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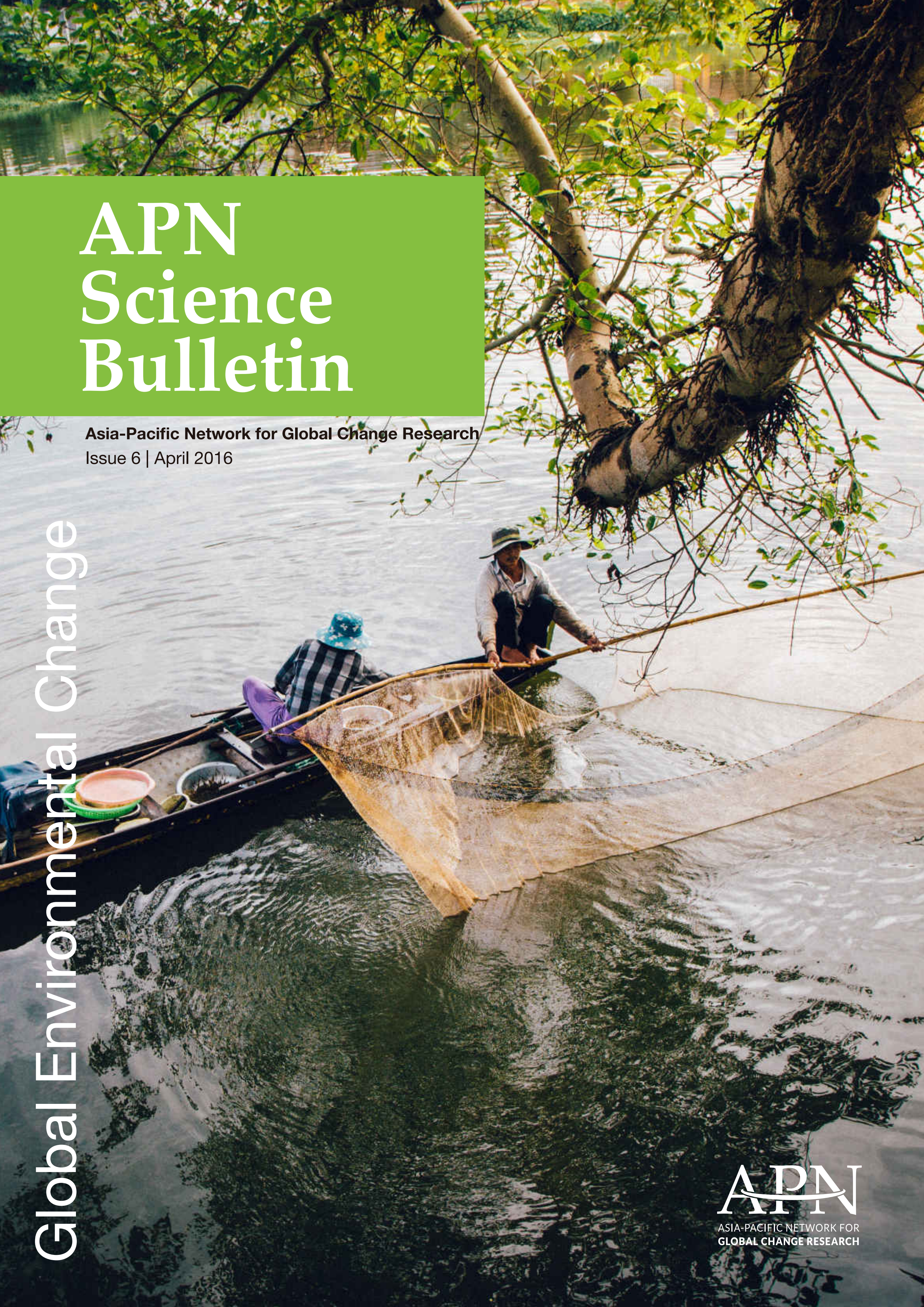

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Preface

On behalf of the editorial board, I am very pleased to present you with the sixth issue of APN's annual flagship publication, APN Science Bulletin, which features the results, outcomes and findings of APN-funded projects while serving as a record of ongoing and recently completed activities by project teams in countries within and, sometimes, beyond the Asia-Pacific region.

The APN Science Bulletin has evolved considerably since its inaugural issue published in March 2011. This year, we have taken a serious step to further enhance our efforts in ensuring the scientific rigour of the articles and their contribution to the body of knowledge in the science-policy arena for global environmental change, by facilitating a more rigorous, open and constructive peer-review mechanism recently embedded in the publication process.

Articles featured in this issue are contributions from projects that were completed in fiscal year 2015 (April 2015 to March 2016). These cover a broad range of topics under APN's science agenda outlined in its Fourth Strategic Plan, which includes climate change and climate variability, biodiversity and ecosystem services, changes in the atmospheric, terrestrial and marine domains, resources utilisation and pathways for sustainable development, and risk reduction and resilience.

Included in the first section of this issue are featured articles from projects implemented under the core programmes of Annual Regional Call for Research Proposals (ARCP, which was renamed to "Collaborative Regional Research Programme" in APN's 4th Strategic Phase) and Capacity Development Programme (CAPaBLE), as well as two thematic frameworks: APN Climate Adaptation Framework (CAF) and Low Carbon Initiatives (LCI) Framework.

Section Two presents a compilation of all ongoing projects that are currently being implemented under various programmes and frameworks of the APN. You may find more details about these projects by visiting the corresponding page on our online project metadata portal, APN E-Lib (www.apn-gcr.org/resources).

I would like to take this opportunity to express my heartfelt gratitude to all authors and reviewers—it is your dedication and hard work throughout the publication cycle that ensures the timeliness and quality of this issue.

It is our hope that this publication will be useful for scientists and researchers, policy- and decision-makers, as well as practitioners working in the frontline of leveraging the scientific knowledge on global environment change to build a safer, more resilient, and more sustainable world for this and future generations. I also hope that the information contained in this issue will pave the way to new and deeper collaboration and partnerships among like-minded scientists and researchers within and outside the region where APN focuses its work.

Linda Anne Stevenson

Head, Communication & Scientific Affairs Division

APN Secretariat

Contents

FEATURED ARTICLES

Sources and Sinks of Carbon Dioxide in Populous Asia

Prabir K. PATRA[a ✉], Josep G CANADELL[b], Rona L. THOMPSON[c], Masayuki KONDO[d], Benjamin POULTER[e]

APN Project Reference: ARCP2013-01CMY-Patra/Canadell / Received: January 2016 / Published online: March 2016
Available online at APN E-Lib: http://www.apn-gcr.org/resources

HIGHLIGHTS

- CO_2 sources and sinks are estimated for East, South and Southeast Asia by inverse modelling and terrestrial ecosystem models.
- These Asian regions are either a carbon sink or source neutral but the uncertainties are significant between methods particularly for East Asia.
- High quality observations and model synthesis is recommended for monitoring and verification.

ABSTRACT The recently concluded 21st Conference of the Parties (COP21) under the United Nations Framework Convention on Climate Change (UNFCCC) agreed to limit the increase in global temperature to less than 2°C above pre-industrial levels, with a more aspirational target of 1.5°C. Achieving these policy goals will require extraordinary input from the scientific community to define anthropogenic emission targets that account for natural biosphere sources and sinks of carbon dioxide (CO_2), consistent with the climate targets. Asian countries, being densely populated and emerging global economic powers, are key players in defining future emission trajectories. The average fossil emissions from the three regions are estimated to be 2.4, 0.5 and 0.3 petagrammes of carbon per year ($PgC\ yr^{-1}$) for East, South and Southeast Asia, respectively, and have increased by 67, 58 and 33 percent over the period 2003–2012. Here, we estimate land biosphere CO_2 fluxes using: 1) simulations of terrestrial ecosystem models driven with global and regional atmospheric and climate observations and 2) atmospheric CO_2 inverse models. Based on observations of atmospheric CO_2 and inverse models, we show that on average over the period 2003–2012, the land biosphere (excluding fossil fuel emissions) in the three Asian regions in our study is either a CO_2 sink (0.35 $PgC\ yr^{-1}$ in East Asia) or source neutral (South and Southeast Asia). Consistently, our terrestrial ecosystem modelling suggests that the land biosphere of South and Southeast Asia were nearly neutral, but disagrees for East Asia.

KEYWORDS *Asian CO_2 sources and sinks; atmospheric inversion; terrestrial ecosystem model*

1. Introduction

Tropical and temperate Asia is home to 3.72 billion people and is undergoing rapid social changes and economic growth. We define the three Asian regions for this study as: East Asia comprising China, Japan, the Koreas and Mongolia; South Asia comprising India, Bangladesh, Pakistan, Nepal, Sri Lanka and Bhutan; and Southeast Asia comprising Myanmar, Lao PDR, Viet Nam, Cambodia, Thailand, Philippines, Malaysia, Indonesia, Brunei, Singapore, Timor-Leste and Papua New Guinea (Figure 1).

This research was initiated from the larger international project “Asian Greenhouse Gases Budget” supported by

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the Asia-Pacific Network for Global Change Research (APN) and the Global Carbon Project (GCP). It fully relies on the participants' voluntary contribution. The ensemble of inverse and ecosystem modelling fluxes and uncertainties have been synthesised in the REgional Carbon Cycle Assessment and Processes (RECCAP) project (Patra et al., 2013; Piao et al., 2012; Canadell et al., unpublished). These results suggest large uncertainties in the estimated CO_2 fluxes by different methods and inconsistencies in the carbon flow accounted by the two modelling approaches.

This report aims to update the CO_2 source and sink budgets using recent model simulations as more atmospheric measurements have become available for inverse modelling, and by the terrestrial ecosystem model fluxes following inclusion due to land use and land cover change (LULCC).

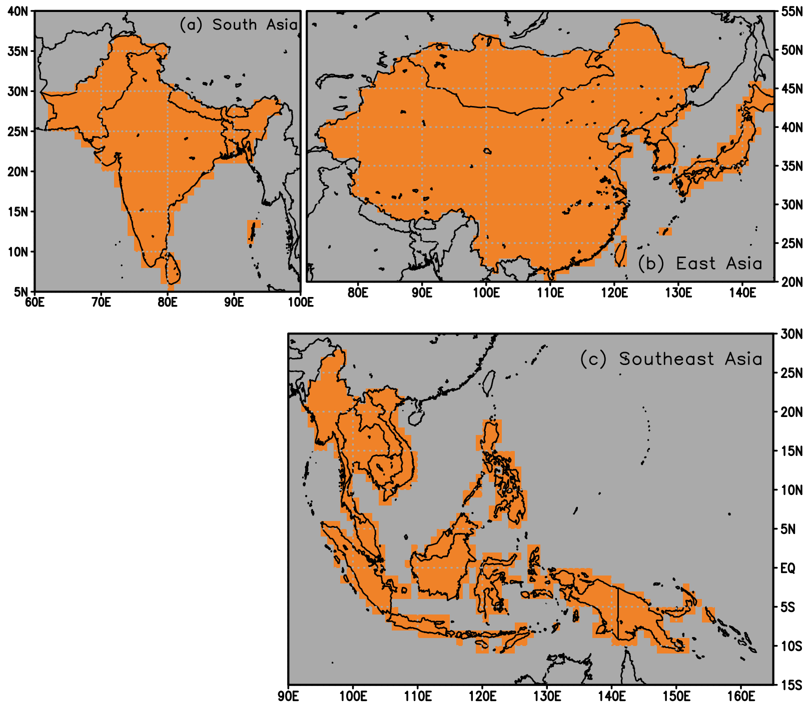

FIGURE 1. The three focus regions of our study - South Asia (top-left), East Asia (top-right) and Southeast Asia (bottom).

2. Methodology

There are two main flux components in the terrestrial carbon balance: anthropogenic emissions (from fossil fuel consumption, cement production and deforestation) and ecosystem flux (balance between gross primary production and autotrophic respiration + heterotrophic respiration + disturbances such as fire and insect damage). Two principal approaches are used to estimate terrestrial CO_2 fluxes: top-down and bottom-up approaches. The top-down approach estimates the terrestrial CO_2 flux that is optimally consistent with atmospheric CO_2 concentration. The bottom-up approach estimates the ecosystem carbon cycle by considering the internal biochemical mechanisms of carbon flows.

The bottom-up CO_2 fluxes are estimated as net biome production (NBP) using five dynamic global vegetation models (DGVMs), namely, the Community Land Model version 4.5 (CLM4), Joint UK Land Environment Simulator ver. 3.234 (JULES), Lund-Potsdam-Jena DGVM wsl (LPJwsl), LPJ GUESS, Orchidee-CN (O-CN), and the Vegetation Integrative SImulator for Trace gases (VISIT). The DGVMs are run using climate dataset from the Climate Research Unit (CRU) TS3.2 and prescribed annual LULCC dataset from the HistorY Database of the global Environment (HYDE) (ref. Kondo et al., 2016, and references therein). The models compute the land use fluxes by adjusting carbon pools over time for defined transitions, e.g., forest to pasture. Fire emissions associated with land use change are accounted by all models but only a few are able to estimate emissions from wildfires.

The top-down fluxes of CO_2 sources/sinks are estimated by using seven atmospheric transport models, observed CO_2 concentrations and inverse modelling/data assimilation. In this study, seven inverse models were used, namely, GELCA: 64-region inversion system using Lagrangian-Eulerian coupled transport, MACC: 4-dimensional variational data assimilation system, WU: CarbonTracker Europe, ACTM: 84-region matrix inversion system, CSIRO: 130-region matrix inversion system, JMA: 22-region matrix inversion system, and CAO: inversion system using empirical orthogonal functions (as described in Thompson et al., 2016). The inverse models were driven using different prior flux information, atmospheric transport models, and CO_2 observation datasets. In this way, the ensemble range resulting from the use of all inversions represents the uncertainties of these various components.

The top-down and bottom-up results are combined and compared to produce a mean average and uncertainty estimates for CO_2 fluxes for three Asian regions as defined in this study (Figure 1).

We additionally investigated trends in the normalised difference vegetation index (NDVI), precipitation (PCP) and temperature (T) for understanding the role of climate variations on the carbon assimilation capacity of the temperate (East Asia), tropical (Southeast Asia) and mixed (South Asia) ecosystems. Detailed results are not presented here for the sake of brevity.

3. Results and Discussions

Figure 2 shows the time-series of mean CO_2 fluxes estimated by top-down and bottom-up approaches and emissions due to Fossil Fuel consumption and Cement production (FFC) for the three Asian regions. Detailed statistics of uncertainties for model-to-model differences are given in Table 1 along with long-term mean normalised difference vegetation index (NDVI), precipitation (PCP) and temperature (T). The uncertainties in CO_2 fluxes are based on 1-σ standard deviation for model differences. The mean values and uncertainties in FFC emissions are

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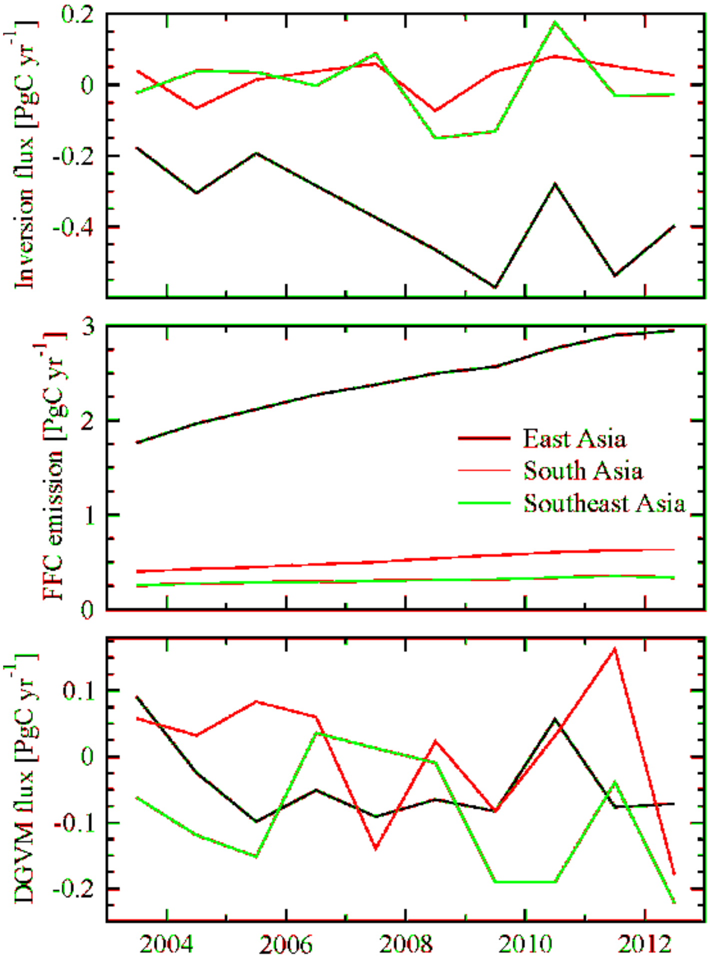

FIGURE 2. Time-series of multi-model mean CO_2 fluxes (top row: top-down method, bottom row: bottom-up method) and FFC emissions (middle row). Uncertainties for model-to-model differences are given in Table 1.

estimated from the values used by 7 inverse modelling systems.

In Figure 2, one can see that the FFC emissions increased rapidly for the East Asia region (118 TgC yr^{-2}), from 1.76±0.15 PgC yr^{-1} in 2003 to 2.95±0.58 PgC yr^{-1} in 2012. During the same period of time (2003–2012), the top-down models estimated an increase in the uptake of CO_2 by the terrestrial ecosystem at the mean rate of 22 TgC yr^{-2} (see also Thompson et al., 2016). The mean CO_2 uptake increase simulated by the bottom-up models is 16 TgC yr^{-2}. However, the net CO_2 flux estimated for 2012 is much greater with the top-down models (-0.40±0.29 PgC yr^{-1}) compared to the bottom-up models (-0.07±0.06 PgC yr^{-1}) for East Asia. The 2012 mean CO_2 fluxes for South and Southeast Asia are estimated to be 0.03±0.08 and -0.03±0.16 PgC yr^{-1}, respectively, with the top-down models, and -0.18±0.14 and -0.22±0.10 PgC yr^{-1}, respectively, with the bottom-up models. Although the net fluxes show reasonably good agreements for the South and Southeast Asia regions, the rates of uptake change are distinctly different for top-down (1 TgC yr^{-2} and 0.5 TgC yr^{-2}, respectively) and bottom-up (24 TgC yr^{-2} and 16 TgC yr^{-2}, respectively) models.

