for obvious reasons.

### Scientific Intervention

Two free floating alga, namely *Enteromorpha intestinalis*, *Enteromorpha prolifera* and one substrate bound alga, *Ulva lactuca*, were stabilised in the inundated areas, of which the free floating species could be harvested in the month of November. The annual average biomass productivity and carbon mitigation potential of cultivated algal stock was calculated from incoming solar radiation and photosynthetic efficiency of the algal species (Sudhakar & Premlatha, 2012). Yield and growth were calculated and compared following DGR% (Dawes et al, 1993). The comparative growth rates and seasonal changes in carbon mitigation potential were derived. Perusal of data showed that

the maximum optimistic CO<sub>2</sub> fixation capacity is 117 metric tons per hectare per year, obtainable in U-Lock culture technique during post monsoon season in *E. intestinalis*, whereas it is lowest in *E. prolifera* during pre-monsoon season nearing to 57 tons of CO<sub>2</sub> per hectare per year only. This estimate is dramatically higher than carbon fixation capacity of terrestrial plants (Ravindranath & Bhatt, 1997). Therefore, it is evident that the accrued biomass through algal growth is a direct evidence of carbon capture by aquatic flora in inundated waters (Campbell et al, 2010; Chi et al, 2011; Kaladharan et al, 2011).

One scientific workshop was organised at Jadavpur University Marine Science Department, wherein the field data collected and other limnological data retrieved from the project site were shared with the scientific community.

### Future Roadmap

In the next few months, scientific seminars and workshops to bring in fresh knowledge in the concerned field will be held. Two more algal stocks from south Indian coasts will be brought for cultivation by Central Marine Fisheries Research Institute and SAFE wishes to impart its experiences on algaculture as a sustainable aquafarming technology. Furthermore, a meeting between SAFE and the beneficiaries for commercial linkages and market research with the products is planned. Publications and manuals in local languages are yet to be developed for the beneficiaries.

## Project Publications

- “Potentials of Algal mass Culture for Biological Carbon Capture and Storage in Saltwater Inundated Coastal Wetlands” scientific paper communicated to WETLANDS (status under review).
- An article published in National Newspaper, “Hindustan Times”

## Acknowledgements

We sincerely acknowledge the support from APN and Korea Green Foundation based in Seoul for sponsoring SAFE. We also acknowledge the support and resource sharing of our collaborators namely Central Inland Fisheries Research Institute (CIFRI), Department of Oceanography and Marine Science, Jadavpur University, NABARD, and the Indian Institute of Technology, Kharagpur.

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### CBA2013-14NSY-MAITY

#### PROJECT TITLE

**Promoting Algaculture in Trapped Waters as Sustainable Aquafarming and Adaptive Climate Mitigation in Inundated Coastal Areas**

#### COUNTRIES INVOLVED

Indonesia, Philippines, Viet Nam

#### PROJECT DURATION

One-year project

#### APN FUNDING

US\$ 35,000

#### PROJECT LEADER

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**CBA2013-15NSY-HEINRICH-SANCHEZ**

# Building Capacity in Marine Litter Management in the NOWPAP (Northwest Pacific Action Plan) Region

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A regional workshop and beach cleanup campaign that comprised participants of NOWPAP member states (China, Japan, Republic of Korea and Russia) from central and local governments, research institutions and NGOs dealing with Marine Litter were undertaken. As Marine Litter is an issue of national, regional and global concern, participants from the US, including Hawaii, Alaska, California and Washington DC; the Philippines, Hong Kong (China), Thailand, Indonesia were also invited and from some international organisations and projects. The four NOWPAP national-based Regional Coordinating Units (RCU) also participated.

Marine Litter extends beyond national jurisdiction and, as there is no global regulatory framework in place, addressing source country responsibilities was expected to strengthen practical regional cooperation among the NOWPAP countries of China, Japan, Republic of Korea and Russia. This expectation was based on the existing international framework adopted by the four countries

under the NOWPAP “*Regional Action Plan on Marine Litter*” (RAP MALI) in 2008. Within RAP MALI, national and regional-based activities are being carried out in an effort to prevent, monitor and remove marine litter in coastal areas. The present project, therefore, was expected to facilitate the implementation of the Regional Action Plan. During the workshop, best practices of Marine Litter Management was shared among participants from local, national and international organisations and projects.

The objectives of the workshop and beach cleanup were to:

- Enhance capacity for the effective management of Marine Litter among NOWPAP member states and for the implementation of the NOWPAP RAP MALI;
- Promote public awareness of Marine Litter impacts on coastal and marine ecosystems in the NOWPAP region;

## HIGHLIGHTS

- » NGOs are taking the lead in mobilising the general public and local governments.
- » NGOs have become a catalyst for change at national and regional levels.
- » A natural systems approach for monitoring and cleanup of marine litter is being undertaken that includes: Extended Producer Responsibility (EPR), plastics as hazardous waste, new methods for monitoring micro-plastics and new partnerships.
- » Mapping of Marine Litter sources, including dumps and landfills is becoming more common place
- » Social media is effective in showcasing Marine Litter issues.
- » China’s NGO sector is growing and becoming active in forming regional partnerships.
- » Russia is expanding its campaigns.
- » China’s 12<sup>th</sup> Five-year Plan, Japan’s Marine Litter Fund, and Republic of Korea’s 2<sup>nd</sup> Marine Litter Management Plan 2014-2018 are showing on-going commitment.
- » There is a new level of international cooperation in the NOWPAP region.



**Figure 1. NOWPAP Workshop participants: Backdrop is the “My Island: My Earth” Charter. Art by Naka Bokunen.**

- Strengthen cooperation among countries to deal with Marine Litter, including data collection and exchange of information; and
- Share best practices for waste management, including policy measures introduced for sustainable production and consumption (e.g., introduction of mandatory recycling, deposits for beverage containers, free plastic bags distribution).

The workshop was held from 24-25 October 2013 at the Okinawa Institute of Science and Technology Graduate University (OIST) and co-organised by the NPO Okinawa Ocean Culture and Environment Action Network (OCEAN) and NOWPAP RCU. The workshop comprised four sessions: 1) Efforts of NGOs to deal with marine litter; 2) Central and Local Government action; 3) Research, Monitoring and New Technologies in Marine Litter; and 4) International Cooperation. Key APN participants attended the First Okinawa NGO Asia-Pacific Environmental Forum held the previous day at OIST Seaside House where participants used the AtKisson Sustainability Compass and ISIS Pyramid Approach (see diagram), which is adopted as a sustainability lens to observe perspectives and action to tackle the problem of Marine Litter.

All presentations are available at the NOWPAP Data and Information Regional Activity Center: <http://dinrac.nowpap.org/document-ICC-2013.php>

Directly following the workshop, a special evening session was dedicated to the modelling (and observations) of tsunami-generated debris drifting in the Pacific. NOWPAP workshop participants had a rare opportunity to hear firsthand about collective work of experts from Japan, USA and the UK. Details of sessions can be found at: <https://groups.oist.jp/all-oist-event-category/external-event>

In a separate half-day meeting on the NOWPAP Regional Action Plan, the implementation of RAP MALI or the year ahead was discussed among the Focal Points and other representatives of NOWPAP.