The DGVM simulated increase rates of uptake are quite similar for all three regions, while for the inverse models we find a large increase in uptake for East Asia but almost no trends for South and Southeast Asia. This could be due to overestimation of CO_2 fertilisation by the DGVMs given that most models do not include nitrogen-limitation on gross primary production (GPP) and/or the LULCC database prescribed lower trends in deforestation. The differences in the rate of regional CO_2 uptake increase could also arise from an overestimation of the uptake increase over East Asia and an underestimation over South and Southeast Asia. This may be possible because although the global uptake rates are constrained by atmospheric data, the distribution of the uptake between regions is only weakly constrained and may be reflected as weak or no increase in uptake over South and Southeast Asia. The latter two regions are also largely void of atmospheric CO_2 measurements, while the East Asian fluxes are fairly well constrained by measurements in Japan, South Korea and China. A further possibility for the weak to no increase in uptake over South and Southeast Asia may be an underestimate of the

	CO_2 flux (model mean ± 1-σ difference) units: PgC yr^{-1}			Biosphere and meteorology (mean ± 1-σ inter-annual variation)		
	TOP-DOWN	BOTTOM-UP	FFC	NDVI	PCP (MM D^{-1})	T (°C)
East Asia	-0.36 ±0.28	-0.04 ±0.08	2.40 ±0.33	0.33 ±0.005	51.39 ±2.90	6.81 ±0.38
South Asia	-0.02 ±0.17	0.005 ±0.14	0.52 ±0.11	0.39±0.007	79.88 ±5.32	22.3 ±0.24
Southeast Asia	0.00 ±0.19	-0.09 ±0.15	0.31 ±0.06	0.45 ±0.002	170.7 ±9.13	20.2 ±0.11

TABLE 1. Mean values (± 1-σ difference/variation) of top-down and bottom-up CO_2 fluxes (1 Pg = 1015 g; 1 Tg = 1012 g) and the climate drivers for the period 2003–2012. The model-to-model differences (1-σ standard deviations) are always greater than those estimated for interannual variations for the top-down and bottom-up fluxes.

increase in FFC emissions in these regions, which is assumed a posteriori and is subtracted from the total optimised CO_2 flux (see Thompson et al., 2016).

4. Conclusions

One of the biggest challenges in implementing mitigation policies is the capacity to monitor, report and verify (MRV) as required by the UNFCCC. The new Paris Agreement further emphasises the need for robust and transparent reporting of greenhouse gas fluxes in order to enable successful implementation. Here, we have estimated CO_2 fluxes using two complementary approaches (top-down and bottom-up) for the three regions of the populous Asia. Use of multiple models enable us to show more robust model ensemble means of CO_2 fluxes that suggest the Asian land biosphere is generally source-neutral, albeit there are large uncertainties associated with the ensemble mean values. Differences between top-down and bottom-up approaches also suggest both lack of higher density data to drive the models and possibly missing processes.

At the large regional scales such as those reported in this study, there will always be the need to employ a diverse array of models that capture enough variability and flux components. In order to further improve the models and ultimately the quantification of the Asian greenhouse gases budget, we require a higher density of atmospheric observations, biospheric flux measurements such as eddy-covariance, and increased spatial resolution of land use and land cover changes. We have initiated measurements of CO_2, CH_4, N_2O, SF_6, CO and H_2 from Comilla, Bangladesh since 2012. This site is strategically located for sampling the air mass from the South Asia region during most seasons of the year. Noting the importance, continuation of this measurement programme is now supported by the Ministry of Environment, Japan. We have also begun to work closely with inventory and space agencies, whose data provides new insights into the rapid land use and land cover changes in the region; this undoubtedly will reduce uncertainties of the resulting fluxes.

Acknowledgement

We gratefully acknowledge all those who contributed inversion estimates of land biosphere CO_2 fluxes: F. Chevallier, S. Maksyutov, T. Shirai, M. Ishizawa, R. M. Law, T. Ziehn, I. T. van der Laan-Luijkx, W. Peters, A. Ganshin, R. Zhuravlev, T. Maki, T. Nakamura, T. Saeki. We are also very grateful to all those who provided atmospheric observations that were used in the inversions and for validation. The terrestrial ecosystem model fluxes are provided by L. Calle, S. Sitch, P. Friedlingstein, A. Arneth, A. Harper, E. Kato, C. Koven, T. A. M. Pugh, S. Zaehle, A. Wiltshire. We thank APN for providing partial support for the activity that has led to the set of analysis presented here. JG Canadell thanks the Australian Climate Change Science Programme.

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Traditional Livelihoods and Mining in Mongolia's Changing Climate: Exploring the Potential of Cross-sectoral Partnerships in Achieving Sustainability

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HIGHLIGHTS

- This project was a first of its kind to discuss the complex links between livelihoods, the mining sector and climate change and natural disasters in Mongolia.
- A key focus of the project was brainstorming the idea of establishing a network hub of key actors that would value the strengths of individual sector groups and allow partnerships by identifying issues of common concern.
- A clear highlight of the project is the greater appreciation of traditional herding knowledge and its indispensable role in natural disaster management and relief.
- Mining industry in Mongolia is open to discussion centred around climate change and discussing its future implications on the sector. This is particularly noteworthy in light of a more reserved take on global warming internationally across the sector.

ABSTRACT The growing scale of resource development activities accentuates the complexity underlying the sustainability of traditional livelihoods in Mongolia. At the same time, Mongolia experiences growing vulnerability to climatic variability and change, expressed in the form of intense desertification, water stress, and extreme dzuds. This paper is based on APN-funded capacity building workshops that focused on understanding a) how climatic changes impact herding and mining—although in varied forms, and b) how each sector may leverage its resources to devise action, strategies and tools that may help build capacities and boost resilience towards changing climatic conditions. Workshop discussions highlighted that traditional livelihoods remain under multiple threats from climatic variability and change; and institutionalised mechanisms of creating cross-sectoral partnerships - such as a network hub of key stakeholder groups - is fundamental in ensuring climate-resilient coexistence between mining and herding sectors.

KEYWORDS *climate change; mining; traditional livelihoods; Mongolia; public-private partnership; natural disasters*

1. Introduction

Transitioning to a market economy, Mongolia's large share of traditional pastoralist communities have struggled with restricted water availability largely due to extreme weather conditions, poor service delivery and limited government intervention to address some of the underlying causes of water-related community concerns. As explained in further detail below, an expanding mining industry and its water-intensive activities together with a looming climatic disorder present Mongolia with complex biophysical and socio-economic drivers of change. These changes interact with and influence each other, and challenge the existing social, cultural and institutional fabric of local communities, and cause irreversible loss and damage (L&D). The fact that communities possess neither the capacity nor the resilience needed to address these complex climatic challenges further reinforces the need for a project that transcends sectoral boundaries to address disaster risks and resulting L&D.

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Dialogue, coordination, coherence and synergy among relevant stakeholders have been considered key instruments to strengthen risk management approaches to address L&D. In relation to building capacity to address L&D, the significance of better appreciating non-economic losses and the impacts of slow-onset processes such as desertification and loss of biodiversity can hardly be underestimated, particularly for economic enterprises such as herding and mining, which are so integrally dependent on suitable environmental conditions for their long-term viability.

Mongolia's mining sector has grown significantly in the past decade due to intense national and international investment in resource development activities and the recent global commodity boom. It is widely recognised as a country with vast resources of copper, coal, gold, fluorspar, uranium and other natural resources—12 large mining operations are located across the country and 9 more are set to begin operations in the near future (Austrade, 2011). Mongolia's GDP grew by approximately 17.3% in 2011, a direct result of large-scale mining investments, particularly in the South Gobi region (UN Stats, 2013). Latest census reveals that the two major mining centres in the South Gobi, Khanbogd and Tsogttsetsii, both have witnessed an exponential growth in their population between 2000 and 2010 (Ochirsukh, 2011). In 2012, mining accounted for approximately 9% of all new employment opportunities created in Mongolia (Dalaibuyan, 2013). The minerals sector already employs over 14,000 people and contributes to more than 70% of Mongolia's total export earnings (Austrade, 2011). Oyu Tolgoi (OT), besides being the world's largest copper mine, is expected to contribute to approximately 34% of Mongolia's total GDP once fully operational by 2020 (Dalaibuyan, 2013). It is not surprising then that a study of poverty and inequality in Mongolia undertaken by the Asian Development Bank suggested employment in the mining sector as one of the significant factors reducing the likelihood of poverty both at household and individual levels (Ochirsukh, 2011).

In a country where nomadic herding remains the primary source of livelihood, increased mineral exploration and mining activities have led to competition over access to key natural resources such as land and water (Combellick-Bidney, 2012; Reeves, 2011). Over the past two decades, climatic changes—both slow-onset and extreme events—have severely impacted the livestock sector in Mongolia, directly affecting nearly 30% of the country's population. In the last 40 years, Mongolian ecosystems have been noticeably altered by increased variability and changes in global climate conditions (Myagmar & Chuluun, 2013). Statistically, Mongolia's annual mean temperature has increased by 2.07°C between 1940 and 2013. This is a much greater rate of warming than has been observed in global average temperatures, which increased by 0.74°C from 1906 to 2013. Since 1961, the annual potential evapotranspiration rate has increased by 118.1 mm and growing season precipitation has decreased by 33 mm due to climate change, leading to severe aridity and desertification.

Due to rapid rates of pasture degradation and an increase in the total number of extreme hot days annually, animals are unable to gain enough weight and energy to survive harsh autumn and winter months, resulting in severe weight loss and declining resistance to dzuds. In particular, the occurrence of hazardous weather events has increased and the socio-economic losses associated with these events have roughly doubled in the last 20 years. As a result, herder households have borne huge socio-economic costs, with some families having lost more than 90% of their primary source of income. With climate-influenced changes to bio-physical conditions, impacts may also be expected upon the minerals sector as the latter remains highly dependent on suitable natural conditions for accessibility to, and subsequent extraction of, underground resources (Sharma & Franks, 2013).

Although from a conventional viewpoint, mining-led economic boost to the national economy may be considered as one of the early signs of development in Mongolia, economic growth alone that disregards resulting impacts on the country's socio-ecological way of life contravenes the overarching Mongolian identity, as is demonstrated by Mongolians' deep concern for the environment and its extensive reliance on natural resource-based traditional herding lifestyles. Therefore, to maximise the industry's potential to contribute to Mongolia's future development, not only does it need to co-exist with herding but also formulate a better understanding of its role and significance in supporting sustainable livelihoods in a changing climate.

2. Methodology

The proposal acknowledges mining not only as the emerging economic enterprise in Mongolia—one that offers immense socio-economic promise for development—but one that is closely dependent on a suitable natural environment for its operations and long-term viability. With a changing climate, the demands for water and land by both herders and miners are going to increase as their supply and/or quality shrinks. Rather than competing with each other, the project emphasised the synergies that could be developed between the two sectors to build collaborative adaptive capacities and address L&D.

This project was a collaborative effort between the Sustainable Minerals Institute of the University of Queensland in Australia and two Mongolian partners, Civic Solutions NGO and The Institute of Geography of the Mongolian Academy of Sciences. The project entailed capacity building workshops that focused on understanding how climatic changes that impact both herding and mining may provide the impetus to build trust and partnerships between the two industries to better manage climate risks and address L&D in affected rural communities. Specifically, the workshops aimed to identify (a) impacts of climate change on herding and mining, and current capacity to deal with these impacts, (b) priority impacts and specific activities that can be undertaken in a collaborative manner for each impact, and (c) main barriers to collaboration and ways to overcome these barriers.

The project undertook three workshops representing herding groups; mining companies; local, provincial and national government; academics; media; and civil society. These workshops were organised between 14 and 30 September, 2014. Two workshops were at the local/regional level (Umnugovi and Bayankhongor aimags in the Gobi and Gobi-Altai regions respectively), followed by a concluding multidisciplinary workshop in Ulaanbaatar. Findings from the regional workshops informed the final workshop to identify both short- and long-term policy concerns and possible solutions. The number of participants across the three workshops totalled 115 (Umnugovi: 41; Bayankhongor: 35; Ulaanbaatar: 39).

Appropriate participants for the research were chosen on the basis of 1) the level of impact experience from mining activities and climate change; 2) the extent of knowledge in the extractive industry and regional development to inform research, and 3) the level of influence in decision-making. Participant selection was established firstly through in-country partners as well as via information in the public domain such as media reports, government ministry websites, community organisations and companies, publications such as community directories, and submissions made in response to the Environmental Impact Statements of major projects in the region. Special guidance was sought from advisory members suggested by the APN and expert contacts of the project's in-country team. Snowballing technique was further applied to include networks from these initial contacts and achieve an equitable representation from key stakeholder groups.

Discussion at the workshops was organised around three group activities. The first activity was undertaken with groups made of same sector representatives (e.g. all herders were in one group, all large scale miners in another group, etc.) while participants were mixed for the second and third activities to ensure a fair representation (and therefore, a reasonable voice) of all stakeholder groups. The workshop discussion flow was organised to allow each group activity to target a particular question or set of questions that aligned with addressing the project's objectives.

3. Results and Discussion

Questions followed the 'what, why, how' order to allow participants to gradually move from simple to layered questions and to ensure they were comfortable before addressing questions that were more complex in nature and that required a greater level of thought, content and analysis.

Table 1 provides more detail on the flow of each workshop, with the flow for the last two workshops adapted slightly in light of experience drawn from the first workshop.

Across Mongolia, there are mining areas where formal mining co-exists with informal artisanal and small-scale mining. The co-existence of mining and traditional livelihoods has become an inevitable reality for many mining areas in Mongolia. In some areas, their relations are adversarial because of environmental and social risks and impacts caused by mining. In some areas, they are synergised in different ways such as multiple employment or livelihood opportunities, company-community partnerships, and community-based ventures.

The interconnection between mining, traditional livelihoods and climate change has not been addressed often by research institutes and government agencies in Mongolia. Nor have the mining and other economic sectors raised this issue for broad discussion. In fact, when Civic Solutions first approached some mining industry representatives to discuss their interest in this issue many of them were very keen to learn and promote the project. It was clear that the whole scholarly and policy discourse in Mongolia on climate change adaptation and mitigation and L&D has not fully considered the role of mining.

The project brought together two of Mongolia's key economic sectors of herding and mining to consider climate change as a common concern and one that would require unconventional but realistic changes to the current modus operandi of policy- and decision-making in Mongolia. The project was successful in addressing all of its objectives and was able to capture in some detail, current levels of regional knowledge of disaster management, emerging climatic thresholds, as well as key grassroots concerns and priorities in relation to reducing vulnerability by building resilience to disaster events. Table 2 highlights key findings based on workshop discussions.

Activity	Key questions addressed
Activity 1 (Participants organised in sector-specific groups)	Identify impacts from mining and climate change on your sector. How do you currently address these impacts. Identify impacts from climate change on your sector and current capacity to address these impacts. Identify impacts of climate change on other sectors and what their current capacities may be to address these impacts.
Activity 2 (Participants organised in mixed groups)	Identify two or three priority impacts from the previous activity. Suggest specific activities for collaboration for each priority impact. Identify what barriers exist to these collaborative activities.
Activity 3 (Participants organised in mixed groups)	What support mechanisms, tools, policy instruments would you require to overcome these barriers? And from whom?

TABLE 1. Workshop discussion flow

Climate change impacts	Opportunities for cross-sectoral collaboration	Key barriers to collaboration
Across all stakeholder groups, the following key impacts of mining and climate change were identified (in order of importance).		
Pasture degradation	Increase the number of green facilities.	Lack of trust across sectors.
Desertification Water shortage	Protect groundwater resources by creating water reserves and encouraging water recycling.	Lack of, or insufficient budget allocation to, disaster management, including raising disaster awareness among citizens.
Dust Loss of traditional livelihoods	Improve infrastructure for mine-related shipment to minimise impacts on herder lifestyle and pasture quality. Monitor impacts using citizen participation.	Limited technological know-how, in particular on workings of the mining industry (including use of water, treatment of waste water and other chemical pollutants during and or after the mining process).

TABLE 2. Workshop findings

It was noted that political instability and a lack of legislative requirement for key sectors to cooperate on matters of national priority and concern greatly hinder any systematic approach to building cross-sector synergies and identifying avenues for close cooperation. To counter this, a key output of the project has been to recommend setting up a 'Knowledge Hub' platform to bring stakeholders together, and to generate new knowledge by sharing perspectives, that would allow for a more holistic understanding of Mongolia's development challenges. The hub would bring representation from mining companies, herder groups, districts, provinces and central government authorities, civil society and media to facilitate dialogue on capacity building in relation to climate adaptation and managing climate change-related loss and damage.

While herding maintains a deep social and cultural significance for Mongolia, the mining sector offers huge potential for socio-economic development. As such, the rationale behind the knowledge hub is to promote the idea of "cooperation for co-existence". The hub will function to:

- Identify strengths of each sector and foster partnerships to address common concerns;
- Facilitate innovative means to address climate-related concerns and disaster management; and
- Provide districts and provinces with decision-making responsibilities.

4. Conclusion

As a result of the finding of this study, policy recommendations are presented for five key areas:

Green development: the significance of green development at the local level is fundamental to guide changes in behaviour across Mongolia with regard to climate change, disaster management and resilience building. Workshop participants strongly advocated for stakeholder involvement in the development of a climate change policy framework at the local level.

Disaster management: central government needs to build a better knowledge base on what forms a disaster, and disaster management and prevention plans, both for pre- and post-disasters. Investment in terms of obtaining best practices from national and international sources may help the process with better managing and addressing disasters.

Mining and impacts of climate change: the mining sector in Mongolia is open to discussing potential impacts of climate change, climate variability and natural disasters on the mining sector. The sector is willing to embrace action to address climatic perturbations as there is an acceptance of a strong business case for the mining industry to take note of changing environmental conditions across Mongolia.

Greater recognition of traditional herding knowledge: Mongolia should further invest in studies that reaffirm the importance of herder movement, and its role in disaster management and maintaining pasture quality. Additionally, a systematic policy refocus to move attention from herd quantity to quality is essential in the country's current policy landscape. Improved government funding may allow studies on genetic herd improvements and the importance of focusing on a balance herd composition.

Knowledge hub: an established avenue for stakeholder groups to come together, discuss common concerns, debate options and identify pathways forward is vital to Mongolia's future sustainability. Until such time when legislative requirements call for cross-sectoral cooperation, a knowledge hub may help institutionalise the practice of nudging sectors that may have been in conflict thus far to cooperate and use consensus—not conflict—to ascertain solutions to common challenges.

Acknowledgement

The team would like to thank APN for supporting the project. We also greatly appreciate various Mongolian organisations, companies, individuals and local communities for their encouragement and contribution, both financial and in-kind, at various times during the project.

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Toward a Fire and Haze Early Warning System for Southeast Asia

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HIGHLIGHTS

- Four different downscaling methods were developed and integrated into the prototype of EWS in order to improve the predictability.
- Long-term predictability of monthly precipitation for the four regions within Borneo Island was evaluated.
- APCC led a two-day workshop in Malaysia, including hands-on training sessions on statistical downscaling and prototype.
- Needs assessment for early warning information was conducted through field surveys with resource managers.
- Monthly precipitation forecasts for dry season (August to October) over 4 provinces in Borneo Island showed good predictability less than four-month lead time by showing temporal correlation coefficients (TCCs) greater than 0.5 in all provinces.

ABSTRACT Smoke haze from forest fires is among Southeast Asia's most serious environmental problems and there is a clear need for a fire and haze early warning system (EWS) for the region. APEC Climate Center (APCC) has been collecting monthly dynamic prediction data produced by 16 institutions and has been producing 6-month lead multi-model ensemble (MME) climate forecasts every month. In this study, we developed four different statistical downscaling methods and assessed the forecast skill of the integrated forecast system over four provinces in Borneo Island. We developed a EWS prototype in which three-month precipitation (August to October) is predicted during April to July and the forecasted precipitation amount is then translated into four fire danger ratings based on the relationship between precipitation amount and CO_2 emission. A needs assessment for early warning information was conducted through field surveys with resource managers at three provinces in Indonesia. A two-day workshop was held for the improvement of the EWS. Finally, the forest fire early warning information on Borneo Island created using the EWS will be provided though the hosting server in APCC.

KEYWORDS *fire danger; seasonal forecasts; statistical downscaling; dynamical downscaling; seasonal drought*

1. Introduction

Smoke haze from forest fires is among Southeast Asia's most serious environmental problems. Severe burning in Indonesia occurs only during years with anomalously low rainfall. Monitoring for these conditions is important, but has limited effectiveness because the burning is opportunistic. As a result, measures to prevent these fires and mitigate their impacts remains limited by the absence of long-lead early warning system (EWS). Severe burning conditions, therefore, need to be forecast weeks to months in advance for any prevention to be effective. In this context, little of the progress made in seasonal forecasting has been applied to fire early warning in Indonesia and there is a clear need for a fire and haze EWS for the region. The project builds upon current fire danger rating systems by providing forecasts at a longer lead-time using seasonal forecast data maintained at APCC, a time-scale that is more relevant and useable for decision makers. The final objective of the project is to develop a prototype of fire danger EWS by considering field survey results and conducting a training workshop.

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2. Methodology

An EWS for forest fire was developed based on an open source license for further training workshops and free distribution of the developed prototype. The overall procedures for development of EWS prototype include 1) construct statistical downscaling model for forecasting monthly area-average precipitation amount for each region, 2) determine number of categories and corresponding ranges of fire danger rating system based on the relationship between total three-month precipitation amount and CO_2 emission, and 3) forecast probabilistic fire danger ratings based on predicted precipitation (Figure 1).

Regarding the statistical downscaling, four different downscaling methods in accordance with the degree of utilising the seasonal climate prediction information were selected for developing the EWS. These methods are: the Simple Bias Correction (SBC), the Moving Window Regression (MWR), the Climate Index Regression (CIR), and the Integrated Time Regression (ITR). SBC is a forecast-based direct downscaling method, which uses GCM's prediction data after adjusting the monthly mean of predicted data. For example, if the precipitation prediction data on a specific region is needed, SBC directly uses the grid values of precipitation variables, which are produced from GCMs over the given area. The systematic bias is adjusted for making the monthly average of prediction the same as the average of observation for the same period. Table 1 shows the selected dynamical prediction models used in the study. If there are limitations in directly predicting target variables such as precipitation in the target area, the MWR method uses the oceanic and atmospheric circulation variables as predictors to improve the seasonal prediction predictability in the target area (eg. Kang, Park, Hameed, & Ashok, 2009; Kang, Hur, & Ahn, 2014). As a result, MWR is a forecast-based indirect statistical downscaling method, which uses the simultaneous proxy variables produced by GCMs as predictors of regression model when high correlation exists between proxy variables and regional target variables. CIR is an observation-based indirect statistical downscaling method that can be used when there is a high correlation between global climate indices and regional target variables with lag time (eg. Kim, Kim, & Lee, 2007; Kim & Kim, 2010). Twenty five climate indices which are updated monthly from NOAA (http://www.esrl.noaa.gov/psd/data/climateindices/list/) and APCC (http://www.apcc21.org/ser/indic.do?lang=en) were used for real time operation of CIR method. In this case, lag time between the monthly precipitation and indices should be larger than the lead-time. The CIR method is similar to the MWR method in that both methods indirectly utilise the correlation between regional target variables and global scale climate variables related to oceanic and atmospheric circulation. There is a difference between the CIR and MWR methods when selecting predictors to forecast future seasonal target variable values. While the MWR method uses the forecasted climate information, the CIR method uses the observed information from a few months before taking into account the lag time. ITR is an indirect statistical downscaling method that uses both forecast and observation-based predictors from the

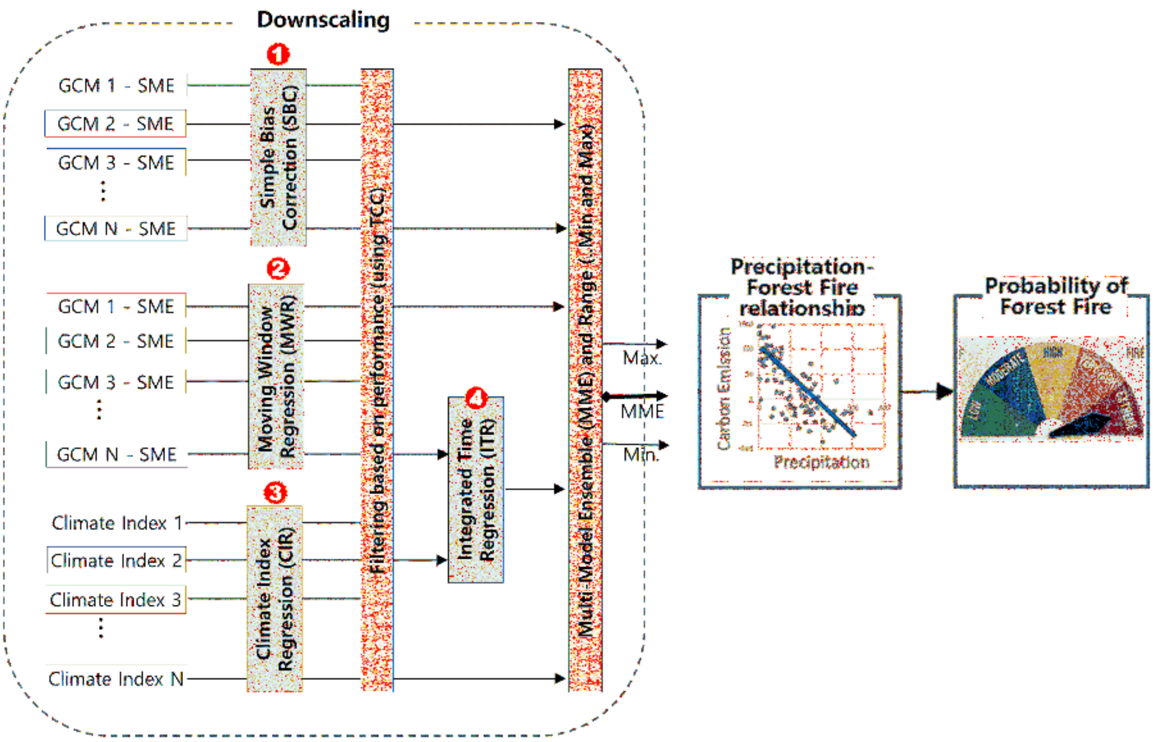

FIGURE 1. Schematic diagram of Early Warning System (EWS) prototype.

Model	Institution	Raw Resolution	Ensemble Size
CANCM3	Meteorological Service of Canada (Canada)	T63L31 (AGCM) 1.41°× 0.94° L40 (OGCM)	10
CANCM4	Meteorological Service of Canada (Canada)	75.37	10
NASA	National Aeronautics and Space Administration (USA)	220.1	10
NCEP	Climate Prediction Center - NCEP/ NWS/NOAA (USA)	11.41	17
PNU	Pusan National University (Republic of Korea)	320.41	4
POAMA	Centre for Australian Weather and Climate Research/ Bureau of Meteorology (Australia)	T47L17 (AGCM) 0.5–1.5°LAT × 2°LON, L25 (OGCM)	30

TABLE 1. Description of dynamical seasonal prediction models used in the study.

MWR and CIR methods, respectively. As a result, it can be used only when the MWR and CIR methods simultaneously select predictors for a particular target period.

We used the same regions from previous research by Field and Shen (2008) for developing and evaluating the statistical downscaling methods. The regions include Southern Sumatra (SSUM), Central Sumatra (CSUM), Eastern Kalimantan (EKAL) and Southern Kalimantan (SKAL). However, we decided the administrative boundary for managerial purpose of the EWS and four provinces in Borneo Island were used in this study (Figure 2).

Second, an analysis of the threshold levels for the study regions was conducted in order to translate the predicted precipitation amount to the fire danger ratings. If the amount of precipitation dips below the threshold level, this predicts an increased risk for severe burning, carbon emissions, and transboundary haze. It is necessary to connect the forecasted precipitation to the possible EWS index based on region-specific threshold level. We used the relationship between region-average ASO precipitation and carbon emission data. The region-average monthly precipitation and carbon emission data were derived from APHRODITE's Water Resources (http://www.chikyu.ac.jp/precip/) and Global Fire Emissions Database (http://www.globalfiredata.org/) webpages, respectively. At first, we attempted to determine the ranges for each category using a segmented regression method. However, the resulting threshold precipitation was too low, which increased the likelihood of extreme carbon emissions being predicted due to scattered data. As a result, we set the threshold value manually based on the time series of three-month accumulated monthly precipitation and carbon emissions.

Based on an earlier version of the prototype, APCC led a workshop including hands-on training sessions on statistical downscaling and the prototype. After the training, we improved the predictor selection algorithm for the MWR and CIR methods in order to avoid overfitting in real-time forecasts. The concepts of both cross-validation and split-validation were applied in order to prevent overfitting problems. The Leave-one-out Cross-Validation (LOOCV) technique was applied to the observation period (1983–2013). In other words, when predicting target variables for a specific target period (year/month), all predictors for the same target period are removed from the model construction procedure in order to reproduce the same conditions as real time forecasting. For example, when predicting

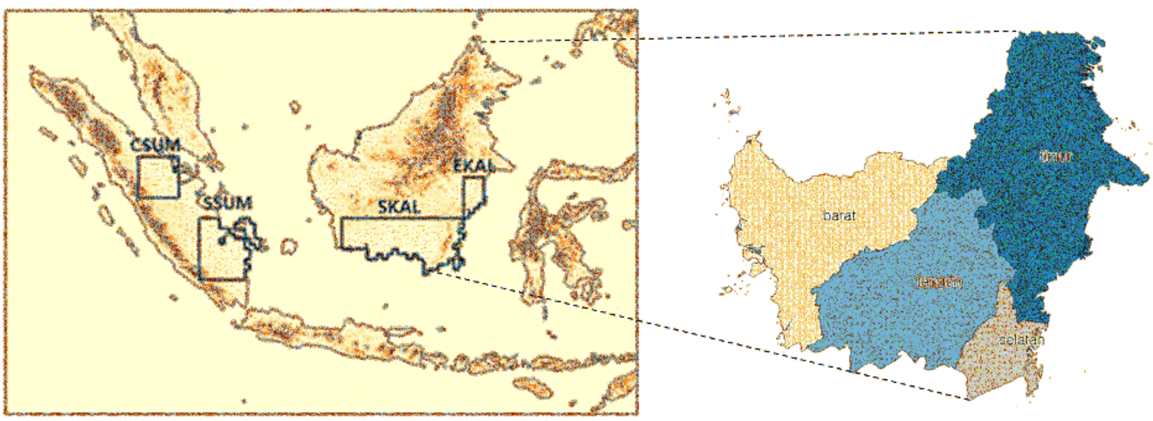

FIGURE 2. Selected regions for developing statistical downscaling methods and early warning system.

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for January 1983, only predictors from January 1984 to 2013 are utilised in constructing the regression model. Predictions are made in the same way for the rest of the simulation period. For each cross-validation process, the split validation approach was applied, and then the best predictors that showed consistent performance for both training and verification periods were finally selected. In addition, a needs assessment for early warning information was conducted through field surveys with resource managers. Based on the survey results, we decided to use four danger rating categories and six-month lead time in developing the EWS prototype by considering ASO precipitation as a trigger for forest fire. As a result, we are able to issue an ASO precipitation forecast from April to July.

3. Results and Discussions

Only individual forecast models that show consistent selection of predictors through cross and split validation procedures with significant forecast skill score (TCC) were finally selected for the EWS. The SBC method, which is based on dynamic prediction data, shows the highest model selection and is followed by statistical downscaling methods such as MWR and CIR/ITR. In most of the months, when the selected models are based on dynamic model predictions (SBC), there is a decreasing trend in TCC values as the lead times increase. Table 2 and Figure 3 show the TCC values for each month according to changes in lead time. The TCC values were calculated using MME with the condition that forecasts are issued every month. Figure 4 shows the comparison of observed and forecasted monthly precipitation for August issued in April using all selected individual models. Equal weight average of individual forecasts were used for estimating MME and the result showed a trend that lower precipitations were overestimated and higher precipitations were underestimated. Finally, monthly precipitation forecast for dry season (August to October) over four provinces in Borneo Island showed good predictability less than four-month lead time by showing temporal correlation coefficient (TCC) greater than 0.5 in all provinces. When we consider ASO precipitation as a trigger for forest fire, we can issue an ASO precipitation forecast from April to July because we are using 6-month lead forecast data in developing prototype EWS.

In order to translate forecasted precipitation into fire danger ratings, four categories (Extreme, High, Moderate and Low) were established based on the results from the field survey. We designed a template for delivering forecast information on both precipitation and probability of forest fire for ASO period. Figure 5 shows the forecast summary for monthly precipitation and probability of forest fire in Selatan region for August to October in 1997, which was issued in April, 1997. The graph shows the graphical information for previous and current years by providing climatology (blue), observed (red), and forecasted precipitaion (black). The boxplot in the figure shows the variations of predicted values by individual models. The dots at the end of the boxplots represent outliers defined by less than Q1 – 1.5×IQR or greater than Q3 + 1.5×IQR. Where, Q1, Q3, and IQR are 25th and 75th percentiles, and difference between Q3 and Q1, respectively. The figure shows that severe drought during August to October, 1997 was closely predicted in Selatan region. The bottom-left table shows the overall summay of one-month lead forecast skill scores based on the long-term period with monitoring data. Skill score with resepect to TCC according to different lead time was presented in Table 2. The used performance measures include TCC and NRMSE, which can be used for continous variables and Accuracy and Heidke Skill Score (HSS), which in turn can be used for category forecasts. For calculating Accuracy and HSS, we equally divided the observed monthly precipitation into four categories (25% for each). Finally, the forecast information for four regions within Borneo Island will be issued each month from April to July and the forecast summary will be posted on the APCC's web hosting server (http://www.apcc21.org/eng/html/apn.jsp).

Month	Region	1 Month	2 Month	3 Month	4 Month	5 Month	6 Month
JAN	Barat	0.52	0.52	0.52	0.52	0.52	0.52
	Selatan	0.69	0.69	0.63	0.49		
	Tengah	0.42	0.42	0.42	0.42		
	Timur	0.75	0.72	0.69	0.59	0.56	0.56
FEB	Barat	0.68	0.68	0.63	0.45	0.45	
	Selatan	0.72	0.68	0.59	0.5	0.5	
	Tengah						
	Timur	0.71	0.68	0.62	0.63	0.62	0.63
MAR	Barat	0.8	0.69	0.7	0.42		
	Selatan	0.82	0.82	0.76	0.55	0.55	0.45
	Tengah	0.57	0.43				
	Timur	0.68	0.69	0.67	0.59	0.57	0.55

Month	Region	1 month	2 month	3 month	4 month	5 month	6 month
APR	Barat	0.68	0.68	0.63	0.43	0.43	0.43
	Selatan	0.49	0.49				
	Tengah	0.65	0.51				
	Timur	0.74	0.72	0.72	0.69	0.69	0.62
MAY	Barat	0.77	0.75	0.52	0.52	0.52	0.52
	Selatan	0.68	0.64	0.61	0.51	0.52	0.52
	Tengah	0.8	0.85	0.83	0.83	0.71	0.71
	Timur	0.65	0.67	0.72	0.72	0.57	
JUN	Barat	0.51	0.51				
	Selatan	0.58	0.58	0.41			
	Tengah						
	Timur	0.81	0.81	0.69	0.52	0.52	
JUL	Barat	0.62	0.62	0.64	0.6	0.45	0.48
	Selatan	0.6	0.59	0.58	0.58	0.47	0.47
	Tengah	0.55	0.52	0.55	0.58	0.43	0.43
	Timur	0.53	0.53	0.54	0.56	0.52	
AUG	Barat	0.7	0.69	0.68	0.67	0.67	0.65
	Selatan	0.76	0.76	0.75	0.75	0.74	0.7
	Tengah	0.67	0.66	0.67	0.68	0.68	0.62
	Timur	0.57	0.56	0.55	0.54	0.49	
SEP	Barat	0.63	0.59	0.59	0.59	0.57	0.53
	Selatan	0.54	0.54	0.53	0.51	0.52	0.54
	Tengah	0.6	0.61	0.62	0.63	0.64	0.61
	Timur	0.66	0.64	0.63	0.61	0.58	0.57
OCT	Barat	0.7	0.61	0.64	0.47	0.43	
	Selatan	0.62	0.59	0.55	0.51	0.51	0.5
	Tengah	0.6	0.57	0.53	0.53	0.46	
	Timur	0.58	0.57	0.51	0.45		
NOV	Barat	0.75	0.71	0.65	0.67	0.69	0.67
	Selatan	0.58	0.56	0.56	0.59	0.58	0.58
	Tengah	0.71	0.7	0.68	0.68	0.68	
	Timur	0.68	0.5	0.5	0.5		
DEC	Barat	0.63	0.63	0.63	0.63	0.55	0.55
	Selatan	0.69	0.62	0.62	0.62	0.62	
	Tengah	0.69	0.63	0.54	0.49	0.45	
	Timur	0.63	0.63				

TABLE 1. Temporal correlation coefficients (TCC) according to changes in lead time for predicting precipitation using multi-model ensemble (MME) average.