The beach cleanup was organised on the final day. At the first location at Cape Maeda, Onna Village, Jyane Beach, NGO and Okinawa Clean Coast Network (OCCN) volunteers held a small ceremony where the Okinawa International Clean Beach Club was started in 1992. A NOWPAP team of about 20 participants collected and sorted much Marine Litter from Kuraha Beach, which is a special monitoring point, and compiled data using ICC data cards in English, Chinese and Russian. The compiled data is to be submitted to the Ocean Conservancy by the ICC coordinator for Okinawa.

Outcomes from the workshop and beach cleanup could be summarised below.

“...A promising first date in the regional courtship for clean, resilient and sustainable seas” included:

- Exposure to enhanced knowledge and skills on Marine Litter management of national NOWPAP Marine Litter focal points, NGO and international organizations’ representatives, ICC national coordinators from developing countries through sharing best practices and know-how.
- Further strengthened cooperation in the NOWPAP region on Marine Litter, including cooperation between NOWPAP and other international organizations.
- Enhanced cooperation within local Marine Litter networks.
- NGO-generated on-line tools are needed to help government officials who are recently transferred to the Marine Litter sector.
- While there is increased awareness there is

lacking methodology to connect local best practices at a wider scale on the need to reduce Marine Litter (through better sustainable production and consumption patterns) among those involved.

- The NOWPAP RCUs require metrics to gauge progress.
- Okinawa Prefecture will be included in the NOWPAP geographical scope.
- The “My Island: My Earth” Charter project will incorporate Education for Sustainable Development (ESD) and be released in Nagoya for the end of the UN Decade ESD.

While the project was undertaken according to plan, some stumbling blocks included two major typhoons. The Okinawa NGO Center provided logistical support and NGOs will continue to lead Marine Litter initiatives. While governments and UN agencies need to work more closely with local NGOs, NOWPAP could be more effective if a panel of three NGOs led by an ICC Coordinator were invited as part of an advisory committee.

### ***Marine Litter is a Symptom of Unsustainable Practices***

After the Tsunami in Japan and with the recent typhoon Haiyan in the Philippines, debris generated will take a fast track on the Kuroshio current making Okinawa islands a key location for monitoring and cleanup action. A deeper and more active partnership between Northwest Pacific countries and the Philippines will be important. The following challenges on marine litter management are yet to be realised:

1. The before and after of a NOWPAP WS has to



**Figure 2. Coastal clean-up participants.**

be looked at as to how effective its impact is on creating tangible long-term results for measurable capacity building.

2. NGO’s leading ICC Campaigns need to form part of the NOWPAP Intergovernmental decision-making process.
3. A follow up report will be presented at the 2014 NOWPAP WS in Korea and 20<sup>th</sup> Anniversary special session.

### **Acknowledgements**

We thank the APN for its support, OIST for the venue and the NOWPAP RCU and UNEP Regional Seas Programme for the opportunity to host the 2013 workshop. We thank the Okinawa NGO Center and our staff as we celebrate the 20<sup>th</sup> Anniversary of the *I Love Okinawa Campaign*<sup>®</sup> started by our founding members of Okinawa International Clean Beach Club/NPO Okinawa O.C.E.A.N. ICC Coordinators since 1993.

## **CBA2013-15NSY-HEINRICH-SANCHEZ**

### **PROJECT TITLE**

**Building Capacity on Marine Litter Management in the NOWPAP (Northwest Pacific Action Plan) Region**

### **COUNTRIES INVOLVED**

China, Japan, Republic of Korea, Russia

### **PROJECT DURATION**

One-year project

### **APN FUNDING**

US\$ 33,000

### **PROJECT LEADER**

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**CBA2013-16NSY-DARGANTES**

# University Initiatives for Food and Water Security in a Changing Climate

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## Introduction

During the 6<sup>th</sup> Executive Forum on Natural Resources Management conducted by the Southeast Asian Regional Centre for Graduate Study and Research in Agriculture (SEARCA) from 11-13 April 2012, participants reported their respective initiatives in dealing with climate change and water and food security. A number of participants expressed the need to share research results, and to find climate-resilient natural resources utilisation modalities.

## Objectives

This project intends to strengthen the capability of agriculture academicians to formulate research and extension agenda, design curricular programs, and produce knowledge materials that address water and food security concerns within the context of climate variability and change. In the process, it provides a venue for university professors and government planners to exchange ideas, knowledge and experiences on water-efficient and climate-resilient food production.

## Work Undertaken

During the Inter-University Project Planning Meeting held from 28-30 October 2013 at the Center for Land Resources Study, Faculty of Agriculture, Gadjah Mada University, updates to the country papers on the topic "Water and Food in a Changing Environment" were discussed. Appropriate methodologies for implementing

the ongoing activity "Documentation and Mapping of Relevant Experiences and Good Practices in Incorporating Food and Water Security and Climate Change Issues into Agricultural Research and Extension Projects" were identified.

## Project Results

### *Sustainable Peatlands Development for Food Production*

Peat burning in Indonesia's 20.6 million-hectare tropical peatlands contributes about 469MT of CO<sub>2</sub> emissions per year. Maas (2008) reported that regulating water levels in peatlands can improve rice cropping, while uncontrolled canalisation reduces water holding capacity, accelerates water flow, lowers the water level, and makes the peat dry leading to fire outbreaks during long dry periods. CO<sub>2</sub> emissions for oil palm plantations with a drainage depth of 80 cm can reach 1820t/ha for a 25-year production cycle. Batistel (2008) concludes that conversion from rubber to oil palm accelerates CO<sub>2</sub> emissions, and reduces diversity.

### *Climate Change for IWRM: Lessons Learned from the Citarum Catchment*

The Institut Pertanian Bogor (IPB) has been advocating for resilience of agricultural systems through policies and plans that take into account the El Niño Southern Oscillation (ENSO) phenomenon. The Center for Climate Risk and Opportunity Management (CCROM)

## HIGHLIGHTS

- » Landscape characteristics and farm-level crop production potentials should be considered in peatland development. This is in order to minimise greenhouse gas (GHG) emissions and maximise carbon stock accumulation, and to optimise crop productivity. Appropriate management practices of peatland ecosystems could reduce GHG emissions while contributing to ensuring food and water security.
- » Hydrologic modelling at the river basin or catchment level could provide substantial insights into effective mitigation and adaptation practices to ensure water and food security in upstream, midstream and downstream areas. Such insights could significantly contribute to improving land and water use planning at various sub-catchment levels.
- » Participatory management of irrigation systems provides a platform for increased community involvement in water resources management. Although the transition from centralised management to community-based planning and implementation may take time and resources, university engagement may strengthen the incipient local development initiative.
- » Conflicts in access to and/or availability of resources (e.g. minerals versus land and water for food production) and in the levels priority of access (e.g. domestic water use versus irrigation) have become more pronounced when juxtaposed with community level experiences in climate variability. Scientists and policy makers need to review the criteria on beneficial resource use, and take into consideration water and food security requirements within the context of a changing environment.
- » The Bicol region of the Philippines is prone to extreme climate and geologic events such as typhoons, landslides and volcanic eruptions. Responses to disaster risks include the design of buffering mechanisms for food production systems to make them resilient to extreme events (e.g. rehabilitation of mangroves, riparian ecosystems, and agroforestry farms), and of procedures for the quick recovery of such systems (e.g. introduction of short gestation crops to address household food needs).

has been conducting hydrological modelling for the upstream, midstream and downstream areas of Citarum, Central Java. Recommendations include institutionalising the use of climate information in agricultural development, giving priority to structural interventions to minimise climate risks, expanding agriculture to areas with lower climate risks, developing resilient varieties, and climate modelling of mitigation and adaptation technologies.