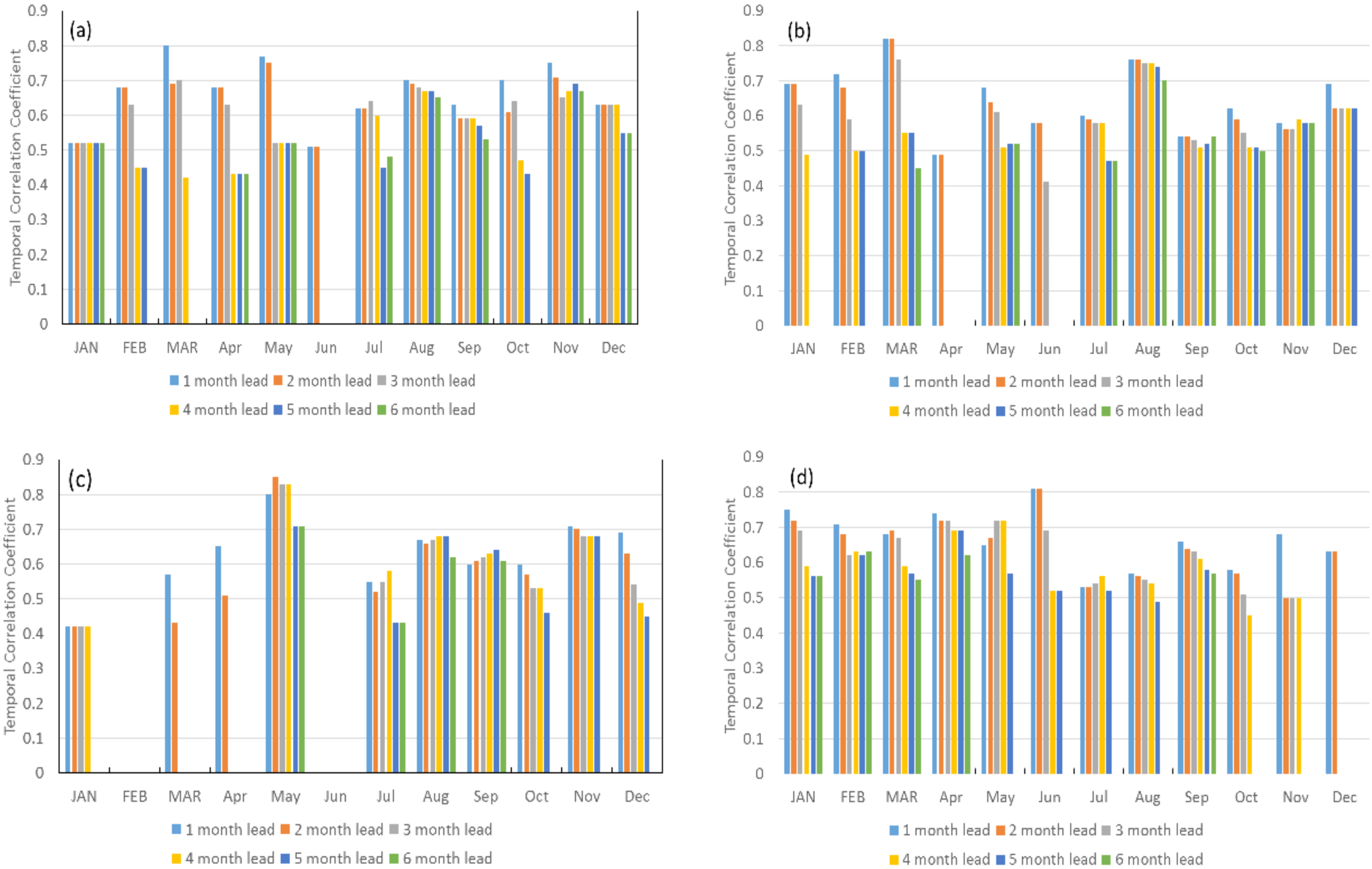


FIGURE 3. Temporal correlation coefficients (TCC) according to changes in lead time for predicting precipitation in Barat (a), Selatan (b), Tengah (c), and Timur (d) regions using multi-model ensemble (MME) average.

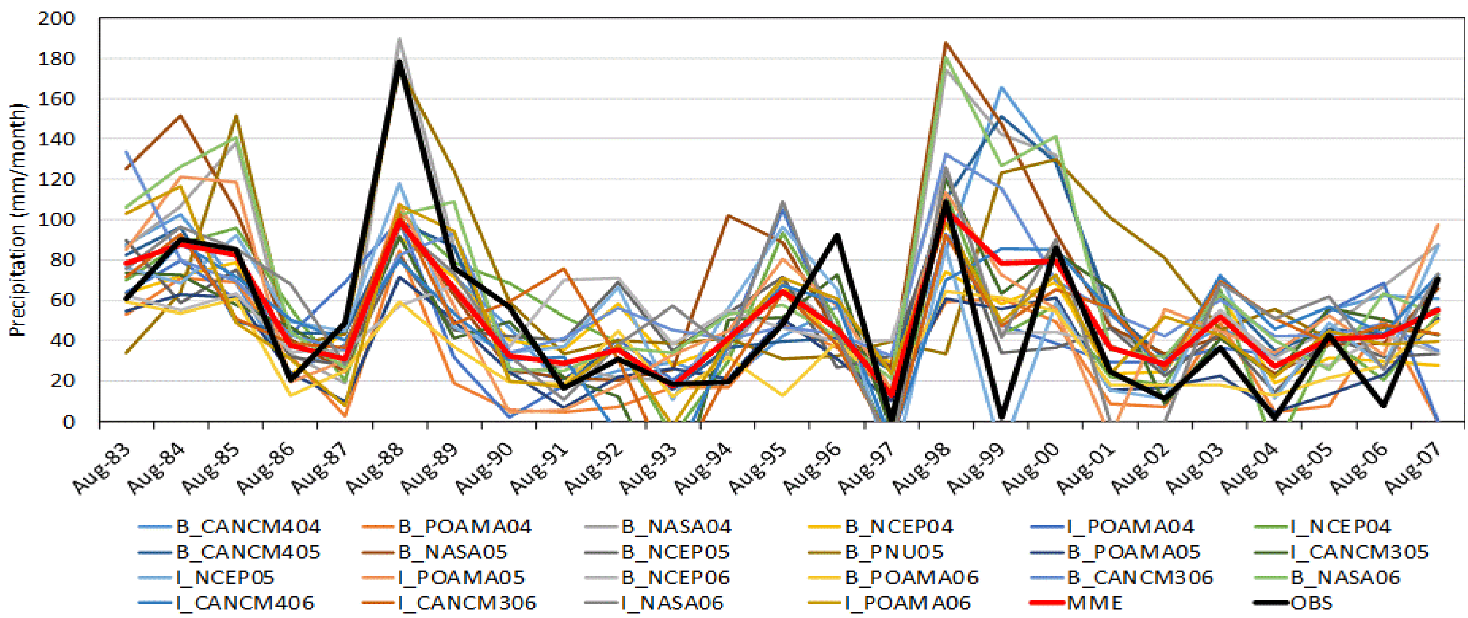
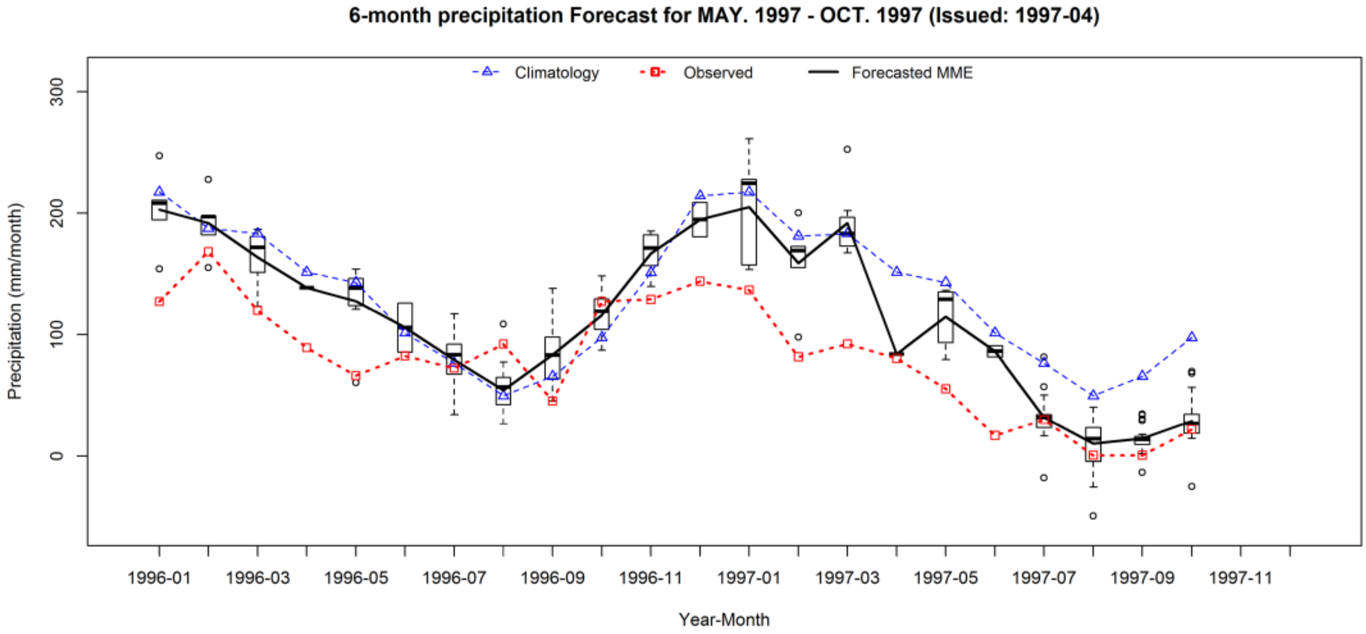


FIGURE 4. Timeseries (left) and scatter plot (right, next page) of monthly precipitation for August issued in April, where B_, M_, C_, I_ indicate SBC, MWR, CIR, ITR downscaling methods, respectively.



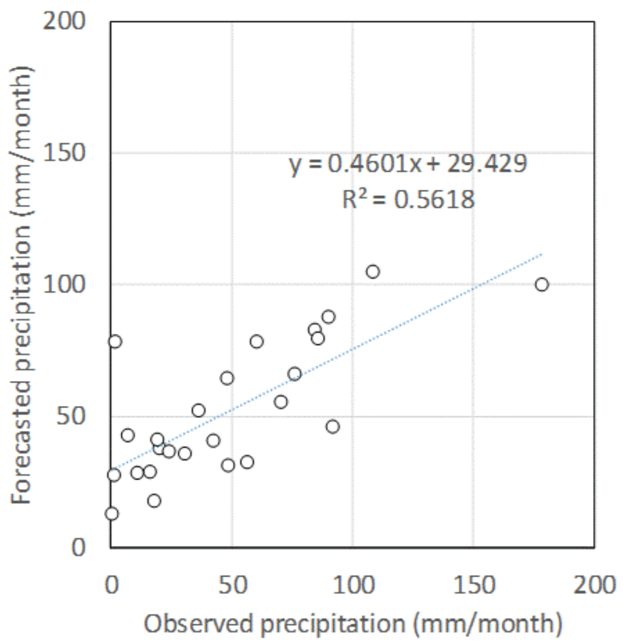
Monthly skill score for JAN - DEC (1983-2007, 1-month lead forecast)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
TCC	0.69	0.73	0.82	0.49	0.7	0.6	0.59	0.76	0.53	0.63	0.58	0.69
NRMSE	0.75	0.8	0.74	0.86	0.76	0.8	0.79	0.66	0.86	0.76	0.8	0.71
Accuracy	0.68	0.48	0.56	0.33	0.76	0.84	0.72	0.76	0.64	0.64	0.44	0.72
HSS	0.35	0.26	0.35	-0.085	0.53	0.44	0.17	0.54	0.26	0.2	0.079	0.52

Probability of Forest Fire for 1997: Aug~Oct (%)

Extreme	5
High	95
Moderate	0
Low	0

FIGURE 5. Forecast summary for monthly precipitation and probability of forest fire in Selatan region for August to October, in 1997 (issued in April, 1997).



4. Conclusions

Based on the downscaling experiments, four different downscaling methods, in accordance with the degree of utilising the seasonal climate prediction information, were developed and integrated into the prototype of EWS in order to improve predictability. The downscaling system is based on an open source license for further training workshop and free distribution of the developed prototype. Long-term predictability of monthly precipitation for the four regions within Borneo Island was evaluated. Based on an earlier version of the prototype, APCC led a two-day workshop in Petaling Jaya, Malaysia, including hands on training sessions on statistical downscaling and prototype. Needs assessment for early warning information was also conducted through field surveys with resource managers. Finally, predictor selection algorithm in EWS prototype was improved based on the training workshop and six-month lead forecast for three months (August to October) precipitation was decided as a trigger for forest fire based on the field survey results. The SBC method, which is based on dynamic prediction data, shows the highest model selection result. In most of the months, when the selected models are based on SBC method, there is a decreasing trend in TCC values as the lead times increase. Equal weight

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averages of individual forecasts were used for estimating MME and the result showed a decrease trend in yearly variation. A template was designed for delivering forecast information on both precipitation and probability of forest fire for ASO period. Monthly precipitation forecast for dry season (August to October) over four provinces in Borneo Island showed good predictability less than four-month lead time by showing TCC greater than 0.5 in all provinces. The forest fire early warning information on Southeast Asia created using the EWS will be provided though the hosting server in APCC.

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Coastal Ecosystem and Changing Economic Activities and Vulnerabilities along Chinese and South Asian Coasts

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HIGHLIGHTS

- Traditional economic activities of coastal communities are moving away from fisheries and agriculture.
- The change is due to declining fish stock, cyclones, storm surges, soil water intrusion and water stress.
- Low income from traditional livelihood, competition for land, and pollution load has also contributed to the change.
- Related policies are creating short-term alternative livelihood options.
- Threats to current coastal economic activities will be exacerbated in the region due to climate change.

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ABSTRACT This field-based study documents the changing pattern of economic activities along selected coastal stretches in South Asia in Bangladesh, India, Sri Lanka and China. Economic activities vary with coastal ecosystem types and service flows. In the first phase, field study sites were identified based on multiple meetings and discussions with policy makers in each of the countries and they continued to be part of scientific discussions within an ecology-economy framework through the project lifetime. In the second phase, for Bangladesh, India and Sri Lanka, further in-depth enquiry and analyses were carried out to understand the perception of various economic stakeholder groups of natural and anthropogenic threats in the coastal regions and the resultant vulnerability and risks. Possible future climate scenarios for the study sites were developed to assess the nature of future climate risks to various ecosystem-based economic activity groups.

KEYWORDS *coastal ecosystem, coastal economic activities, changing livelihood, threats, vulnerability, risk.*

1. Introduction

Very high population density characterises South Asia and China coasts. At the global level, coastal population densities are almost three times larger than that of inland areas (UNEP, 2005) with an exponential rise over the years (Barbier et al., 2008). In their study of coastal regions at the global scale, Martínez et al. (2007) have estimated the ecological, economic and social importance of coasts. The wide variety of economic activities, which prevail along the coasts, has either direct or indirect connectivity with the coastal ecosystems through its provisioning of a diverse range of goods and services (Burke et al., 2001). Globally, coastal ecosystems have been experiencing rapid alteration (Barbier et al., 2008; UNEP, 2006; Turner et al. 1998; Martínez et al. (2007)) by either human-induced risks or natural forces (Adger, 2000; Klein, Smit, Goosen, & Hulsbergen, 1998). "Coastal ecosystem" refers to the direct interface between ocean, land and atmosphere, extending seawards to about the middle of the continental shelf and inland, which includes all areas strongly influenced by their proximity to the ocean (UNEP, 2005). LOICZ (2011) identified multiple stresses arising from local- to global-scale drivers that have significant

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impact on coastal regions. The Millennium Ecosystem Assessment (UNEP, 2005) has demonstrated that ecosystems have been significantly altered by anthropogenic activity. For South Asian countries, there is a need for better understanding of the extent of human dependence on ecosystem services to assess the vulnerability and risk of coastal ecosystem-based economy. Asian countries like Bangladesh, China, India and Sri Lanka share almost 3 percent of the global coastline and experiencing fast changes over the past four to five decades (Burke et al., 2001). Multiple stressors are inducing coastal habitat modification resulting in degradation of ecosystem services and posing a severe threat to the ecosystem-based economic

Study sites	Population density (per sq. km)	Length of coastline and ecosystem types	Natural threats
Bangladesh: Part of Chittagong and Cox's Bazar 21°23'16" to 21°46'26" N latitude and 91°50'34" to 92°07'50" E longitude	Bangladesh: 964 [a] Coastal Bangladesh: 744 [b] Study Site: 2011 (Cox's Bazar) [c], 887 (Maheshkhali) [c]	Cox's Bazar, 26 km Maheshkhali, 77 km Muddy beach, sandy beach, sand dunes, salt-marshes/salt pans, mangroves and estuary	Tornado, cyclone, tsunami, storm surges, sea level rise, monsoonal precipitation, sea water intrusion, coastal erosion
China: Tianjin Binhai New Area 38°34' to 40°15' N, latitude and 116°43' to 118°04' E longitude	China: 140 [d] Coastal China: 467 [d] Study Site: 994 [e]	153.2 km Mostly muddy coast, estuary, intertidal zone, a few sandy beaches	Sea level rise, storm surge, air temperature rise, sea water intrusion
India: Digha-Sankarpur 21°37'N and 87°32'E	India: 420 [f] Coastal India: 164 [g] Study Site: 517 [h]	17 km Sandy, muddy coast with sand dune, estuary, forest	Cyclones, wind storms, sea level rise, storm wave surge, natural erosion
Sri Lanka: Koggala Area in the Habaraduwa DS division 6°0' N, 80° 20' E	Sri Lanka: 323 Coastal Sri Lanka: 320 Study Site: 877	10 km Wide sandy beaches, lagoons, mangroves, estuary, barrier beach and submerged reef	Sea water intrusion, invasion of sea grass species into lagoon, growth of invasive species
World	52 [i]	3,56,000 kms [a] Evergreen needle-leaf forest, evergreen broad-leaf forest, deciduous needle-leaf forest, deciduous broadleaf forest, mixed forests, closed shrublands, open shrublands, woody savannas, savannas, grasslands, permanent wetlands, sandy shores, coral reefs, mangroves, sea grass, coastal shelf, swamps–floodplains, estuaries (Martinez et al., 2007)	Temperature rise (air and seawater), storms, waves, floods (due to sea level, runoff), rising water tables (sea level), erosion (due to sea level, storms, waves), salt water intrusion (sea level, runoff), biological effects (all climate drivers) (IPCC, 2007)

TABLE 1. Four Study Sites
Feasibility Study reports by country partners: a-The World Factbook, CIA, accessed on Aug 15, 2011; b-Islam, M.R. (ed.), 2004. Where Land Meets the Sea: A Profile of the Coastal Zone of Bangladesh, The University Press Limited, Dhaka; c-Population census-2011, Community report, Zila: Cox's Bazar (June 2012); d-China Statistical Yearbook 2011; e-Tianjin Statistical Yearbook 2012; f-data.worldbank.org/indicator/EN.POP.DNST; 2011; g-UN, 2005. Human Development Report. International Cooperation at a

activities in the region. Studies have shown that vulnerability will vary with time, space and among social groups (O'Brien, Sygna, & Haugen, 2004; IPCC, 1997). The objective of this study is to add to existing literature with a better understanding of the coastal ecosystem types in the four countries in Asia and how and why economic activities are changing over time, relating them to ecosystem service flows and market forces. How communities perceive various sources of threats to their economic activities and what climate-model-based predictions can inform about the risks to current economic activities are some of the questions that have also been touched upon within the limited space of this article.