### ***Water Management for Food Production: Concerns for Agricultural Education***

The Faculty of Agricultural Technology and Management of the Cambodian Royal University of Agriculture handles courses in water resources management for food production, conducts research on irrigation and drainage systems, and implements projects to strengthen Farmer Water User Committees (FWUCs) and promotes inclusiveness and environmental health. One of its major initiatives is the Participatory Irrigation Management and Development (PIMD), which establishes FWUCs to take over the management of irrigation systems from government. The FWUCs regulate access to water, collect fees, and monitor, interdict, and prosecute violators.

### ***Water and Food Security as Affected by Mining and Water Use Options***

The LIDAROIMMA Irrigators Association in the town of MacArthur, Leyte, Philippines had to confront a fish kill in a nearby lake, the destruction of irrigation canals, and flooding of the rice fields as a consequence of mining operations; and the lack of consultations regarding the impact of mining. These events served as direct threats to local food availability through the loss of rice and fish.

In 2007, a mining company operating in Kasibu, Nueva Vizcaya planned to use 3.8 million cubic metres of water annually, a volume that could be used to produce 1,538 metric tons of rice. Residents opposed the WPAs because the mining operations could generate waste which could render the Addalam River Irrigation Project inoperable.

### ***Water Resources Management and Food Production in Bicol***

Rice, coconut, corn and abaca are the major crops of Bicol, Philippines. Inadvertently, water impounding projects have deprived many downstream areas of water. Moreover, the flash floods of January 2011 destroyed 93 sq. km. of farmlands with production



**Figure 1.** Inter-University planning meeting held in October 2013 at the Center for Land Resources Study, Gadjah Mada University, Indonesia.

losses of 16,563 tons, and led some farmers to abandon their lands. Some communities have undertaken mangrove rehabilitation to protect estuarine production areas, revegetation of riparian areas to protect farms and irrigation structures, and establishment of short-rotation crops to address immediate household food requirements in order to make livelihoods resilient to climate events.

### Upcoming Project Publications

Peat Utilization for Food Production by Maas, Azwar (Corresponding Author)

Climate Change for IWRM: Lessons Learned from Citarum by Suharnoto, Yuli (Corresponding Author)

Water Management for Food Production: Issues and Concerns for Agricultural Education in Cambodia by Ek, Sopheap (Corresponding Author)

Food and Water Security as Affected by Mining and Water Use Options by Dargantes, Buenaventura (Corresponding Author)

Water Resource Management Affecting Food Production in Bicol, Philippines by Batistel, Cheryl (Corresponding Author)

### Acknowledgements

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**CBA2013-16NSY-DARGANTES****PROJECT TITLE**

**Strengthening the Capability of Colleges of Agriculture in Incorporating Food and Water Security and Climate Change and Climate Variability into Curricular Programmes, Research and Extension Projects and Teaching Modules**

**COUNTRIES INVOLVED**

Cambodia, Indonesia, Japan, Philippines

**PROJECT DURATION**

One-year project

**APN FUNDING**

US\$ 43,000

**PROJECT LEADER**

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LCI  
PROJECTS

3

*Focused activities under the*  
**Low Carbon Initiatives (LCI)  
Framework**

LCI2012-01NMY(R)-VASHIST

# Identification of Policy and Institutional Gaps, Drivers and Strategies to Scale-Up Low Carbon and Energy Efficient Technology Application in the Construction and Infrastructure Sectors of South Asia

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## Introduction

The research is dealing with the rapidly growing construction and infrastructure sectors in the identified APN developing countries (i.e., India, Pakistan and Nepal) with a focus on low carbon, resource and energy efficient options. It will study the policy thrusts and national commitments towards transformation of the sectors and the barriers with respect to technology know-how, regulatory mechanisms, capacities of stakeholders and market promotion. It will look at drivers for change within the institutional mechanisms, financing systems, incentives and partnership arrangements to define the critical elements of the ecosystem for promoting low carbon development pathways in the identified sectors.

The study is built on the rationale that construction, one of the fastest growing sectors, is a significant contributor to the development process of South Asia. However, this sector has an enormous ecological footprint. It is one of the highest contributors to greenhouse gas (GHG) emissions. It is also responsible for massive resource consumption. The need for improvement of the construction sector is obvious. However, despite continuous efforts, examples of successful initiatives can be observed only in a few clusters. It is extremely necessary to mainstream low carbon technologies in order to mitigate the impacts of increased GHG emissions.

Proclaimed by the United Nations Framework Convention on Climate Change (UNFCCC) as one of

## HIGHLIGHTS

- » Project planning meeting was held on 21 August 2013 at the Development Alternatives World Headquarters, New Delhi. It was attended by all the partners (i.e., CANSA, DA, LEAD and CEN).
- » Risk management plan and communication dissemination plans have been developed.
- » Technology and institutional mapping initiated.

the cheapest avenues for GHG mitigation, the potential for adopting Clean and Low Carbon options in the construction sector have largely remained untapped. The regional-based research project will look at economic, technological, and regulatory and policy frames in the different country situations and will strengthen regional global change research by identifying key gaps and areas for integrative research. Identified drivers for change will highlight areas for capacity building and partnerships for sustainable delivery of low carbon solutions for sustainable development.

Key policy questions that the study will seek to answer are:

- How can regulatory and financing frameworks create an enabling environment for the proliferation of low carbon technologies across the region in public and private construction and infrastructure development?
- What kind of institutional capacity gaps need to

be filled (and how) for accelerating low carbon construction and infrastructure?

- What kind of partnerships are required to ensure a robust ecosystem for the accelerated application of low carbon construction and infrastructure technologies?

A project planning meeting was held on 21 August 2013 at the Development Alternatives World Headquarters, New Delhi with the objectives of orienting the partners to the research and discuss the action plan and responsibilities of each partner. It was attended by all the partners such as the Climate Action Network South Asia (CANSAs), Development Alternatives (DA), Leadership for Environment and Development (LEAD) and Clean Energy Nepal (CEN). Detailed discussions were held on the scope of activities. It was decided to focus the research on housing, especially social housing in small towns and peri-urban areas. A mindmap was prepared to help narrow down the scope of the project. Regarding policy and regulatory framework, it was proposed to focus at both national and regional levels and link it with the international framework.

A risk management plan and communication dissemination plan for the project were also prepared. The communication plan consists of a list of communication materials that need to be developed. As a part of the literature survey, the process of technology and institutional mapping and profiling has been initiated. The technology mapping includes traditional, conventional and alternate in the sector. Special emphasis is given to new and emerging technologies. The institutional map highlights relevant public and private bodies working in this space, along with their mandate, to help identify capacity gaps. Simultaneously, we are in the process of finalising the case

studies, which would feed into the research. The case studies will be supplemented by consultations with experts at national and regional levels.

### Upcoming Project Publications

- Country reports on Low Carbon Construction, Drivers and Barriers
- Blogs on Low Carbon Construction
- Newsletter articles on Low Carbon Construction
- 2-3 Case studies of good practices in each country
- Project brochure on Low Carbon Construction, Drivers and Barriers

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## LCI2012-01NMY(R)-VASHIST

### PROJECT TITLE

**Identification of Policy and Institutional Gaps, Drivers and Strategies to Scale-up Low Carbon and Energy Efficient Technology Application in the Construction and Infrastructure Sectors in South Asia**

### COUNTRIES INVOLVED

Bangladesh, India, Nepal, Pakistan

### PROJECT DURATION

Year 1 of a two-year project

### APN FUNDING

US\$ 83,600

### PROJECT LEADER

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LCI2012-02NMY(R)-DHAKAL

# Understanding and Quantifying the Water-Energy-Carbon Nexus for Low Carbon Development in Asian Cities

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## Introduction

Water, Energy and Carbon (WEC) Nexus is central to the interaction of natural, social and economic environments. The nexus directly influences three key contemporary policy objectives facing policy makers, namely, climate change mitigation, energy security, and water security. Past researches and our understanding of drivers, processes and implications of this nexus in cities are very limited, while cities are key places to analyse this nexus given the present context of speed and scale of urbanisation. Today's Asia's urban population is 44%, which is expected to reach 64% at the middle of the century (UN, 2012). Water and energy are inherently linked, with added challenges due to population growth, climate change, urbanisation, and increasing consumption patterns of energy and water. Hence, there should be an integrated approach in decision-making and planning processes. This is novel research in the emerging field and highly relevant in the Asian context due to very limited research done in Asia but of high policy relevance.

The study is to be carried out in three Asian cities: Bangkok, Delhi and Tokyo. These cities are characterised by different stages of development with distinct differences in geographical, social and climatic environments.

## Objectives

The WEC Nexus project is aimed to achieve the following objectives:

- Characterising nature of WEC Nexus through comparative case studies in Bangkok, Delhi and Tokyo.
- Quantifying the nexus to determine the extent of

## HIGHLIGHTS

- » The first phase focuses on characterising nature of Water, Energy and Carbon (WEC) nexus through comparative case studies in Bangkok, Delhi and Tokyo.
- » The second phase focuses on quantifying the WEC nexus to determine the extent of the direct and indirect significance and to exemplify the potentials of the nexus to the low carbon development in cities.
- » The study highlights key issues such as drivers, major linkages for WEC nexus in urban water and energy systems, which will address barriers and opportunities for optimising the nexus with policy implications.

the direct and indirect importance and to exemplify the potentials of the nexus to the low carbon development in cities.

- Gauging the extent and relevancy of addressing the barrier and opportunities for optimising the nexus, as well as influence the policy for low-carbon development.

## Work Undertaken

**Project Meetings.** Conceptual framework and protocol has been finalised following the two meetings on 1 September 2013 and 9-11 September 2013 between project implementers and co-project implementers. The outcomes of the meeting were the deliberation of project planning, scheduling, scoping, and development of framework and protocol.

**Conceptual Framework and Research Protocol of WEC Nexus.** The research protocol of WEC Nexus is aimed to apprehend the major linkages, key indicators, drivers and implications of water, energy and carbon in every element and components of the urban water and energy cycle. It provides guidelines for the case studies in three cities in both broad and in-depth scale. Furthermore, the protocol is aimed to address important questions such as: (1) How those drivers can be influenced through policy?; (2) Where are the option and policy linkages?; and (3) What are the barriers?

The other components of the research protocol are developing comprehensive understanding and quantifying energy implications in every elements of the urban water system: water abstraction, transport, treatment, distribution, consumption, collection and treatment of waste water; and water use implications in energy utilities, from power plants to end uses. One outcome of the project includes refined protocol intended for application in other cities.

**Project Website.** The project website is developed under the domain name of Asian Institute of Technology (AIT) for information sharing among global development and scientific communities.

**Initiation of Case Studies.** Case studies in all three cities have been initiated under the common framework of the WEC Nexus. AIT has the role of coordinating overall projects as well as focusing specifically on case study of Bangkok, while TERI University and Hiroshima University is undertaking case studies of Delhi and Tokyo, respectively.

The project team is expecting to complete the case studies and organise syntheses workshop for finalising quantification methodology by end of February 2014.

## Acknowledgements

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### LCI2012-02NMY(R)-DHAKAL

#### PROJECT TITLE

**Understanding and Quantifying the Water-Energy-Carbon Nexus for Low Carbon Development in Asian Cities**

#### COUNTRIES INVOLVED

Japan, India, Thailand

#### PROJECT DURATION

Year 1 of a two-year project

#### APN FUNDING

US\$ 80,600

#### PROJECT LEADER

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LCI2012-03NMY(R)-LOPEZ

# Assessment of Carbon Sequestration through Vermitechnology in Organic Farming

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## Introduction

The impact of climate change can never be underestimated in the Philippines, one of the countries in the Asia-Pacific region that has bitterly suffered the onslaught of typhoons, floods, earthquakes, volcanic eruptions and landslides. Enhancing climate change resiliency through mitigation and adaptation are challenges for any research and development endeavour in the country, while at the same time addressing other critical issues of food security and food safety. This research may be considered an ambitious attempt to bridge the knowledge gap between climate change and an environment-friendly method of food production through organic farming that involves the use of waste recycling with the action of earthworms. The research is timely and relevant as the technology of vermicomposting, or composting with earthworms, is widely popular as a mature technology adopted in Sustainable Organic Agriculture in the Philippines and other Asia-Pacific countries. Vermicomposting is an aerobic process of treating biodegradable farm and domestic waste using litter earthworm species to produce a vermicompost or vermicast. Earthworm excreta is called a vermicast, while vermicompost is a mixture of the earthworm excreta and the decomposed organic matter from the aerobic action of microorganisms in the composting substrate. In the last decade, innovations have been introduced like variation in substrate type and proportion, liquid formulations by vermicompost brewing called vermitea and variations in production design and scale. Vermicompost or vermicasts are being valued for their slow-nutrient-release action in the soils because of the peculiar characteristics imparted by earthworms. The worm-worked product resembles a stable organic matter that can act as a nutrient and carbon sink.

## HIGHLIGHTS

- » Criteria of a Permanent Monitoring Site (PMS).
- » Baseline information of the PMS, soils and vermicompost quality, and earthworms.
- » Development of gas collection and measurement protocol.
- » Dialogue with policy makers and technology adopters.

However, being microbially active, the application of a vermicompost or vermicast in the soils may contribute to faster mineralisation of nutrients with a resultant larger emission of methane and nitrous oxide. There are also contrasting results showing the reduction of carbon mineralisation-effect of casts when these are naturally present in soils. In a vermicomposting system, the emission of biogenic carbon dioxide may be high because of the larger population of earthworms and microorganisms, and the enhanced earthworm-microbial synergies.

Generally, agriculture is known to contribute significantly to greenhouse gas emissions specifically methane and nitrous oxides, because of the use of synthetic fertilisers, and the interaction of soil organic matter and soil biota. However, this may differ in an organic system that makes use of earthworm-based technologies (vermitechnologies) in lieu of the synthetic inputs. Nitrogen and carbon mineralisation-fixation dynamics and gas emission pathways in a controlled vermitechnology-based system and as applied in the field is less understood and needs to be investigated. Hence, this research project aims to assess the carbon budget, and estimate greenhouse gas emissions within a vermitechnology-based organic farming system. The basic knowledge relating organic agriculture to climate change, specifically on the



**Figures (left to right):** (1) Experimental gas collection set-up; (2) Earthworm and soil sampling; (3) Gas measurements by gas chromatography and gas sensors; (4) The Project Leader discussing the APN-LCI Research with the Department of Agriculture Secretary Proceso Alcala at the PMS1, Kahariam Realty and Farms, Lipa City, Batangas, Philippines, 6-8 November 2013.

role of earthworms and its associated technologies can contribute to the Science Agenda of the APN Third Strategic Plan. The main output is a carbon footprint and a model that can provide a quantitative basis of the carbon balance in the closed system and its effectiveness to climate change mitigation and adaptation.