Anthropogenic Threats	Traditional economic activities	New economic activities
Industrial pollution, poisonous chemicals and even radioactive elements discharged from ship breaking activities	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 fry, shop business, speed boat driving, beach concert, hawking on the beach, shrimp farming and salt production
Decline in fisheries and low marine environmental quality due to severe pollution from industries in catchment area (waste discharged into the sea)	Mariculture, fishing, sightseeing, education	Leisure, vacation, game, experience, golf, business, meeting, disney park
Drainage and sewerage network, disposal of liquid and solid waste, unauthorised construction of hotels on the beach violating Coastal Regulation Zone (CRZ) regulations, poor protection against wave action particularly during high tide (ingress of tidal water), beach erosion and lowering of beach level	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	Hawking on the beach, motorbike rides, horse-riding and photography on the beach for tourists, shell-crafting, motorised and manual van-driving, hotels, resorts and restaurants
Encroachment of mangroves, industrial pollution in the form of liquid and solid waste	Agriculture, lagoon fishing, coastal fishing, fish trading, cottage industry, carpentry, small business	Export and hotel industry, tourist guest houses, cinnamon industry, souvenir shops, tourist transportation services
Coastal development (ports, urbanisation, tourism-related development, industrial sites), destructive fisheries (dynamite, cyanide, bottom trawling), coastal deforestation (especially mangrove deforestation), mining (coral, sand, minerals, dredging), civil engineering works, environmental change brought about by war and conflict, aquaculture-related habitat conversion, eutrophication from land-based sources (agricultural waste, sewage, fertilisers), pollution: toxins and pathogens from land-based sources, pollution: dumping and dredge spoils, pollution: shipping-related, alien species invasions, overexploitation of resources (MEA, 2005)	Activities related to urban, industry, mining, agriculture/forestry/aquaculture and fisheries, commerce and transportation (LOICZ, 1998)	

Crossroads: Aid, Trade and Security in an Unequal World; h-Census of India, 2011; i-Population Reference Bureau, 2012 World Population Data Sheet, available at: http://www.prb.org/Publications/Datasheets/2012/world-population-data-sheet/data-sheet.aspx.

2. Methodology

The multi-country study was carried out in two phases: the first phase comprised field studies in four countries: Bangladesh, China, India and Sri Lanka. The second phase covered the same countries except China. In each country, we selected changing coastlines induced by economic activity, developmental policy and population pressure. Using semi-structured questionnaires[1] the natural and anthropogenic threats faced in the study sites by various stakeholder groups categorised by primary economic activity were identified through individual face-to-face interviews. The coverage of surveys varied from 330 in India to 175 in Sri Lanka. Besides direct stakeholders, officials at various levels of policy-making and implementation, and (where existing) economic activity associations were also covered. Some participatory focused group discussions were arranged for policy makers along with the research team to enhance mutual understanding. Various characteristics of the study sites are shown in Table 1. The sites also represent varied coastal ecosystem types and thus different service flows and economic activities. In the second phase, in the three countries of South Asia, various economic groups were interviewed individually with a goal to understand the various threats and related individual level perceived risks[2], and how effective they consider the adaptive measures taken by the local administrative bodies against natural events. The same field survey instrument was used to facilitate cross-country comparison. The data are mainly from individualised face-to-face primary field surveys from various economic categories in India, Sri Lanka and China. Field visits in Phase 1 were mainly organised to obtain information on socio-economic and demographic characteristics of people living in these sites, and the changing patterns in economic activities over the years. The main focus of the second phase of the survey was to identify important threats (natural and anthropogenic) to different economic activities and ecosystem types, to help with the assessment of vulnerability using the IPCC 1997 method. Surveys in both phases were conducted between 2012 and 2014. We adopted the risk-resilience framework (Figure 1) based on literature to frame various questions for our field survey. Various threats in coastal areas driven by environmental change and human activities (Adger et al., 2005) impact coastal ecosystem-based economies through their vulnerability to multiple threats, risk perception and level of resilience determined by adaptive capacity, sensitivity and exposure—the three components of vulnerability (IPCC, 2013). Exposure is the magnitude and duration of climate-related events (Gabor & Griffith, 1980; Adger, 1999). Sensitivity is the degree to which the system is affected (Timmerman, 1981; IPCC, 1997) by the exposure. Adaptive capacity is the system's ability to withstand or recover from the exposure. Adaptation involves reducing risk and vulnerability, seeking opportunities and building the capacity of nations, regions, cities, various stakeholders and natural systems to cope with stresses, as well as mobilising that capacity by implementing decisions and actions. Adaptation options can be implemented to modify either the drivers or exposure and vulnerability or both (IPCC, 2013). Risk in this study refers to the potential for adverse effects on human lives, livelihoods, health status, economic, social and cultural assets, services (including environmental), and infrastructure. Risk can also be subjective in the sense that the likelihood and outcomes are based on the knowledge or perception that a person has about a given situation (IPCC, 2013). Resilience (Timmerman, 1981; Adger, 2000; Dolan & Walker, 2004) is a concept that takes into account how systems, communities, sectors, or households deal with disturbance, uncertainty and surprise over time, and it is characterised by both adaptability and transformability. The schematic of the complex links of interdependence among vulnerability, risk and other components as mentioned above are presented in Figure 1.

Climate change projections for the three countries of South Asia are being done using IPCC AR4 Projections based on PRECIS A1B Scenario and IPCC AR5 Projections using SMHI RCP4.5 Scenario.

1 The full questionnaire can be accessed on request. The method provided scope to get narratives from the respondents along with answers to structured questions.

2 Individual level risk assessments are available in detail with the corresponding author and are omitted here for presentation in limited space.

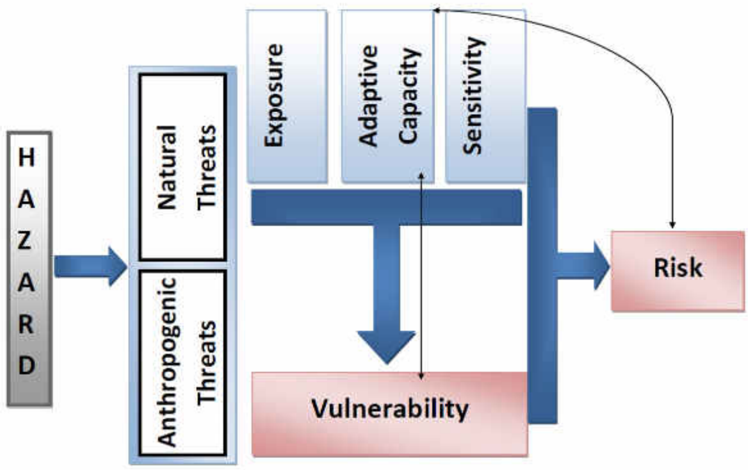

FIGURE 1. Components of the Vulnerability, Risk and Resilience Assessment Framework.

3. Results and Discussions

In all the four countries, Bangladesh, China, India and Sri Lanka, coastal study sites are facing population pressure with population density levels significantly higher than national averages (Table 1). A variety of ecosystem fisheries and agriculture dominated the traditional livelihood pattern, but new activities are heavily biased towards tourism-related activities and services. In Bangladesh, the agricultural productivity of traditional mono-cropping is declining due to the lack of cultivable land, poor sandy soils, the risk of flooding and saline water intrusion, lack of irrigation facilities and sand storms, conversion of agricultural land, expansion of saltpan-shrimp farming and infrastructural development in the tourism sector. Farmers are moving to marine fish catch as it is emerging as a higher value added activity with relatively higher market price with changing demand.

According to the farmers in India and Sri Lanka, expenditure on agricultural inputs is increasing, leaving a smaller margin of income over expenditure. Stress on water availability and increasing salt water intrusion are also reported by some as reasons. Traditional activities are considered as laborious activity. Decline in fish catch is also a reason for the move away from traditional activities. In China, high-end tourism services are increasing. In Tianjin, the natural marine fishery resources declined dramatically due to overfishing, land-based pollution, habitat destruction, coastal development and utilisation, etc. The government is also encouraging coastal tourism through incentive design.

The Bangladesh study site has been facing devastating cyclones, landslides and storm surges. Around 49% of the sampled population opined that coastal storms are a major threat for the coastal community. Two important anthropogenic threats reported by 50% of respondents are due to wastewater discharge from hotels and vehicles running on fossil fuels on the beach. Seawater intrusion affecting agriculture, salt-shrimp farming and fish drying (22% reported), while such impacts were reported the least on hoteliers. Cox's Bazar sea beach and ecosystem are under great threat from erosion due to unplanned development of resort area by cutting hills, establishment of shrimp hatcheries along the seashore, deforestation, over-fishing, salt fields, hill cutting for unplanned construction and tourism activities. Coastal storms pose medium risks for salt-shrimp farming, hotel industry, fish drying and shop business.

The Chinese study site has different characteristics. Tianjin sea waters belong to Bohai Sea, which is an enclosed sea with limited power of self-purification and fragile ecological environment. Coastal waters are polluted mainly by inorganic nitrogen and active phosphate. About 2,870 sq km do not meet national sea water quality standards, and among them, about 380 sq km are categorised as less clean, about 630 sq km lightly polluted, about 760 sq km, and about 1100 sq km seriously polluted. The Tianjin coastline is used for fishery, transportation, tourism, sewage dumping and there is reclamation as well. Of the major economic activities, marine fisheries (i.e. for fishing and mariculture) is an important one. Mariculture has received a lot more attention than before. With strict marine fishing regulations and declining natural fishery resources, shallow sea and beach mariculture were developed to increase mariculture production. The coastal zone of Tianjin is among the most vulnerable areas in China. Sea-level rise and storm surges remain a major problem. As sea-levels rise, the defence capability of breakwater gradually declines. Of all influencing factors, the largest contributor is land subsidence, which makes ecosystem-based economic activities in the region quite vulnerable. Opinions expressed by the respondents show that the traditional economic activities such as agriculture and fisheries are more vulnerable to natural hazards than new economic activities.

For India, responses show that three major threats to coastal economic activities in Digha-Sankarpur-Mandarmoni region are coastal storms (54%), sea water intrusion during high tides (78%) and coastal erosion (79%). After factoring in risk, horse-riding and fishing using manual boats and deep sea fishing using trawlers are perceived to be most threatened economic activities. Due to coastal storms, a substantial proportion of the respondents have reported to have experienced very significant loss of fixed assets and income among different types of risks. Sea water intrusion during high tides has led to very significant loss of roads, embankments and other public resources, according to a considerable proportion of the respondents. The survey findings showed that the majority of the households have not heard of climate change and were not aware that this could cause an increasing threat in the future. Interventions by local administration through adaptive measures are not equitably distributed across economic groups.

The long term trends in annual and seasonal-precipitation, as well as maximum and minimum temperature over the study sites of South Asia (India, Bangladesh and Sri Lanka) at daily time scales has been analysed to arrive at current baseline climatology and climate change projections. Characteristics of climate change projections for the study sites show:

- Mean annual maximum and minimum temperature rise by mid-century is projected to be the highest for India (1.5°C to 2°C min, 1.0°C to 1.4°C max).
- Mean annual rainfall is projected to decrease marginally towards the mid-century for India while increase for Bangladesh and Sri Lanka. Maximum increase is projected in Bangladesh. By IPCC AR5 projections with SMHI RCP4.5 Scenario, increase is projected to be the maximum for Sri Lanka.

The predictions become relevant for current trend towards increasing tourism-related activities as it can become affected in future with reduced recreational time window on the beach and with increasing coastal erosion and flooding.

4. Concluding remarks

Field experience shows that various anthropogenic and market changes are driving people away from traditional livelihood options in coastal areas. But, natural hazards are also exacerbating the changes. Taking a risk reduction strategy, people are moving towards new economic activities mostly related to tourism, which is also supported by the government in all the countries. However, we realise there is need for further research on strengthening the risk assessment study of new economic activities with alternative climate scenarios, alternative adaptation strategies designed for managing the risks, cost assessment of alternative adaptation strategies with risk reduction potential, and efforts are necessary for capacity building of different policy makers for better informed policy decisions relating to ecosystem vulnerability to various threats and possible adaptive strategies to reduce this vulnerability.

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Adaptive Capacity of Coastal Resource Management Institutions in Cambodia, Viet Nam and Australia

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HIGHLIGHTS

- Institutional adaptive capacity varied within and across case studies.
- Such capacity was influenced by enabling and disabling conditions at play.
- Higher-level institutions need to support enabling conditions at lower levels.
- This may involve poverty alleviation and building human and social capital.

ABSTRACT Responding to environmental change requires a better understanding of how institutions—the rules and norms that structure human interactions—enable society to adapt to impacts of such change. By drawing on the Adaptive Capacity Wheel framework and empirical cases of coastal resource management decentralisation in the context of the Peam Krasaop Wildlife Sanctuary (Cambodia), Tam Giang Lagoon (Viet Nam) and the state of South Australia (Australia), this study examines how institutions support adaptive capacity. The characteristics of institutions analysed both facilitated and constrained adaptive capacity, depending on the enabling and disabling conditions at play. Despite the constraints, institutions have, to a certain extent, enabled actors to: organise themselves; learn and improve resource management; mobilise leadership, resources and authority; and, make progress towards improved governance. These illustrate the creation and mobilisation of adaptive capacity, which resulted in positive outcomes in responding to environmental change. In some of the cases studied, reinforcing enabling conditions of adaptive capacity will require creating livelihood alternatives, alleviating poverty, reducing inequality, and building human and social capital.

KEYWORDS *adaptive capacity; institutional analysis; decentralisation; coastal resource governance; environmental change; Southeast Asia*

1. Introduction

The Earth system is experiencing social-ecological changes at a pace that is unprecedented in human history. Some of the most pressing issues facing human societies include overexploitation of natural resources, biodiversity loss, and climate change. In this context, adaptation is a societal response, which can reduce the adverse impacts of such changes (Fidelman, Leitch, & Nelson, 2013). Adaptation refers to "…the decision-making process and the set of actions undertaken to maintain the capacity to deal with current or future predicted change" (Nelson, Adger, & Brown, 2007).

Successful adaptation relies on the capacity of individuals, communities, organisations and governments to adapt to different climatic and non-climatic stressors (i.e., adaptive capacity) (Engle, 2011; Hill & Engle, 2013). Adaptive capacity involves a better understanding of relevant physical and social

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FIGURE 1. Environmental, social and political change in the Peam Krasaop Wildlife Sanctuary and Tam Giang Lagoon (CRM: coastal resource management).

Dimension	Evaluative criteria
Variety	Inclusive participation of relevant actors
Learning capacity	Joint activities that entail learning (e.g., meetings, decision-making, monitoring and enforcement etc.)
Autonomy	Autonomy to make and implement decisions
Leadership	Ability of actors to direct and motivate others to follow
Resources	Human, financial, and technical resources
Fair governance	Legitimacy, equity, responsiveness, accountability

TABLE 1. Dimensions and evaluative criteria of institutional adaptive capacity.

conditions that enable action to prevent, mitigate and adapt to impacts of a changing Earth system (Biermann et al., 2010). In sum, adaptive capacity is a critical property in fostering adaptation to environmental change (Engle, 2011).

Adaptive capacity particularly focuses on governance, institutions and management; therefore, it is translatable to decision- and policy-making applications (Engle, 2011). These may explain an increasing number of studies on institutional dimensions of adaptive capacity in recent years (Gupta et al., 2015; Hill & Engle, 2013)[1]. These studies suggest that responding to environmental change will necessarily demand responsive and flexible institutions that facilitate adaptive capacity. This involves, enabling social actors to design new institutions and reform existing ones to better respond and adapt to a changing environment (Gupta et al., 2010).

This study seeks to examine how institutions support (or reduce) adaptive capacity. It draws on empirical cases of decentralisation of coastal resource management in the context of the Peam Krasaop Wildlife Sanctuary (Cambodia), Tam Giang Lagoon (Viet Nam) and the state of South Australia (Australia).

2. Resource Management in a Changing Environment

The case studies examined in this study, i.e., Peam Krasaop Wildlife Sanctuary (Cambodia), Tam Giang Lagoon (Viet Nam) and South Australia Fisheries Management (Australia), are illustrative of environmental, socio-economic and political changes. They feature decline in resource conditions associated with resource use intensification. Such changes take place in the context of a centralised and hierarchical system of government, which, nevertheless, was promoting reforms towards decentralisation in response to social-ecological changes (Figure 1).

Decentralisation includes different types of policy reforms aiming to shift powers from centralised to more localised actors and institutions, such as sub-national units of administration, local government, the civil society, and/or local user groups (Meinzen-Dick & Knox, 2001). Accordingly, existing institutions were changed and new ones created to foster participatory, collaborative and decentralised coastal resource management. These were based on government intervention—and in the case of Cambodia and Viet Nam, involved international development initiatives in partnership with the community. Institutional reform included changes in the legislation, sharing responsibility over resource management, and establishment of community-based, resource-user and/or stakeholder entities (e.g., Village Management Committees in Cambodia, Fishing Associations in Viet Nam and Fisheries Council of South Australia). Information for each of the case studies is summarised in Appendix 1.

3. Methodology

3.1. Analytical Framework

This study draws on the Adaptive Capacity Wheel (ACW) of Gupta et al. (2010), an analytical approach developed to assess institutional adaptive capacity. The ACW is a useful heuristics to examine strengths and weakness of institutional capacity to adapt to environmental change (Grothmann, Grecksch, Winges, & Siebenhuner, 2013). It consists of six broad dimensions, i.e., (1) variety of actors, perspectives, and solutions, (2) learning capacity, (3) room for autonomous change (autonomy), (4) leadership, (5) resources and (6) fair governance. For each of these dimensions evaluative criteria were identified by drawing on Gupta et al. (2010) and related literature (e.g., Biggs et al., 2011; Dietz, Ostrom, & Stern, 2003; Ostrom, 2010) (Table 1).

[1] The notion of adaptive capacity used in this paper draws on the vulnerability framework. However, adaptive capacity has also developed in the domain of the resilience framework, where it is often referred to as 'adaptability' to describe the capacity of actors to manage and influence resilience (Engle, 2011; Nelson et al., 2007). Further, other theoretical perspectives, e.g., adaptive governance and adaptive co-management cover adaptation and institutions related themes (e.g., Armitage et al., 2009; Folke, Hahn, Olsson, & Norberg, 2005).

3.2. Selection of cases

Peam Krasaop Wildlife Sanctuary and Tam Giang Lagoon were selected to illustrate responses to environmental, socio-economic and political change in the context of coastal resource management, which provide a dynamic context to examine adaptive capacity. The availability of data and information from previous studies, and their history of engagement with coastal resource management were additional criteria used in their selection. The inclusion of the Australian case was a suggestion of one of the assessors of our initial proposal. The South Australia Fisheries Management was selected because it is the only state in Australia where fisheries co-management was formalised through specific government policy. It is important to note that unlike the Peam Krasaop Wildlife Sanctuary and Tam Giang Lagoon cases, which consist of community-based small-scale fisheries, South Australia Fisheries Management is mostly state-wide in scale and include commercial, recreational and traditional fishing.

3.3. Data collection and analysis

This study adopted a qualitative case study approach (Yin, 2003). It used multiple sources of data, i.e., documents (e.g., grey [technical reports] and academic literatures, organisation's websites, policies and legislation), participant observation, interviews and focus groups.

Observation, interviews and focus groups were undertaken between April and December 2014. Interview respondents and focus group participants were selected based on their history of involvement with and/or knowledge of the case studies. These respondents included community/villagers, resource users, members of decentralised entities (e.g., fishing associations and village management committees), and government officials (for details see Appendix 2). Interviews and focus groups explored perceptions of respondents and participants of the extent to which the case studies met the evaluative criteria outlined in Table 1.

Documents, interview and focus group data were analysed using systematic qualitative techniques (Miles & Huberman, 1994; Paton, Curtis, McDonald, & Woods, 2004). These included content analysis of documents, and interviews and focus groups data. Coding was based on the six dimensions and criteria described in the analytical approach. Data analysis was undertaken using the software NVivo.

4. Results

This section presents the characterisation of adaptive capacity in the context of the Peam Krasaop Wildlife Sanctuary (PKWS), Tam Giang Lagoon (TGL) and South Australia Fishery Management (SAFM). General strengths and weaknesses in terms of enabling and disabling conditions are also identified, as summarised in Table 2.

4.1 Variety

The three cases examined included, to different extents, a variety of state and non-state actors representing different sectors and levels of governance. For example, in the PKWS and TGL, these actors included international donor agencies, researchers, government officials, resource users and villagers.

Dimension	Adaptive Capacity	
	Enabling	Disabling
Variety	Engagement of state and non-state actors from various sectors and multiple levels of governance Involvement of diverse knowledge and expertise	Diversity of perspectives, interests and authority may lead, in some cases, to conflicts and tensions between actors
Learning capacity	Decision-making and management activities with potential to entail learning, e.g., training workshops, discussion forums, joint implementation, regular meetings	Limited resources for learning activities, conflict and tensions between actors, power imbalance, change in committees' membership, weak leadership
Autonomy	Policies and legislation support decentralised resource management	Limited decision-making and implementation authority Partial support from higher-level authorities
Leadership	Engagement and commitment of local and external leaders	Leadership qualities eroded by limited resources, self-interest, power imbalance, conflicts and tensions between actors
Resources	Ability of actors to mobilise external and internal financial, technical and human resources	Limited and inconsistent resources, over dependence on external sources
	Decentralisation of resource management, devolution of authority, allocation of property rights	Inconsistent policy implementation, tensions and conflicts, power imbalance, partial support from high-level authorities

TABLE 2. General enabling and disabling conditions of institutional adaptive capacity in the PKWS, TGL and SAFM.

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In addition, some of these actors aggregate a variety of other actors in their composition. For example, the Fisheries Council of South Australia consists of members with collective knowledge and expertise in relevant areas related to fisheries management (e.g., fisheries science, research and development; conservation; social science; law; business; Indigenous, commercial and recreational fishing). In contrast, involving a variety of actors, sectors and levels in policy- and decision-making may pose significant challenges. For instance, in the PKWS, the diversity of perspectives, interests and authority has, in some cases, underscored existing conflicts and tensions between actors. This was evident in Koh Sralao and Koh Kapic communities where the head of the commune council and village chief considered Village Management Committees as adversaries.

4.2 Learning Capacity

The involvement of multiple actors, sectors and levels (*variety*) in coastal resource management, has significant implications for learning. Such *variety* has the potential to enhance learning capacity through, for example, combining information and knowledge (e.g., local and technical), sharing of experiences through networks, and learning from other actors through joint activities. For example, in the PKWS, the Participatory Management of Mangrove Resources (PMMR) project adopted a "learning by doing" approach. Such approach proposes that decentralised resource management may be an experimental, reflective and adaptive process. Thus, the PMMR team spent its first few years developing activities to facilitate learning, i.e., activities by which actors could exchange ideas and perspectives, and build capacity. These included a number of awareness raising and training workshops, and study tours covering a range of topics (e.g., environmental management, governance, project management, livelihood improvement, coastal conservation, and mangrove inventory and restoration).

On the other hand, factors that hindered learning capacity included: inadequate resources to support learning activities, conflict and tensions among actors, and power imbalance. In the case of SAFM, the change in membership of committees and the Fisheries Council may have led to loss of institutional knowledge. Another critical factor constraining learning capacity is weak leadership (see e.g., Marschke and Sinclair [2009] for discussion on learning in the context of the PKWS).

4.3 Autonomy

In all case studies, legislation and policies have been enacted providing for decentralisation of resource management. This involved transferring some level of authority over the design and reform of management arrangements to actors at sub-national and/or local levels. Examples of such legislation include the Sub-decree on Community Fisheries Management 2005, 2007 (PKWS), Decision 3677/2004/QD-UB (TGL) and the Co-management of Fisheries Policy in South Australia. Despite the formal support to decentralisation, entities responsible for management at the local level, such as Village Management Committees in the PKWS, and Fishing Associations in the TGL, still have limited power in terms of decision-making and implementation. In the three case studies examined, the ultimate responsibility for decisions over coastal resource management remains with high level policy- and decision-makers.

4.4 Leadership

Leadership qualities of actors varied across and within the case studies. However, strong leadership was regarded as an important attribute enabling decentralised resource management. For example, the Peam Krasaop Village Management Committee's strong leadership has helped mobilise support from its members and villagers. In the TGL, members of the Fishing Association executive boards may include experienced, responsible and prestigious fishers. In these instances, leadership has proven to be an enabling factor contributing to success of these entities (Marschke & Sinclair, 2009). In SAFM, focus group participants considered leadership critical to decentralised management, and building and mobilising adaptive capacity. Conversely, weak leadership in Koh Sralao and Koh Kapic communities was regarded as a main contributor to ineffective and/or dysfunctional Village Management Committees. Likewise, in the TGL, the Co-management Board, which was established to facilitate coordination between Fishing Associations and local authorities, had a poor record of accomplishments given, in part, the weak leadership. In general, leadership qualities were eroded (e.g., the PKWS case) by limited resources, self-interest, power-imbalance, and conflicts and tensions among local actors.

4.5 Resources

Decentralisation of resource management in the PKWS and TGL were supported, particularly during its inception, by external human, financial, technical resources. They were provided by international donor agencies, researchers and government authorities. In addition, to external support, some communities were able to use funds from other activities to support resource management. That was the case of Peam Krasaop, which used financial resources generated from ecotourism to fund conservation, development and poverty alleviation activities. In the TGL, annual membership and exploitation fees helped support their operations. Local actors were also able to mobilise human and technical support through their networks. Nevertheless, resources have overall been limited, inconsistent, and, very often, over reliant on external sources; which has constrained management activities. In the PKWS, for example, the absence of a speed boat and limited technical support impacted on the capacity of Village Management Committees to engage in patrolling. Similarly, limited financial resources hindered further development of co-management in SAFM, for instance, through trialling of co-management in different fisheries.

4.6 Fair Governance

Overall, the resource management initiatives examined have helped improve principles of fair governance, such as legitimacy, equity, responsiveness and accountability. It is important to note that in Cambodia and Viet Nam decentralisation takes place in a complex and evolving political context, characterised by centralised government systems. In this context, the transfer of authority (yet somewhat limited) over resource management to local non-state actors is a positive outcome. Further, local entities to which such authority has been transferred (such as Village Management Committees) comprise elected villagers and resource users. In the case of SAFM, Fishery Management Committees provided, in the past, opportunity for stakeholders to provide input into South Australia's fisheries management. Nevertheless, fair governance remains challenging in the cases examined. Tensions and conflicts, power imbalance, partial support from high-level authorities, limited resources, and inconsistent policy implementation are some of the constraining factors. Importantly, as seen previously, the ultimate authority to make decisions in all cases examined remains with high-level government authorities.

5. Discussion

This study examined institutional adaptive capacity in the context of decentralisation of coastal resource management in the Peam Krasaop Wildlife Sanctuary (PKWS, Cambodia), Tam Giang Lagoon (TGL, Viet Nam) and South Australia Fisheries Management (SAFM, Australia). The six dimensions of institutional adaptive capacity (i.e., *variety, learning capacity, autonomy, leadership, resources and fair governance*) varied within and across the case studies examined. These dimensions may both facilitate and constrain adaptive capacity, depending on enabling and constraining conditions at play.

The fact the institutional dimensions examined may both serve as enabler and/or deterrent to adaptive capacity may be explained by the very nature of institutions. That is, institutions can inherently both expand and/or limit human decision-making and action (Ostrom, 2005). It may also be explained by the interdependent nature of these dimensions; that is, these six dimensions of adaptive capacity can reinforce and/or undermine each other (Gupta et al., 2010). For example, in the PKWS and TGL, external financial and technical resources were critical to support learning activities (*resources* have supported *learning capacity*). Such activities aimed, among others, to enhance the ability of villagers, fishermen, government authorities and technical staff to participate in decentralised resource management (*learning* has reinforced *variety*). *Resources* also helped mobilise *leadership* by reducing the transaction costs of participation. *Leadership*, in turn, proved critical to mobilise external technical *resources* and authority (*autonomy*). Later, policies and legislation formalised and provided legitimacy and legal authority for local actors to take part in resource management (*autonomy* has supported *governance* and *variety*). Conversely, limited *resources* and *autonomy* have constrained *leadership* qualities of local actors; and, inconsistent policy implementation and law enforcement have undermined local authority in some instances (*governance* has constrained *autonomy*).

The constraints to resource management, highlighted in the assessment of the six institutional dimensions of adaptive capacity, are common to decentralised initiatives elsewhere (see e.g., Larson & Ribot, 2004; Larson & Soto, 2008). They indicate that democratic decentralisation of natural resources, similar to the case studies investigated here, is rather challenging to implement, and results are therefore variable (Larson & Soto, 2008). The literature on decentralisation of natural resources emphasises that these constraints arise fundamentally from governments transferring inadequate powers to local actors (Larson & Ribot, 2004). Further, as highlighted previously, decentralisation takes place, particularly in the PKWS and TGL, in complex and evolving socio-economic and political contexts, characterised by centralised government regimes. These are compounded by different reasons underpinning governments' motivation towards decentralisation (Marschke, 2012).

6. Concluding Remarks

Despite the constraints to adaptive capacity discussed above, coastal resource management has, to a certain extent, enabled actors to: organise themselves; learn and improve resource management; mobilise leadership, resources and authority; and, make progress towards improved governance. These illustrate the creation and mobilisation of adaptive capacity, which in some cases resulted in positive outcomes in responding to environmental change.

Nevertheless, responding to issues involving complex external factors seems to be beyond the means of the institutions examined. These issues usually comprise some of the most pressing environmental change issues, such as climate change. Responding to such issues requires action at multiple governance levels. At the local level, a priority strategy is reinforcing existing enabling conditions and minimising those constraining adaptive capacity of local institutions. At sub-national and national levels, in addition to building and mobilising adaptive capacity at those levels, institutions need to provide and reinforce enabling conditions at lower levels. These include providing adequate financial and technical resources and authority so that adaptive capacity may be strengthened, and adaptation may emerge locally. In some cases, such as the PKWS and TGL, reinforcing enabling conditions may also include creating livelihood alternatives to the exploitation of coastal resources, alleviating poverty, reducing inequality, and building human and social capital.

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APPENDIX 1

Characterisation of the case studies

Peam Krasaop Wildlife Sanctuary, Cambodia

Peam Krasaop Wildlife Sanctuary (PKWS) is located in the Koh Kong province, southwest Cambodia. The PKWS contains extensive areas of mangroves (24,000 hectares, approximately) (Marschke & Nong, 2003).

Ten thousand people live in PKWS across three administrative districts, containing 6 communes and 15 villages. For most of these people, mangroves and associated resources provide opportunities for income generation and livelihood. However, since the early 1990s, coastal resources have significantly declined as a result of population growth, clearing of mangroves for aquaculture and charcoal production, destructive fishing practices (e.g., cyanide fishing), and illegal fishing (Marschke, 2012; Marschke & Nong, 2003).

In response to resource decline, in the late 1990s, an initiative known as Participatory Management of Mangrove Resources, led by the Ministry of Environment, facilitated the establishment of Village Management Committees comprising members of the community and resource users (The Participatory Management of Coastal Resources Project, 2008)

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Tam Giang lagoon, Viet Nam

The Tam Giang Lagoon (TGL) is located in Thua Thien Hue Province, Central Viet Nam. It covers an area of approximately 22,000ha and stretches approximately 70km along the coast (Tuyen, Armitage, & Marschke, 2010). It is estimated that the lagoon's aquatic resources are directly or indirectly important for 300,000 people living in 33 communes and towns, and 326 villages across the lagoon area (Tuyen, 2002; Tuyen, Armitage, & Marschke, 2010).

The decline in fish catch and restricted access to the lagoon resulted from a rapid resource use intensification over the past 15 years or so (Tuyen, 2002). In addition, these problems were exacerbated by agricultural development and urbanisation (Tuyen, Armitage, & Marschke, 2010).

Decentralised resource management was initially adopted at the district level to complement the existing centralised, top-down management approach. Fundamental elements of resource management decentralisation in the TGL include the Fishing Associations. These are a type of social-professional organisations with responsibility for resource management at the village or user group level (Tuyen, Armitage, & Marschke, 2010).

South Australia Fisheries Management

Over the years, the management of South Australia's fishery resources has been undertaken in partnership and consultation with the fishing industry and other key stakeholders. This consultative co-management arrangement was largely implemented through Fisheries Management Committee processes. Nevertheless, conflicts between the government, industry and other key stakeholders still persisted. This led the South Australian government to recognise the need for its fishery managers and scientists to engage regularly with commercial, recreational and traditional fishers, and other key stakeholders and the general community that use or have a stake in fishery resources in the state (PIRSA, 2013).

In 2007, the Fishery Management Council of South Australia was established; and, replaced the Fishery Management Committees. The Council's functions include the preparation of fisheries management plans; advising the Minster on allocation issues; promoting the co-management of fisheries; and promoting research, education and training in relation to fisheries and their management (Fisheries Council, 2013).

APPENDIX 2

Data collection methods used in the case studies

Case Study	Methods
Peam Krasaop Wildlife Sanctuary (PKWS) Case sites (communities): • Koh Kapic • Koh Sralao • Koh Kang • Peam Krasoap	***Desktop review*** of co-management in PKWS Informal scoping discussions and participant observation in each site ***Focus groups***, three in each site, involving 25-30 participants e.g., Village Management Committee members, fishers and villagers ***Interviews*** with 50 key informants, including: former Staff of the Participatory Management of Coastal Resources project, high level officers and managers from the Provincial Department of Environment, Department of Agriculture, Fisheries and Forestry, Provincial Department of Women's Affairs, and PKWS; former UNDP-GEF small grant's manager; past representatives of Village Management Committees; and, respected village elders ***Validation and dissemination workshop*** involving 26 participants
Tam Giang Lagoon (TGL) Case sites (communes): • Loc Binh • Vinh Giang • Vinh Phu	***Desktop review*** of co-management in TGL ***Interviews*** with 20 key informants, including researchers and officers from government, fisheries and environment/resource agencies, and Fishing Associations ***Focus groups*** in each of the case sites involving 12-15 Fishing Association officers and members
South Australia Fisheries Management	***Desktop review*** of co-management in South Australia's fisheries Focus group with 6 fishery managers

Capacity Building in the Assessment of Biodiversity and Ecosystem Services for Conserving Wetlands for the Future

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HIGHLIGHTS

- Wetlands, their biodiversity and ecosystem services are degraded and lost because they are neither assessed nor valued by projects related to land and water resources development or management.
- Most stakeholders are unaware of the wetland ecosystem services other than those related to direct consumptive use.
- Conflicting interests of various stakeholders can be resolved by promoting awareness and capacity building.
- The future of wetlands can be ensured by effective policies and legislation rooted in the understanding of their biodiversity and ecosystem services together with the factors that sustain them.

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ABSTRACT Wetlands support a significantly large proportion of biodiversity. Their ecosystem services range from provision of water, food (fish and rice) and other resources to the regulation of water regimes, water quality and climate. They enhance the aesthetics and are hubs of cultural and recreational activities. Wetlands are threatened most by changes in land use/land cover and inappropriate water resources management because of poor understanding of their biodiversity and ecosystem services and lack of capacity for their assessment and valuation. To improve the capacity of various stakeholders, we prepared guidelines for rapid assessment (sampling, identification and enumeration) of biodiversity and major ecosystem services of wetlands. These guidelines were tested briefly in three different wetlands in Kolkata, Guwahati and Kathmandu by demonstration in the field and discussion with over 230 researchers, scientists, managers, policy makers and NGOs representatives besides about 100 members of the local wetland-dependent community. It generated interest and helped improve their understanding of the wetland benefits. The guidelines (available online) may be elaborated and adapted for assessment of biodiversity and ecosystem services and capacity building in different regions. A policy brief (also available online) highlighting the ecosystem services of wetlands and their relationships with biodiversity was prepared and discussed at another workshop for managers and policy makers. Extensive capacity building effort is recommended for the necessary change in wetland related policies.

KEYWORDS *wetland biodiversity; ecosystem services; rapid assessment; deepor beel; kholsi beel; Nagdaha lake*

1. Introduction

Wetlands include periodically shallow flooded areas such as floodplains along large rivers and littoral zones of lakes and reservoirs, seasonal or perennial shallow water bodies (fresh, brackish or saline, with or without vegetation) and mangroves (dominated by woody vegetation) along the estuarine coastal areas in the tropics. Paddy fields and fish ponds are among the most important human-made and managed wetlands. Other wetlands include peatlands where organic matter produced by the plants has accumulated over many centuries, and coastal salt marshes. Wetlands occur in all climatic zones—from tropical deserts to cold tundra, and at all altitudes—from below the sea level to about 6000 m elevation in the Himalayas.

Wetlands, especially the riverine floodplains, gave birth to human civilisations across the globe and were an integral part of the socio-cultural ethos of the people in South Asia where they were held sacred and even bestowed with divinity. Humans depended on wetlands for water, fish and plants such as reeds, papyrus and lotus. Rice which was domesticated serves half of the humanity today.

Wetlands, however, were extensively drained and over-exploited for their plant and animal resources as well as peat, particularly in Europe and North America (see Williams, 1990). Concerns were raised first, less than a century ago, for their protection in view of the large populations of migratory birds visiting them. They became the subject of an international agreement—the Ramsar Convention (signed on 2 February 1971 in Ramsar, Iran), under which practically all countries have committed themselves to the wise use and maintenance of the ecological character of wetlands. The Ramsar Convention has gradually widened its scope to bring all aquatic ecosystems, except oceans, under the banner of wetlands (see Ramsar Convention Secretariat, 2013).

Here we discuss the importance of capacity building in the assessment of biodiversity and ecosystem services of wetlands that will help integrating wetlands into land and water management policies. We draw upon our experience from an APN-funded project where we developed the rapid assessment guidelines and tested them briefly in three different wetlands. Some recommendations are made for further work.