### Work Undertaken

*Procedures and Criteria Setting.* The partners met in the Philippines in May, October and November 2013 to refine methodologies and timeframe of activities. Gaps in the microbiological testing and DNA sequencing methods were identified, and a target to send samples to laboratories in Korea and the Soil-Food-Web in Oregon, USA, were set. Being bound by strict Philippine regulations, biological sampling and sending samples abroad are considered tedious and are limiting factors in the research.

The criteria for the selection of a Permanent Monitoring Site (PMS) was established, which includes:

- A practicing organic farm for at least five years.
- Produces vermicompost or vermicast as input to its farming operation.
- Certified by a third party certification in the Philippines, and adheres to the organic integrity.

With these criteria, three sites were selected serving as three sampling replications. PMS1 is located in Luzon, PMS2 in the province of Panay and PMS3 in the island of Negros. Conventional farms adjacent to the PMS sites were sampled for comparison.

Three field sampling periods of earthworms, i.e. peak of 2013 dry season (March), start of 2013 wet season (May) and peak of 2013 wet season (November), soils and vermicomposts were undertaken. The

last sampling schedule supposedly covers the end of the wet season and start of the dry season, but the Monsoon rains and typhoons extended the wet season period. Soils and vermicompost were sent to the laboratories in the Philippines for microbial and physico-chemical analyses. Earthworm data included biomass, population/density counts, and species identification. Earthworm samples included the natural and possibly the migrant residents in the vermicomposting beds and the sampling areas where vermicompost is applied. Earthworm collection is intended for deposition at the National Museum, but while this is in process, the species collected are being stored at the National Institute of Molecular Biology and Biotechnology Laboratory of the University of the Philippines Visayas (UPV). The first batch of earthworm extracts sent for DNA sequencing at Hanyang University, Seoul, Korea were not successful, primarily because of the long-transit with inadequate handling/storage conditions for the samples. The second batch for DNA sequencing makes use of earthworm tissues instead of extracts.

### Gas Collection and Measurement Protocol

APN's agenda on capability and capacity building in research and technology development on climate change is being realised through designing and methodological development of GHG collection and measurements done by the chemical engineering students of the School of Technology, UPV. Preliminary testing on variables such as substrate types and size of the gas collection unit showed effects on the rate of gas emission in the vermicomposting bins. As part of protocol development, gas sensors from

GASTECH, Australia will be compared and validated with values obtained by volumetric methods and with the CNS analyzer. A preliminary run using gas chromatography failed to yield results for the gases, rather, the volatile organic components in the collected gases were indicated.

### ***Dialogue with Policy Makers and Technology Adopters***

The impact of climate change in agriculture is primarily perceived by farmers and other stakeholders as “drought, flooding, unpredictable weather and higher field temperature compared to previous years”. This is a summary of the perceptions of the participants during the PANEL SESSION ON CLIMATE CHANGE: Dialogue on Science, Technology and Policy Interface in Climate Change Mitigation and Adaptation at the 3rd International Symposium on Vermitechnologies (ISVT-3) held at KAHARIAM Farms (which is PMS1) from 6-8 November 2013. The concept and objectives of the APN-LCI Research on Carbon Sequestration was presented back to back with the Farmers’ Field School Curriculum for Climate Change Adaptation, a USAID funded project being implemented in the Philippines. During the Farmers’ Forum, the need for the APN-LCI Research to interface with Farmers’ Field School for Climate Change was seen as a means to disseminate a clear and simple knowledge of the mechanism relating climate change to the soils and the farming environment. To focus on the organic agriculture agenda, the Secretary of Agriculture, Secretary Proceso Alcala who participated in the dialogue and consultation forum stressed

the need for a scientific investigation on the value of vermitechnology, noting its positive effect on water conservation and natural soil fertility building due to earthworms, the soil biota and soil organic matter build-up. About 123 males and 81 females comprised of farmers, educators, agricultural and environmental workers, researchers, agripreneurs and policy makers from government, non-government and private sectors participated in ISVT-3. The Symposium which was organised by four partners including the APN-LCI Research Project aimed to provide basic information and updates in vermitechnologies not only in the Philippines but also in other countries.

### **Acknowledgments**

We would like to thank the Asia-Pacific Network for Global Change Research for providing the opportunity for us to work within the Low Carbon Initiative (LCI) Framework. The financial support is an enabling factor to work together on an urgent issue and contribute to building knowledge on climate change among the users of vermitechnologies and the organic farming sector. Acknowledgement is also due to our individual institutions for the support and assistance, and the KAHARIAM Farms and Realty, Inc. and Peñalosa Farms who acceded to be the permanent monitoring sites in the Philippines.

## **LCI2012-03NMY(R)-LOPEZ**

### **PROJECT TITLE**

**Assessment of Carbon Sequestration through Vermitechnology in Organic Farming**

### **COUNTRIES INVOLVED**

Korea, Philippines, Viet Nam

### **PROJECT DURATION**

Year 1 of a two-year project

### **APN FUNDING**

US\$ 83,500

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LCI2012-04NMY(R)-MACANDOG

# Knowledge and Opinion on the Sustainability of Bioenergy Production in Asia: Cases in China and the Philippines

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## Project Objectives

A better understanding of human perception on the sustainability issues confronting bioenergy will help develop appropriate policy for promising renewable energy sources. PIC-STRAP project aims to contribute to this challenging task through application of integrated assessment modelling approach called STRAP (Sustainability TRade-offs and Pathways), which highlights social perception and policy preferences. PIC-STRAP's specific objectives are: (1) to systematise existing knowledge on sustainability of bioenergy; (2) to understand social perception on and policy preferences for different feedstocks; (3) to determine society's sustainability trade-off decisions in the use of resources; (4) to assess alternative pathways in bioenergy development and their effects on sustainable low carbon society transition, and (5) to facilitate the integration and dissemination of the generated knowledge.

## Project Results

### *Survey Report: Knowledge and Opinion on Bioenergy*

PIC-STRAP case study countries include the Philippines, India and China where bioenergy is considered a promising sector to improve energy security and thus "fuel" economic growth. Online and field surveys are

## HIGHLIGHTS

- » Many respondents in China consider fossil fuel and in the Philippines consider biomass and other renewables as very important for promoting economic growth.
- » Bioenergy feedstock from starch-rich crops are more favoured in China and oil-rich crops in the Philippines.
- » In the Philippines, many farmers in Calabarzon (Luzon) are misinformed and in Davao (Mindanao) are unaware about bioenergy.

being conducted in these Asian countries to understand knowledge and opinion on bioenergy. Preliminary survey results show that most respondents in the Philippines think that bioenergy and other renewables have high and very high contribution to the economy (Table 1). In China many respondents consider fossil fuel as an important source of energy. Among first-generation feedstocks, starch-rich crops are more favoured in China and oil-rich crops in the Philippines. The latter reflects the perceived potential of coconut for bioenergy. Among second-generation feedstocks, agriculture/forest residues and fast-growing trees are considered high/very high potential energy sources both in China and the Philippines. More respondents in China do not know the contribution of first-generation feedstock, while those in the Philippines of second-generation feedstock.