2. Wetland Biodiversity, Functions and Ecosystem Services

2.1 Biodiversity in Wetlands

Wetlands are best known for their very high biodiversity including microorganisms (Gopal, 2009). The diversity and abundance of macrophytes as well as the fauna are governed by the water regime (depth and duration, frequency and amplitude of change and the time of the year as well as flow velocity) which controls their various life processes. Macrophytes play a major role in enhancing the biodiversity by providing food both directly and indirectly (through detritus) as well as habitat, shelter, nesting and breeding sites. Numerous birds, fish, amphibia, reptiles and invertebrates seasonally migrate between wetlands and other open water or terrestrial habitats as they require different water regimes and food sources at different times of their life cycle. Wetland fauna includes various residents, regular migrants, occasional visitors and those indirectly dependent on wetland biota.

2.2 Functions and Ecosystem Services

Similar to other ecosystems, wetland functions include capture and transfer of energy through plants to food webs and biogeochemical cycling (including water cycle). Wetlands are among the most productive systems and capture large amounts of energy and carbon dioxide. They play a major role in the hydrological cycle by regulating the flux of water at every stage (see Gopal, 2016).

Humans derive many direct and indirect benefits from these wetland functions. Such benefits have recently been termed as "ecosystem services", which are categorised into provisioning, regulating, cultural and supporting services (MEA, 2005; Finlayson & D'Cruz, 2005). High rates of organic matter production by wetland plants and animals means that a large diversity of biological resources is available for direct use as food, fibre, fuel, fodder, medicine, etc. (i.e., provisioning service). At the same time, high organic production and its relatively slow decomposition and mineralisation results in significant carbon sequestration. Wetlands therefore contribute to regulating climate change. Under certain conditions, wetlands also release methane and nitrous oxide which contribute to global warming. Recent studies however show that wetlands may be a source for greenhouse gases only on a time scale of decades; over long-term (100 to 300 years), most wetlands become net carbon sinks (Mitsch et al., 2012).

Humans benefit from wetlands indirectly as they regulate the water regimes. Wetlands receive water from the catchments, retain it for varying periods of time, retard its flow, transfer it downstream and facilitate its infiltration below ground but may also enhance losses in evapotranspiration. The evapotranspiration through the macrophytes moderates the microclimate of the surrounding areas (see Gopal, 2016). Humans benefit directly in terms of water availability for different uses over a longer time and space as well as through protection against the hazards of floods and drought.

A suite of physical, chemical and biological processes involved in the cycling of nutrients and other elements help improve the water quality by stripping the nutrients and pollutants. Floodplains and littoral zones help maintain the water quality in rivers and lakes by intercepting and transforming the nutrients and various pollutants from non-point sources.

Wetland habitats are also preferred for recreational and socio-cultural activities such as bird watching, boating, angling, swimming etc or just relaxing in aesthetically pleasant, serene places. Many wetlands have high spiritual and religious values and are held sacred. Further, the livelihoods of many communities and social groups depend almost exclusively upon wetlands.

2.3 Linkages between Biodiversity and Ecosystem Services

All ecosystem services noted above are linked with some components of biodiversity because different plants, animals and micro-organisms are involved in various processes of energy capture and transfer, water cycle, uptake and transformation of nutrients, and development of habitats. These linkages are discussed in detail by MEA (2005), Duffy (2009) and Mace, Norris, and Fitter (2012). In wetlands, the ecosystem services of fish, macroinvertebrates and microbes, birds and macrophytes have been discussed by Holmlund and Hammer (1999), Covich et al. (2004), Green and Elmberg (2014) and Gopal, 2016 respectively.

2.4 Wetland Threats and Ecosystem Services Assessment

The ecosystem services of wetlands have been assessed to have very high economic value at global scales (Costanza, Farber, & Maxwell, 1989; Costanza et al., 1997; Ghermandi et al., 2010). Yet in most of the developing countries, wetlands continue to be considered as unproductive wastelands—a perception transplanted from Europe, and therefore, are being lost to urbanisation or degraded by domestic and/or industrial wastewaters. Important factors responsible for this state are (a) inadequate assessment of their biodiversity, (b) failure to recognise the ecosystem services, particularly the intangible and non-use benefits and those related to the livelihoods local communities, and link them with the biodiversity, and (c) ignoring the valuation of ecosystem services for factoring them in the cost-benefit analysis of land and water resources management projects (see Kumar et al., 2011, Kumar & James, 2012). This in turn stems from a general lack of the capacity to assess and valuate the wetland biodiversity and ecosystem services.

3. The Capacity Building Project

The Ramsar Convention chose the theme "Wetlands for Our Future" for the 2015 World Wetland Day. We believe that our future is closely linked with the future of wetlands, which in turn depends upon our capacity to understand and assess the benefits we derive from them and to integrate that understanding into policy and action. This motivated us to initiate activities for capacity building on wetlands among a wide range of stakeholders, from students and young researchers to wetland managers and policy makers, with support from the Asia Pacific Network for Global Change Research (APN) under its Capacity Building programme. We focused on the wetlands in the Ganga-Brahmaputra river basin, particularly those in the Eastern Himalayan region. This area lies within the Himalaya and Indo–Burma global biodiversity hotspot (Allen, Molur, & Daniel, 2010). It is also a distinct freshwater ecoregion (Abell et al., 2008) and differs significantly from the Western Ghats (another biodiversity hotspot) in its freshwater biodiversity (see Molur, Smith, Daniel, & Darwall, 2011). The area has thousands of large floodplain wetlands which include Ramsar sites like Deepor Beel and World Heritages like Kaziranga and Manas National Parks. These wetlands are threatened by numerous hydropower projects (Das, 2013) and climate change (Gopal, Shilpakar, & Sharma, 2010).

The project focused on (i) preparing the Guidelines for rapid assessment of wetland biodiversity and ecosystem services, (ii) communicating and testing these Guidelines by bringing together a range of stakeholders in workshops, and (iii) preparing a policy brief for wetland managers and policy makers.

3.1. The Guidelines

The Guidelines were prepared by experts in different biota to facilitate quick assessment of biodiversity and ecosystem services (Gopal, 2015a). The Guidelines for biodiversity assessment include an introduction, simple low cost methods for sampling, identification and quantification as far as possible in the field and with minimum laboratory requirement. The guidelines bring together the macrophytes, microphytes (phytoplankton and periphyton), zooplankton, macroinvertebrates, fish, waterfowl and herpetofauna along with notes on ecosystem services associated with them. Common taxa (other than birds) occurring in the East Himalayan region are illustrated in colour for easy identification. Five posters accompany the Guidelines to help identification in the field, especially by the local community. Microorganisms were not included because they necessarily require elaborate laboratory examination.

PICTURE 1. Wetland Biodiversity and Ecosystem Services Workshop: Kolkata, 19-21 February 2015

The Guidelines for rapid assessment of ecosystem services emphasise upon a participatory approach (also suggested by the Ramsar and Biodiversity Conventions; De Groot, Stuip, Finlayson, & Davidson, 2006). Starting with the identification of stakeholders, especially among the local communities, the Guidelines describe ecosystem functions and their indicators for selected ecosystem services followed by methods for their assessment. Ecosystem services related with water, biomass and water quality and the cultural/recreational services are covered briefly. We plan to revise and elaborate the Guidelines periodically.

3.2. Capacity Building Workshops

We organised three capacity building workshops in Kolkata, Guwahati (India) and Kathmandu (Nepal) in active collaboration with partner organisations. Participants included students, young researchers, scientists from universities and research institutes, wetland managers, government officers, NGO representatives and several policy makers. On the first day, after introduction and presentations on wetland issues in South Asia, the Guidelines were discussed. On the second day, the participants visited a wetland where a sizeable number of community members representing different sections were invited along with the wetland managers and other local officials for detailed interaction. Biodiversity assessment methods were demonstrated in the field, and the ecosystem services were assessed in consultation with the community stakeholders. The local community provided useful insights into their viewpoints on wetland benefits, traditional management practices as well as their problems (see below). Next day the information gathered during the field visit was analysed and discussed among the participants. Methods for economic valuation of identified ecosystem services were also discussed but not applied due to the lack of adequate data. The 3-day workshop was grossly inadequate for comprehensive discussion and demonstration.

PICTURE 2. Sampling on Khalsi Beel

3.2.1 Khalsi Beel, Kolkata

This wetland near Kolkata (West Bengal) is a 62-ha perennial oxbow lake surrounded by human settlements and intensively farmed agricultural land with a dependent fishing community. The fisher community was aware of the biodiversity other than fish and the role of submerged macrophytes as fish food. The community exotic and fisheries development officers were concerned at the loss of biodiversity (especially fish and birds) and habitat changes such as a reduction in water depth. They recognised siltation and loss of connectivity with the river together with the exotic species (water hyacinth and Chinese

PICTURE 3. Discussion with local community

carp) as major factors. The community also recognised other benefits such as flood control and groundwater recharge, water for jute retting, duck rearing, bathing and domestic use and local tourism.

3.2.2 Deepor Beel, Guwahati

This 4 sq km wetland near the Guwahati (Assam) airport is a Ramsar site in the floodplain of river Brahmaputra. A part of the wetland is a wildlife sanctuary though most of it supports the livelihood of fishing and farming community of the surrounding villages. The community is aware of the importance of Deepor beel for wildlife and birds as well as the issues of its degrada-

PICTURE 4. Sampling macrophytes

tion and shrinkage in area due to encroachment for housing and industries, solid wastes, sewage, and also the reduced connectivity with the river through a canal. The director of the wildlife sanctuary discussed on site the conservation problems, particularly the conflict between people and the wildlife.

3.2.3 Nagdaha Lake, Kathmandu

It is a relatively small shallow lake near Kathmandu (Nepal). A concrete wall along its margins restricts its area. It is visited by many people for recreation and for religious functions on specific days, as is affected by agricultural activity in the surrounding areas. The local community is concerned over erosion, water pollution due to uncontrolled washing, cleaning and bathing, aquatic weeds, exotic fishes and very low biodiversity as well as decline in water table. The local community have

PICTURE 5. Sampling in Nagadaha wetland-Kathmandu

formed Naghdaha Improvement Committee to conserve it for local people as a source of income from tourism and recreational fishing.

3.2.4 Wetland Network

We set up a web page (www.aquaticecosystems.org/network/) for an online networking of individuals and institutions interested in wetlands, their biodiversity and ecosystem services, anywhere in Asia. This is expected to provide a useful database for exchange of information and communication among the wetland community. It can be searched by geographic regions, wetland types, groups of organisms, ecosystem processes and services.

3.3. Lessons Learned

Brief interaction with the local communities around the three wetlands revealed that the local communities, which depend upon wetlands for their subsistence and livelihoods, are fairly aware of many provisioning, regulating and cultural services of wetlands as well as the major causes of wetland degradation (including pollution and exotic species). Even the minor produce such as rhizomes of lotus, makhana (Euryale ferox) and the leafy shoots of Ipomoea aquatica were valued highly by the local community. The cultural services such as tourism and recreation were also recognised by the local communities. The field visits also confirmed that most of the impacts on wetlands arise from the catchment-based human activities of which the hydrological changes and conversion to other land uses were most significant.

Discussions with stakeholders ranging from local communities to the policy makers made it clear that the biodiversity and ecosystem services of wetlands need to be assessed properly in a participatory manner by involving all sections of the local community and giving due weight to their livelihoods. Wetland managers and local communities tend to manage wetlands to maximise a few ecosystem services that result in the loss of other services providing indirect benefits. The capacity building needs greater emphasis on the assessment of the regulating and cultural services and the issues related to climate change.

3.4. Policy Workshop

We prepared a policy brief focusing on the biodiversity and ecosystem services of wetlands (Gopal, 2015b) and presented it together with the Guidelines at a workshop specifically targeted at policy makers and wetland managers. Our experiences from the three wetlands were discussed with policy makers from the Indian Government and several international organisations. It was emphasised that conservation requires a major shift in policies related to land and water use, and that both natural and human-made wetlands should be declared as specific land use category and their biophysical and hydrological characteristics should be documented and monitored regularly for any change. Further, all development projects such as those related to urban or industrial development, or those concerned with storage, diversion and abstraction of water from any source should consider all kinds of wetlands to be affected directly or indirectly, within the project area or far away from them. In the case of rivers, hydrological changes often cascade down to the entire river downstream (e.g., on floodplains). These projects should take into account especially the changes in biodiversity and the ecosystem services of wetlands, and their economic valuation should be integrated into the cost-benefit analysis of the project.

4. Conclusions

Capacity building requires far more effort than a one- or two-day interaction. Most of the biodiversity components which contribute to ecosystem services exhibit large seasonal

PICTURE 6. Capacity Building Workshop: "Conservation of Biodiversity and Ecosystem Services of Wetlands in Relation to Global Change", 12-14 March 2015, Kathmandu

variation in occurrence and abundance. Hence even the rapid assessments of biodiversity need more than a single visit of short duration for adequate sampling and analysis. Similarly, the assessments of ecosystem services require quantitative data and greater interaction with different groups of stakeholders. The project succeeded in preparing the guidelines and bringing the stakeholders together and generating interest in the ecosystem services and their assessment. Both the biodiversity and ecosystem services need to be assessed on an extensive scale to cover different kinds of wetlands and communities of different socio-economic status. The Guidelines will also require adaptation for different ecoclimatic regions and regular updating.

Wetland conservation meets the goals and objectives of several international conventions other than the Ramsar Convention; for example, the Conventions on Biodiversity, Climate Change and Migratory Species. Ecosystem services assessments followed by their economic valuation will help integrate wetlands into land and water management policies and help in ecosystem-based adaptation to climate change.

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Building Capabilities of Local Climate Change Communicators towards Climate Change Adaptation in the Upland Communities in Southeast Asia

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HIGHLIGHTS

- The capability of smallholder upland farmers to experiment the appropriate climate change adaptation strategies, their ability to teach other farmers, and the effectiveness of farmer-to-farmer teaching were the basic considerations in implementing this capacity development programme.
- A total of 109 farmers and technicians in the selected upland communities in the Philippines, Lao PDR, Indonesia and Viet Nam were trained as local climate change communicators.
- A total of 205 students, farmers, agricultural technicians and faculty members formed as the trainees of the local climate change communicators in the four national local climate change awareness programmes organised in the four collaborating countries.
- Climate change information materials were developed to help in the information dissemination and education of the public about climate change—its issues, impacts and adaptation strategies.
- A policy brief was developed to facilitate local policy making processes about climate change mitigation and adaptation.

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ABSTRACT This article highlights the experiences of the Southeast Asian Network for Agroforestry Education (SEANAFE) and its collaborators in implementing capacity development activities for climate change adaptation of upland communities in the four collaborating countries, namely Indonesia, Lao PDR, Philippines and Viet Nam. This capacity-building project focused on the training of local climate change communicators who would serve as the local trainers and disseminators of climate change-related issues and developments among the local community members. It also aims to continuously build awareness among the local stakeholders about climate change issues, causes, impacts and adaptation strategies. Among the outputs of this project are the information materials on climate change and a policy brief that would be used as an instrument in lobbying local policy makers.

KEYWORDS *local communicators; climate change; policy brief; Southeast Asia; upland communities*

1. Introduction

Climate change has become a serious global problem as evidenced by the erratic change in temperature and rainfall patterns around the world, which have caused negative impacts, practically, to all living creatures. Yohe and Tol (2002) argue that the high number of poor people in developing countries is generally more vulnerable and likely to feel the negative effects of climate change since they have limited economic and technological capacities to adapt to climate change.

The IPCC (2011) highlights that "yields of some crops in tropical agricultural areas decrease with even minimal increase in temperature because they are near their maximum temperature tolerance. Where there is also a large decrease in rainfall in subtropical and tropical dryland/rainfed systems, crop yields would even be more adversely affected." Among the projections and predictions of climate change experts, the agriculture and food security in Asia would be highly vulnerable to the impacts of climate change. Specifically, there would be crop yield decline which may put many millions of people at risk from hunger; reduction in the soil moisture and increase in evapotranspiration which may increase land degradation and desertification; and expansion of agricultural productivity in northern areas (UNFCC, 2007).

These projections are now a reality. Climate change is already being experienced in the agriculture sector, particularly in the upland farming communities in Southeast Asia. Tolentino and Landicho (2013) highlighted that the smallholder upland farmers in the Philippine and Indonesia have been experiencing abnormal rainfall and temperature patterns, which have greatly affected their agricultural production. These effects include higher incidence of pests and diseases, low crop productivity/yield, stunted growth, delays in the fruiting and harvesting, and declining quality of farm product. These have led to increased labour costs and lower farm income. These findings are consistent with the claim of Aliteri and Koohafkan (2008) that most of the climate change models predict that the small farmers, particularly those engaged in rainfed agriculture would bear the negative impacts of climate change.

Recognising the capability of the smallholder farmers to experiment on the appropriate climate change adaptation strategy, their ability to teach other farmers, and the effectiveness of a farmer-to-farmer-teaching, the need to train farmers and technicians as local climate change communicators was deemed necessary. The Southeast Asian Network for Agroforestry Education (SEANAFE), through its national networks, namely Philippine Agroforestry Education and Research Network (PAFERN), Indonesia Network for Agroforestry Education (INAFE), Lao Network for Agroforestry Education (LaoNAFE), and Viet Nam Network for Agroforestry Education (VNAFE), embarked on the capacity development of local climate change communicators to enhance climate change adaptation of upland communities in Southeast Asia.

This project aimed to develop the capabilities of at least 15 farmer-leaders as climate change communicators in the selected upland communities in each of the four collaborating countries. This project also intended to provide training activities for local technicians and selected farmer-trainers around the science of climate change—its issues, causes and impacts on agricultural production, health and the environment, including the appropriate climate change adaptation practices; produce easy-to-learn and farmer-friendly information materials about climate change, and organise a local climate change awareness programme in the most strategic upland community in each collaborating country with the local climate change communicators as lead persons.

2. Methodology

The capacity development activities centred on training of local climate change communicators, developing and disseminating climate change information materials, and developing a policy brief to facilitate climate change policy-making processes at the local level.

2.1 National Training of Local Climate Change Communicators

This training generally aimed to develop the capability of the local farmers and agricultural technicians as climate change communicators in their respective communities. Specifically, this training discussed the issues on climate change with emphasis on its causes, evidences and impacts; drafted/initially developed farmer-friendly climate change information materials, and provided the farmers and agricultural technicians with the knowledge and skills on basic communication particularly their presentation and facilitation skills. This two-day training revolved around the following methodologies:

- Lecture-discussion, which covered the science of climate change with emphasis on its causes, evidences/indications and impacts; agriculture-related climate change adaptation strategies, and basic concepts and principles of communication.
- Workshop, which gives an opportunity for the participants to articulate their concepts about climate change and their own climate change adaptation strategies being employed in their farms. The initial output of the workshop was used as inputs in the development and production of climate change information materials.
- Field visit, which enabled the local farmers and agricultural technicians to observe the demonstration farms for climate change adaptation strategies. These demonstration farms were established in the APN project CBA2013-10NSY-Visco.
- Planning, which provided an opportunity to train participants in planning for the implementation of the Local Climate Change Awareness Programme, where they would serve as the lead resource persons/speakers.