**Table 1. Opinions on the contribution of different energy sources to economic growth.**

Opinion on Bioenergy Feedstocks	China			Philippines		
	Very low/ Low	High/ Very High	Do not know	Very low/ Low	High/ Very High	Do not know
<b>Energy sources</b>						
Fossil	19.01	78.51	2.48	31.73	59.62	8.65
Bioenergy	38.02	48.76	13.22	13.46	78.36	8.17
Other Renewables	31.40	52.07	16.53	13.46	75.00	11.54
Combined	24.79	52.07	23.14	12.98	76.44	10.58
<b>First generation</b>						
Sugar-rich crops	33.88	53.72	12.40	25.97	65.86	8.17
Starch-rich crops	25.62	65.29	9.09	29.81	62.50	7.69
Oil-rich crops	27.27	62.81	9.92	19.23	73.56	7.21
<b>Second generation</b>						
Agric./forest residues	33.88	58.68	7.44	20.68	65.86	13.46
fast-growing trees	33.88	58.68	7.44	29.33	59.13	11.54
perennial grasses	42.15	42.15	15.70	36.54	47.12	16.35

Note: The values are percent of the total 208 participants (i.e. China 121, Philippines 208), thus each row sums up to 100 percent.

Table 2 reveals that familiarity on bioenergy is higher in the Philippines (86.54%) than in China (66.94%). The proportion of respondents who are familiar with bioenergy is relatively the same across groups of respondents in the Philippines, except for farmers. But in China familiarity with bioenergy is concentrated in academia/research. Half of all respondents in China and the Philippines perceive that bioenergy affects food security. Moreover, about 92% of the respondents in both countries think that bioenergy is good for the economy. In the Philippines none of the farmers thinks that their work is related to bioenergy. But farmers' role as feedstock producers is crucial to developing the bioenergy sector.

## Other Activities

### *Kick-off meeting*

Teams from all partner countries convened for a kick-off meeting in UPLB on 12 June 2013. The activities conducted included training, workshop and field trip. The training covered presentations/discussions on various topics relevant to the project. The workshop was held to plan activities, assign responsibilities and identify deliverables of each partner. The meeting was concluded with a field trip to Quezon, one of the project study sites,

to initiate stakeholder involvement in the Philippines.

### *Stakeholder involvement*

On 15 June 2013, all PIC-STRAP teams met with Mr. Crisostomo (municipal officer) and Mr. Coronacion (officer of farmer cooperative) to make inquiry about the potential of bioenergy production in Quezon. They showed the local distillery for nipa, which like coconut can be used as bioenergy feedstock. On June 6, 2013, teams from the Philippines and Germany met with the representative of Mayor Balbin, Jr. in New Bataan, Compostella Valley in Mindanao, where coconut is a major crop.

### *Project Dissemination*

The project website is available at <http://www.strap.pik-potsdam.org>. A paper was presented at the 2013 International Society for Southeast Asian Agricultural Sciences (ISSAAS) Congress held in Muntinlupa City, Philippines from 11-15 November 2013. As part of the outreach activities, the project leader explained to residents in Quezon the role of bioenergy in the Philippines on 14 September 2013.

**Table 2. Knowledge and opinion on bioenergy in China and the Philippines.**

Knowledge on Bioenergy	China*					Philippines					
	R1	R2	R4	R5	R1-R5	R1	R2	R3	R4	R5	R1-R5
Familiar with the term bioenergy	4.13	7.44	47.11	8.26	66.94	22.12	20.67	9.13	17.79	16.83	86.54
Work is related to bioenergy	2.47	1.23	7.41	6.17	17.28	7.22	1.67	0.00	5.56	2.22	16.67
Bioenergy affects food security	3.31	7.44	33.06	7.44	51.24	15.87	9.62	8.17	9.13	8.17	50.96
Bioenergy is good for the country	6.61	12.40	62.81	10.74	92.56	22.40	22.95	9.29	19.13	18.58	92.35

Note: R1=Public Agency, R2=Private Company, R3=Agricultural/Farm, R4=Research, R5=Other respondents; Survey with farmers is still ongoing in China so no result is available yet. The values are percent of the total respondents, 121 for China and 208 for the Philippines. For the opinion on bioenergy, respondents were asked to answer "yes" or "no". The values presented in the table are only percent of respondents who answered "yes".

### Project Publications

Eugenio, E.A., et al. (2013). Typology of Farmers' Awareness on Sustainability of Alternative Bioenergy Feedstocks in the Philippines, Paper presented in the 2013 International ISSAAS Congress in Muntinlupa City, Philippines, on 11-15 November 2011.

Acosta, L., et al. (2014). Assessment of trade-off decisions for sustainable bioenergy development in the Philippines, Journal of Biomass and Bioenergy (under revision).

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## LCI2012-04NMY(R)-MACANDOG

### PROJECT TITLE

Integrated Sustainability Assessment of Bioenergy Potentials in Asia: An Application of a Hybrid Approach on Trade-Offs and Pathways (PIC-STRAP)

### COUNTRIES INVOLVED

China, Germany, India, Philippines

### PROJECT DURATION

Year 1 of a two-year project

### APN FUNDING

US\$ 90,000

### PROJECT LEADER

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LCI2012-05NMY(R)-JUPESTA

# Low Carbon Urban Infrastructure Investment: Cases in China, Indonesia and Japan

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The concept of “green growth” has been connected to the “green economy for sustainable development and poverty reduction,” which is the first theme of the Rio+20 United Nations Conference on Sustainable Development (UNCSD). To achieve green growth, low carbon development should be initiated at multiple levels, including international, regional, national and sub-national levels. The Asia-Pacific region, where the world’s major population and economic growth are, can show the global impact of sustainable development, partly due to the fact that this region includes an advanced economy such as in Japan and key emerging economies such as China and Indonesia. The UN declared that half of the population was living in cities in 2008 and that this percentage would increase to 60% by 2030. Furthermore, cities account for 90% of global population growth, 80% of the wealth creation and 60-80% of the global energy consumption and global greenhouse gas (GHG) emissions. Thus, a low carbon society could start from creating low carbon cities. Several approaches are already initiated to create low carbon cities across Asia. Due to vast growth, any city requires intensive urban infrastructure development. By the constraint of local government capabilities, the funding of urban infrastructure has become a critical issue.

Based on this background, this project will explore and examine a new funding mechanism with engagement of many stakeholders’ such as public/private partnerships. Several cities have already put some investment in green cities initiatives. This project will be used as guidance on how cities in selected countries can play a key role in the green growth agenda, by stimulating growth through smart investment in urban infrastructure (i.e., by building a physical infrastructure, by financial and tax incentives, energy supply, and heightening society’s

awareness of a sustainable lifestyle).

## Work Undertaken and Results to Date

This research project will use explorative qualitative and quantitative approaches to define, measure and monitor green investment at the city scale. The definition of a low carbon city and indicators will be provided from working package 1 led by Dr. Manu Mathai and by examining activities and progress of local governments regarding their low carbon city initiatives. The master plan, action plan, institutional arrangement and structure of Jakarta has already been made for the first year. Yokohama and Shanghai will be conducted in the second year. The second working package, led by Dr. Ping Jiang, will assess the environmental impact by a life cycle analysis with a tool program SIMAPro (with in-kind support from UNU-IAS). The study case selected for this working package is Shanghai due to high potential for GHG mitigation in particular in the building sector.

The third working package, led by Ms. Takako Wakiyama, identifies risks and barriers of investment in a low carbon city project and examines the role of governments and policy to facilitate and coordinate investments and financing. Yokohama was chosen as a study site due to its interesting renewable energy investment (e.g., solar panel). The tool to be used is discount cash flow analysis using Monte Carlo Simulation with the interface of Crystal Ball (the budget from APN). The fourth working package, led by Dr. Rizaldi Boer, will be used to monitor the progress that has been made with the new funding mechanisms from semester three, based on the selected indicators created in semester two. Several alternatives will be explored through a scenario analysis and projections on economics, social and environment

benefits of green investment in the cities. This study emphasises the importance of long-term planning for GHG reduction in dynamic growth region such as Jakarta. The tool is AIM-EXSS (with in-kind support from NIES). The project outcomes will include policy recommendations to policy makers at city and national levels as well as peer-reviewed journals to be disseminated to scholars in cities and in the field of climate change.

## Project Publications

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## LCI2012-05NMY(R)-JUPESTA

### PROJECT TITLE

Low Carbon Urban Infrastructure Investment: Cases of China, Indonesia and Japan

### COUNTRIES INVOLVED

China, Indonesia, Japan

### PROJECT DURATION

Year 1 of a two-year project

### APN FUNDING

US\$ 83,700

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LCI2012-01NSY(C)-MAEDA

# Building Capacity for MRV of GHG Emissions in Phitsanulok Municipality, Thailand

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## Introduction

Roughly two-thirds of global greenhouse gas (GHG) emissions may be attributed to activities in cities and urban areas. From a policy perspective, it is crucial to be able to measure/monitor, report and verify (MRV) GHG emissions in cities based on a globally-consistent and comparable framework, which would cover methodologies for both GHG emissions inventory development as well as project-level mitigation actions. While methodologies need to be harmonised to a global standard,

they also have to be sufficiently flexible and practical for application in diverse country governance contexts.

Furthermore, as local governments are relatively new to MRV, it is critical to build the capacity of local governments and domestic actors in a sustainable manner towards enabling local mitigation policies and actions to contribute meaningfully to national and global goals. This requires a deeper understanding of local governments' responsibilities, institutional structures and governance factors, which is also a key part of this project's research.

Activity	Date	Outcomes
Inception Workshop	30 May 2013	<ul style="list-style-type: none"> <li>Obtained high-level commitment by Phitsanulok Municipality to implement the project; a formal project Working Group was established.</li> <li>Developed understanding of city's baseline conditions (including attitudes to, and awareness of, climate change and MRV) of municipality officers.</li> <li>Introduced basic concepts and principles of MRV, particularly for inventory development.</li> </ul>
Baseline data collection and consultative meetings	29 July–3 August 2013 19 September 2013	<ul style="list-style-type: none"> <li>Gathered data about: (a) city's socio-economic and environmental profile; (b) municipal institutional structure; and (c) baseline activity data (municipal level) in key urban sectors: energy (stationary and mobile), waste and wastewater, agriculture and fugitive sources.</li> </ul>
Mid-term Workshop and Training	25–26 November 2013	<ul style="list-style-type: none"> <li>Introduced intermediate concepts, principles and lessons learnt (from other cities' experience) on MRV of GHG emissions on inventory development.</li> <li>Introduced basics of project-level MRV and potential mitigation projects.</li> <li>Identified gaps in data collection for inventory development and agreed on further methods to estimate or acquire those data.</li> </ul>

**Table 1.** Summary of activities implemented as of November 2013.

## HIGHLIGHTS

- » Developing a city-level GHG emissions inventory and climate change mitigation actions are not legal mandates nor priorities of Thai municipalities. Therefore, such initiatives should be backed up by high-level commitment (mayor and municipal clerk), while co-benefits to the economy, environment and society, as well as reputational incentives (of being involved in a globally-recognised and pioneering initiative, which may help attract more resources from external organisations to the municipality in the future) should be appealed to.
- » The challenges of activity data collection are closely-tied to institutional and capacity factors. Institutional factors include: (a) Pre-existing unsystematic data management systems, leading to incomplete or missing data; and (b) Costs of coordinating and securing cooperation of staff, across municipal departments, as well as external stakeholders such as national/provincial government agencies, private sector, households, etc., in data collection. Capacity factors relate to poor understanding of the value and purposes of data collection (leading to poor motivation) and lack of knowledge about data gathering and estimation methods (e.g., implementing surveys and sampling).
- » To build capacity, city-level GHG emissions inventory development could be divided into two stages. Stage 1 on establishing a municipal-level inventory, which develops essential knowledge and skills on data collection. This provides a foundation to expand to Stage 2, which collects activity data within the municipality's geo-political boundary to cover the residential and private sectors. On this, a particularly challenging aspect appears to be in accounting for energy use in mobile sources (transport). The project has almost completed Stage 1 and is preparing for Stage 2.
- » Developing a GHG emissions inventory ultimately results in enhancing and modernising overall data management, which is highly useful for sustainable development planning, policy/project design, implementation and evaluation. In terms of projects, feasible actions are confined to sectors within their jurisdiction and are supported by national policies and incentive instruments which lead to short-to-medium term financial savings, such as improving energy efficiency in buildings through lighting retrofits, fuel substitution in vehicle fleets and waste reduction/diversion.
- » Once municipalities have acquired adequate capacity, they can play a valuable role in promoting actions by other stakeholders. The private sector, especially the larger companies, are perceived as being already progressive in such interventions; the local government may add value by formally recognising such initiatives, raising awareness and promoting knowledge exchange in order to motivate actions among the smaller companies.

## Project Overview and Activities

This project aims to raise the capacity of local government officers in a mid-sized Thai city (Phitsanulok Municipality; with a population of about 250,000) in implementing a MRV framework for city-level GHG emissions, including testing a global pilot protocol developed by the World Resources Institute (WRI), United Nations Human Settlements Programme (UN-HABITAT), Local Governments for Sustainability (ICLEI) and partners. It expects to establish a draft city-level GHG emissions inventory and to explore feasible institutional arrangements to sustain MRV actions at both inventory and project levels. The process allows us to understand the gaps between assumptions and expectations behind global MRV frameworks and the realistic application by a Thai local government which has limited experience with MRV, as well as the challenges for building capacity.

## Achievements, Challenges and Way Forward

Based on the latest consultations with the municipality, the municipality's policy makers expressed appreciation for the project's positive impacts on promoting cross-department collaboration in the data collection process, as well as triggering progress towards systematic data collection, which is useful for policy and project planning and design. Systematic data collection is a basic tenet of good governance and management, for which awareness and capacity is still low among middle-level managers and working-level staff. Furthermore, the municipality is interested in applying the data as knowledge for formulating low-carbon city policies and projects, as well as opportunities for gaining support for pilot-scale projects.

This project also motivated the municipality to invest in training to strengthen the English language skills of senior managers, as well as assess and



**Figure 1.** Group photo of the Phitsanulok Municipality Low Carbon City Working Group.

explore more effective institutional arrangements and practices that would sustain MRV efforts into the future. Related to this, a pilot online energy use reporting system was developed by the municipality's IT departmentation to make regular data collection more convenient. This could serve as a model and be potentially replicated/adapted for use in other Thai municipalities. This should be the focus of the Final Project Completion Workshop scheduled in February 2014.

The project mainly encountered challenges in collecting and accessing data for city-wide activities in the residential and private sector. Organising supporting document behind the data collected for the verification purposes tended to be overlooked. However, project members agreed to aim at finalising a draft emissions inventory by January 2014 and strive for the gradual improvement of the accuracy, consistency and transparency of inventory data over time, with technical assistance from IGES and other partners.

Hopefully, this project will receive further support

from APN and other supporting organisations to enable it to mature into an initiative that will provide valuable experience and lessons learnt for other municipalities within the Asian region.

## Project Publications

This project's findings will be published as part of an upcoming IGES policy report or policy brief on Local-level MRV Actions in March 2014. The Municipality's 2013 GHG Emissions Inventory will also be published separately as a public report.

## Acknowledgements

Our appreciation goes to APN for financially supporting this research and capacity building project. We also deeply appreciate the essential guidance and contributions by Phitsanulok Municipality, Japan International Cooperation Agency (JICA), National Municipality League of Thailand and local volunteers in the municipality.

### LCI2012-01NSY(C)-MAEDA

#### PROJECT TITLE

Capacity Building for Implementing a "Measurable, Verifiable and Reportable (MRV)" Model in a Mid-Sized Thai Municipality

#### COUNTRIES INVOLVED

Japan, Thailand

#### PROJECT DURATION

One-year project

#### APN FUNDING

US\$ 28,000

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LCI2012-02NSY(C)-GUERRERO

# Strengthening Community Voices in REDD+ Policy

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## Introduction

The REDD+ Community Carbon Pools Programme (CCPP), a regional initiative in Southeast Asia involving four countries, namely Cambodia, Indonesia, Philippines and Viet Nam, is supported by the European Union and implemented by Fauna & Flora International (FFI) and Non-Timber Forest Products Exchange Programme (NTFP-EP). The core idea behind REDD+ is to make performance-based payments to forest owners for the reduction of emissions. Critical to the success of such payments is a clear definition of land tenure and carbon rights, requiring policy and institutional reforms in the areas of governance, tenure, decentralisation and community forestry management (CFM).

Under different environmental, political and socio-economic contexts, the progress of CCPP site implementation has been affected largely by the speed of obtaining government approval for REDD+ activities. Carbon accounting and biodiversity monitoring, using Verified Carbon Standard (VCS) and High Conservation Value Forest (HCVF) methodologies respectively, are implemented by in-country teams and technical advisors, documenting key recommendations and findings. The project's carbon, biodiversity, socio-economic, as well as policy elements have produced varied and significant lessons learned, which will be promoted at the regional level to broaden the impact of the project for other REDD+ stakeholders.

The APN Low Carbon Initiative Framework-funded project entitled "Strengthening Community Voices in REDD+ Policy" aims to complement the REDD+ CCPP policy initiatives focused on local capacity development for the formation of REDD+ policy, namely: (1) a training workshop, (2) a cross site visit, and (3) a regional policy workshop. These project activities were implemented in 2013 involving 40-50 participants from partner governments and local communities.

## Work Undertaken

### *Benefit Sharing Training Workshop, 23-25 July 2013, Phnom Penh, Cambodia*

<b>Benefit Sharing Training Workshop</b>	
<b>Day 1</b>	<ul style="list-style-type: none"> <li>• Introduction to Benefit Sharing</li> <li>• Equity in Payment for Ecosystem Services</li> <li>• Updates on National Benefit Sharing</li> <li>• Discussions</li> </ul>
<b>Day 2</b>	<ul style="list-style-type: none"> <li>• Approach to designing pro-poor benefit distribution systems (BDS)</li> <li>• Case study presentations</li> </ul>
<b>REDD+ Game: Recommendations and lessons learned</b>	

**Table 1.** Programme of the Benefit Sharing Training Workshop.

REDD+ CCPP requires the development of a benefit distribution system (BDS) for each site. This workshop was designed for developing capacity in this area through the following objectives: (1) establishing a common understanding of the meaning of benefit sharing at all levels; (2) establishing a common understanding on equity in REDD+ as the basis of developing a pro-poor BDS; and (3) identifying ways forward for engaging in the development of BDS at the project level.

Theoretical and case presentations on benefit-sharing and equity in PES (payment for ecosystem services) provided knowledge and basis for developing a BDS design framework. Engaging in the “REDD+ Game,” – an exercise on participatory approach in the selection of REDD+ benefits, further enabled the participants to determine the processes and key elements needed, while identifying challenges, to setting up and implementing a benefit-sharing mechanism suited to the national and local context of the project sites.

### Community Partners’ Learning Exchange Visit to the Philippines, 7-13 October 2013

The learning exchange was designed to identify practical strategies, tools and approaches on community participation and engagement in REDD+. Common lessons and insights were drawn by practitioners in the three REDD+ demonstration sites of the

**G**erry used to make 200 sacks of charcoal per day. Joining the REDD+ demonstration site project, he transformed his views about the forest, shifted to farming and gave up charcoal making. He earns the same amount of income from farming as that from charcoal-making.

Philippines, which contributed to regional knowledge sharing — synthesising key success indicators for community participation, and identifying steps and challenges in community engagement, as well as actual roles played by the local community.

The changed-life stories shared throughout the visit among community partners are probably the most remembered.

Inspired by the visit, the community partners resolved to create new possibilities as they bring home their favourite lessons learned:

- “We intend to form a community forestry organisation dedicated to watershed management and ecotourism.” (Cambodia)
- “We want to build houses with rattan, grow crops along the river, and run our own community enterprise, as we learned from the Philippines.” (Viet Nam)
- “The FPIC process may be costly and time consuming, but it’s rewarding.” (Indonesia)



Figure 1. Community Partners’ Learning Exchange Visit to the Philippines.



**Figure 2.** Vietnamese and Cambodia REDD+ Teams formulating their policy agenda at the Second ASEAN Regional Policy Workshop.

**2nd ASEAN Regional Policy Workshop, 13-15 November 2013, Hanoi, Viet Nam**

The 2<sup>nd</sup> ASEAN Regional Policy Workshop attained what it set out to do — informing REDD+ policy makers on critical issues such as FPIC, land/ carbon rights, benefit-sharing and CFM. The policy dialogues between government partners and REDD+ stakeholders from civil society paved the way in identifying policy gaps and opportunities for greater CF inclusion and appreciation in REDD+ policy processes. As a result, country-level planning effectively focused on a top three policy agenda and produced an eight-month action plan that included key support efforts needed for plan implementation within the project timeline.

**Project Publications**

Non-Timber Forest Products Exchange Programme. (2004a). *A policy brief: FPIC Assessment*. Quezon:

NTFP-EP. Retrieved from <http://climatechange.denr.gov.ph>

Non-Timber Forest Products Exchange Programme. (2004b). *A policy brief: Who owns the carbon in the trees? Clarifying carbon rights in the Philippines and guidance in benefit sharing arrangements* (p. 12). Quezon: NTFP-EP. Retrieved from <http://www.ntfp.org>

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**PROJECT TITLE**

**Strengthening Community Voices in REDD+ Policy**

**COUNTRIES INVOLVED**

Cambodia, Indonesia, Philippines, Viet Nam

**PROJECT DURATION**

One-year project

**APN FUNDING**

US\$ 28,000

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The SPG Members recommend the scientific programme, including proposals for 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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