2.2 Local Climate Change Awareness Programme

This activity generally aimed to create public awareness about climate change, particularly on its causes and impacts, as well as the different climate change adaptation and mitigation strategies that are being employed/practiced by the farmers, local government units, and academic institutions. Specifically, this awareness programme served as a venue for the selected potential local climate change communicators to re-echo the learning that they have gained from the national training of local climate change communicators and provided an opportunity to exhibit and display the different farmer-friendly information materials about climate change adaptation strategies for possible adoption by the other farmers.

FIGURE 1. Potential farmer-trainers in Lao PDR being trained on how to prepare climate change information materials.

Collaborating countries	Participants	Total
Indonesia	30	119
Lao PDR	24	
Philippines	22	
Viet Nam	33	

TABLE 1. Number of training participants in each of the four collaborating countries.

Collaborating countries	Participants	Total
Indonesia	38	205
Lao PDR	42	
Philippines	90	
Viet Nam	35	

TABLE 2. Number of participants in each of the collaborating countries.

2.3 Production of Climate Change Information Materials

Participants of the national training of local climate change communicators, including the project collaborators, developed and produced information materials about climate change in the form of posters, flyers and brochures. These were all exhibited, displayed and distributed during the Local Climate Change Awareness Programme.

2.4 Policy Brief for Enhancing Adaptive Capacities of Upland Communities in the Philippines

The project collaborators held a writeshop to consolidate the project outputs and results. These project outputs, together with the outputs of the earlier initiatives of CBA2013-10NSY-Visco, served as basis in drafting the Policy Brief for Enhancing the Adaptive Capacities of Upland Communities in Southeast Asia. This policy brief will serve as the instrument of the project collaborators and concerned groups/stakeholders in lobbying with their respective local policy makers towards the institution of climate change adaptation programmes in their local development programmes.

3. Results and Discussion

3.1. The Participants

A total of 119 upland farmers and agricultural technicians were trained as local climate change communicators (Table 1). The trainers' training focused on the different climate change issues, climate change mitigation and adaptation strategies, and building communication skills of the training participants. Table 2 shows that the local climate change communicators have re-echoed their training to a total of 205 individuals comprising students, farmers, agricultural technicians and faculty members through the local climate change awareness programme that was organised in each of the four collaborating countries.

3.2 Relevance and Challenges of Building Farmers' Capability for Enhanced Climate Change Adaptation

Information and technologies to guarantee sustainable farming in the uplands abound. However, such usually do not reach the farmers because of inadequate extension services (Carandang, Tolentino, & Roshetko, 2006; Van Noordwijk, et al., 2008). With climate change aggravating the existing constraints to farm productivity and the need to insure the ecological integrity of the farming communities in the uplands, extension will all the more be imperative in such areas.

Communicating climate change-related information was emphasised as the best strategy to be able to create or effect changes among the concerned stakeholders. Moser and Dilling (2011) argue that communicating climate change is essential because not all have noticed and have experienced climate change. The lack of direct experience makes climate change a problem that requires explanations from those who have an expert knowledge and experiences.

Visco (2014) confirms that farmers are the best source of on-the-ground experiences on climate change, and could serve as the best channel of communicating climate change information to the other farmers within the community. Because they have the direct experiences and observations, there is also a higher chance for them to employ climate change adaptation strategies, considering that agriculture is their main source of livelihood. For instance, Tolentino and Landicho (2013) explains that the smallholder upland farmers in the Philippines and Indonesia have been employing their own climate change adaptation strategies in the absence of technical assistance from extension agencies. These include changing the cropping patterns, changing the crop, engaging in agroforestry, and engaging in non-farm activities.

The smallholder farmers may not have the scientific basis about climate change issues and impacts, but their mere experiences on the field-level evidences and impacts of climate change on their agriculture production, therefore, make them a very good candidate as climate change communicators to the other farmers and members of the local farming communities. This capacity-building initiative has seen advantages in training farmers as local climate change communicators. They can easily communicate with the other community members because they share the same symbols and languages, and therefore, they can reflect on the needs and aspirations of the communities. In addition, they have the knowledge about the local conditions and practical experiences. As argued by Karuhanga, Kiptot and Franzel (2012), the constraints in ensuring effective agricultural extension in most of the developing countries include the large number of poor farmers with small plots in geographically-dispersed communities and the underdeveloped transport and communication infrastructure. With these

FIGURE 2. An upland farmer in the Philippines sharing his own experiences in adapting to climate change impacts.

constraints, therefore, the use of farmer trainers' approach offers great potentials in ensuring widespread and rapid agricultural knowledge diffusion. Kaminski (2011) cited Roger's theory of diffusion which places peer networks as an important construct. The innovators and the early adopters who serve as the opinion leaders play a critical role in the innovation adoption process, as they spark the initial take off point. They influence their peers through peer communication, role modelling and networking. Thus, the concept of farmer-to-farmer communication and learning is founded on this theory.

However, there are also challenges when training local climate change communicators. Their facilitation and communication skills are limited particularly for the first-timers, and they have limited access to recent information about climate change because their geographical location is mostly inaccessible to media and other means of information. Farmers have a tendency of getting intimated by their co-participants from the local government units and the facilitators, which can be explained by their limited exposure and engagement. However, their concept about climate change and how climate change has created impacts on their agricultural production were well-articulated during the lecture-discussion and presentation of workshop outputs. In the case of Indonesia, on the other hand, the resource person argued that while implementing climate change mitigation and adaptation practices are necessary for addressing climate change impacts, it requires change among the farmers and individuals. The change could be attitudinal/psychological and behavioural. Thus, the communicators should be able to have a grasp about the principles of change management—that change should be gradual, rather than abrupt, and needs continuous communication, information dissemination and capacity-building. Adopting a particular change, technology or innovation requires attitudinal and behavioural change. Khaila, Tchuwa, Franzel, and Simpson (2015) stress that lead farmers help in changing attitudes of the farmers, who motivate and encourage one another in adopting technologies. The trust, closeness and shared common attributes of one another also influence how farmers learn from their counterparts.

This capacity-building programme has indicated that the farmers have shown their interest and willingness to share their ideas, concepts and field experiences that are related to climate change. The challenge now is to further train and build the capacities of these farmers as local climate change communicators. Support system such as providing them access to climate change information, training them to document the climate change impacts and their corresponding climate change adaptation strategies, enhancing their communication skills, and tapping them as speakers or resource persons in climate change forum and conference, are necessary for sustaining their interest.

Communicating climate change-related information requires information materials and visual aids that would help create awareness among the stakeholders. These information materials should be simple that could be easily understood by a layman. Thus, the project collaborators in the four countries came up with their own versions of the climate change information materials that were used during the conduct of the Local Climate Change Awareness Programmes. The development and production of these information materials were done in cooperation with the participants or trained local climate change communicators.

From the remarks of those who have participated in the local climate change awareness programmes, the project collaborators have validated the relevance of organising this kind of event. Foremost, the audience/participants were ordinary people without any technical know-how about climate change. Overall, this activity served as an eye-opener to the public that indeed, each individual at the household level has contributions to climate change, such that even in their simple household chores such as cooking and cleaning the surroundings/backyard through burning, they already contribute to gas emissions. More importantly, the local climate change awareness programmes have provided reminders to the individuals and community members, that each of them can do a simple practice or strategy to help mitigate climate change impacts. These observations are consistent with the arguments of Moser and Dilling (2011) as regards the essence of communicating climate change.

3.3 Sustaining Communication of Climate Change through Policy Measures

Raising awareness and imparting knowledge do not directly result in behavioural change, nor guarantee that it will be translated into action (Moser & Dilling, 2011; Mwazi & Ndokosho, 2011). For a more effective communication and engagement, Moser and Dilling (2011) contends that policy, infrastructure and economic changes should likewise be installed. They believe that communication for social change should consist of efforts that would motivate people to make a change.

The project collaborators argue that climate change is real, and that, nobody can do away with it. This phenomenon has now become part of human life, and therefore, there is nothing we can do but simply to adapt to its impacts. Because of the severity of its impacts, policy measures therefore should be in place to help enhance the adaptive capacities of the society, particularly the agriculture/farming sector. The locals, particularly the farmers can serve as a channel for disseminating information and educating other farmers about climate change issues, impacts and adaptation strategies. Therefore, policy-making bodies at the local level should consider the following recommendations to enhance adaptive capacities for climate change adaptation.

a) Creation of a Local Climate Change Team comprising representatives from the state colleges and universities, local government units at the municipal and barangay (ward) levels, and farmer-trainers who would develop a plan for enhancing adaptive capacities of the upland farming communities in their respective areas. The team shall also be responsible for (a) organising local public awareness programmes about climate change so that all sectors within their local community would be able to understand this worldwide phenomenon; (b) pursuing research and development programmes related to climate change to test for appropriate crops and cropping combination in the changing climate in their respective areas; (c) establishing demonstration farms showcasing climate change adaptation strategies; (d) linking with the local policy makers to ensure that climate change adaptation measures are integrated in their development programmes; and (e) documentation of best practices showcasing climate change adaptation.

b) Mainstreaming agroforestry in the development programmes of local government units whose majority of land area is classified as upland areas. These areas are vulnerable to climate change because of the marginal conditions of the biophysical and social aspects. Agroforestry can be included as one of the development programmes in the barangay and municipal levels. With this, there could be a regular funding allocation for relevant agroforestry activities that may be identified in the upland communities. These may include training programmes, information drive, and establishment of on-farm demonstration areas showcasing different agroforestry technologies and systems that are appropriate to the local conditions

c) Enhancing adaptive capacities of smallholder holders in a holistic manner so that the human, social, financial and natural capitals are taken into consideration as follows:

- The human capital should be developed through capability-building or training programmes, particularly on the appropriate/site-specific climate change adaptation strategies. As discussed above, there are smallholder farmers in other tropical countries who have been employing climate change adaptation strategies such as changing their cropping patterns, establishment of soil and water conservation measures, planting of short-duration crop varieties, among others.
- The natural capital including the land and the farming system should be enhanced. The farms of the smallholder upland farmers are highly dependent on rainfall (being rainfed areas), and therefore, any change in rainfall pattern would surely affect crop performance, farm productivity and farm income. They have small landholdings classified as public lands, and therefore, these are bound within the policies of the government. Cost-effective and environment-friendly soil and water conservation measures should be introduced in these rainfed areas, without jeopardising the policies that govern the cultivation of upland areas/farms within the public lands. The farmers should capitalise on the presence of forest and fruit trees on their farms. The ecological services of trees, particularly their potential in climate change mitigation and adaptation, should be well recognised by the farmers via information education campaigns and capability-building programmes.
- Social capital enhances the capacity of an individual to address his/her problems or concerns by way of networking and establishing good relationship and solidarity between and among the members of the community (bonding capital) and their linkages with outside organisations (bridging capital). In most cases, the local development organisations channel their technical support services to the existing people's organisations from which farmers are given the opportunity to attend trainings and seminars, avail of the planting materials, and gain access on the recent developments and information about agriculture. In most cases, there has been very little support services that are being provided by the local development organisations. This implies, therefore, the need to link the farmers to relevant organisations to enable them tap the latter's assistance in any agriculture-related problems or concerns (e.g. marketing of products, climate change, etc).

3.4 Lessons learned from the project implementation

This capacity development programme has shown the importance of creating awareness about climate change at all levels and sectors. In this way, these sectors could also be mobilised to help enhance climate change adaptation capacities. This programme has likewise recognised the essence of involving the active participation of farmers in climate change research and capacity-building. Foremost, the farmers have the direct experiences of climate change impacts, and likewise, have the capability to share their own experiences with their fellow farmers.

This project has the potential for scaling-up in other upland communities in the four collaborating countries. Generally, the agriculture sector in these four countries is dominated by smallholder upland farmers, and therefore, it's necessary to scale-up and promote this kind of capacity-building projects to the upland communities. The lessons and experiences, as well as the relevant outputs of this project can be used by the project collaborators in the future capacity development activities. In a broader context, the partnership that was built by this project among the local stakeholders, namely farmers, local government units and state colleges and universities can be harnessed to sustain and scale-up the project.

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What Influences Awareness of Farmers on Sustainability of Bioenergy Feedstock in the Philippines?

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ABSTRACT The paper presents an analysis of bioenergy potential in the Philippines by understanding farmers' awareness on sustainable bioenergy production using different feedstock, i.e. first generation (i.e. sugar-rich crops, starch-rich crops and oil-rich crops) and second generation (i.e. agriculture/forest residues, fast-growing trees, and perennial grasses). Such an assessment is critical for many developing countries including the Philippines due to the impact on food security, particularly as a result of the negative effects of bioenergy feedstock production and processing on increasing water scarcity and agricultural land pressure. Moreover, farmers play a key role in the production of biomass feedstock for bioenergy, so it is important to understand their level of awareness on the effects of bioenergy not only on food security but also economy as a whole. Field survey was conducted with farmers in three regions including Calabarzon, Central Visayas and Davao. The paper presents the results of the factor and cluster analyses, which were applied to determine the socio-economic profiles that characterise the opinions of the farmers. The survey results showed that the diversity of awareness across regions is influenced not only by the socio-economic characteristics of the farmers but also sources of information about bioenergy.

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1. Introduction

Bioenergy is carbon neutral renewable energy, which is considered as source of energy for sustainable development. Although the production and consumption of biofuels like biodiesel and bioethanol have become important policy priorities, sustainable bioenergy production needs to be ensured by using suitable feedstock resources. Due to unstable and increasing energy prices as well as increasing global energy demand, many countries has perceived bioenergy as an attractive alternative or addition to meeting their current and future energy needs (UNESCAP, 2008). Interest in liquid biofuels production and consumption has increased worldwide as part of government policies to address the growing scarcity of fossil fuels and, at least in theory, to help mitigate adverse global climate change. Like many other countries, the Philippines is implementing various bioenergy policies to reduce its dependence on imported oil, enhance economic growth, contribute to climate change mitigation and promote rural development (Acosta et al., 2013). The Philippines has a large potential in producing bioenergy because crops that are used as feedstocks for the production of bioenergy are indigenous or locally grown (i.e. traditional) in the country. Biofuels will give the otherwise traditional crops a boost towards value added processing. It will encourage investments, create jobs, and increase farmgate prices. In the Philippines, production of biodiesel mainly uses domestic raw materials from coconut and bioethanol is mainly produced from sugarcane. Other feedstocks under consideration by the Philippine government are jatropha, sweet sorghum, cassava and corn.

According to Department of Energy (DOE, 2010), domestic fuel industries in the Philippines produced 132.99 million litres of biodiesel and 4.14 million litres of bioethanol in 2011. These industries have much higher capacities (i.e. 393 and 133 million litres biodiesel and bioethanol, respectively), hence the country has more potential to produce biofuels domestically (Corpuz, 2013; DOE, 2010). However, since 2007, the Philippines have been importing bioethanol to meet the mandated level of 10% blending of bioethanol. In 2013, bioethanol imports were as high as 248 million litres, which is about 83% of the required bioethanol blending by the government. The main reasons

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given for the dependence on bioethanol imports despite the available capacity for domestic production are the inadequate capacity of existing sugarcane distilleries, low productivity, and high production costs, which erode the competitiveness of locally grown sugarcane (Corpuz, 2013).

A recent empirical study by Acosta et al. (2013) revealed that an important barrier to the sustainability of bioenergy production in the Philippines is the lack of awareness among farmers, who play a key role as producers of feedstocks. The authors developed cluster typologies (i.e. idealist, ambivalent, realist) based on their perceptions and opinions on bioenergy. The focus of their analysis was however not only the farmers but also respondents from the academe, private companies and public institutions in selected case study areas in Luzon and Mindanao. Moreover, other available studies in the Philippines and other countries mostly focused on the willingness of farmers to cultivate bioenergy crops (e.g. Convery, Robson, Ottitsch, & Long, 2012; Caldas et al., 2014; Zyadin et al., 2015). The issue of awareness, which influences farmers' willingness to produce bioenergy, has received only little attention in other countries (e.g. Halder et al., 2013; Gautam, Pelkonen, & Halder, 2013), and has been so far overlooked in the Philippines. But environmental awareness is important in changing the behaviour towards bioenergy (Maras, Moon, Gridley, Hayes, & Key, 2015; Streimikiene, 2015).

This paper aims to contribute to the above-mentioned research gap and substantiate the findings on the lack of awareness of famers on bioenergy by (1) focusing the analysis only on farmers; (2) expanding the case study areas to cover Visayas, the largest producer of sugarcane for bioethanol; and (3) developing typologies on the level of farmers' awareness. In this paper, we also analysed the preferred crops by the farmers for the production of bioenergy and their knowledge on the impacts of bioenergy on food security and economic growth. Thus, the study assumes that sustainability of bioenergy production (i.e. feedstock will be produced for bioenergy and its production will be sustained in the future) depends on farmers' awareness on the social and economic impacts of alternative bioenergy feedstock. Given this assumption, the relevant questions that guided the study include: (1) Are farmers aware of the diverse feedstock resources for bioenergy? and, (2) what factors influence the level of awareness across different regions? The paper is structured as follows: section 1 describes the development of bioenergy in the Philippines; section 2 discusses the methods used to collect and analyse the survey data; section 3 presents the results of the factor and cluster analyses; and section 4 provides conclusion.

2. Methodology

2.1. Case Study Areas

The study was conducted in three regions that are currently major producers of coconut and sugarcane in the three main islands in the Philippines, i.e. Calabarzon in Luzon, Central Visayas in Visayas and Davao in Mindanao (Figure 1). Calabarzon is designated as Region IV-A and has five adjoining provinces in southern Tagalog region, i.e. Cavite, Laguna, Batangas, Rizal and Quezon. Central Visayas is designated as Region VII and composed of four island provinces including Negros Oriental, Cebu, Bohol and Siquijor. Davao region is designated as Region XI, consisting of four provinces: Compostela Valley, Davao del Norte, Davao Oriental and Davao del Sur. Calabarzon has large monoculture coconut plantations and large forest of various trees. Central Visayas has large arable land with cereals and sugar, while Davao has large diversified coconut plantations. Both regions have large cultivated areas with grass. Climate is relatively variable in the three regions due to their geographical locations.

Calabarzon region has a total land area of 1,622,861 hectares, which comprise 5% of the Philippine Archipelago and is the most populated region of the country with a population of 12,609,803 (Table 1). During the period 1971–2000, the measured average annual rainfall is 4,150.1 millimetres (BAS, 2011, CropsReview, 2011). The study sites for conducting survey

Characteristics	Calabarzon	Central Visayas	Davao
Population in 2010 Growth from 2000	12,609,803 3.07%	6,800,180 1.77%	4.468.563 1.97%
GRDP million PhP Share of agriculture to GRDP	1,030,165 6.25%	36,638 7.81%	224.849 18.87%
Agricultural land area Share of agriculture to total area	588,516 35.0%	522,433 33.0%	758335 37.0%
Agricultural employment Share of agriculture to total employment	742,000 16.0%	905,000 31.0%	746000 41.0%
Daily agricultural wage Poverty incidence	269.00 10.3%	173,76 30.2%	182.03 25.6%

GRDP = Gross Regional Domestic Product at constant 2000 prices
Source: National Statistics Office (NSO), 2010

TABLE 1. Description of social-economic and biophysical characteristics in the case study regions.

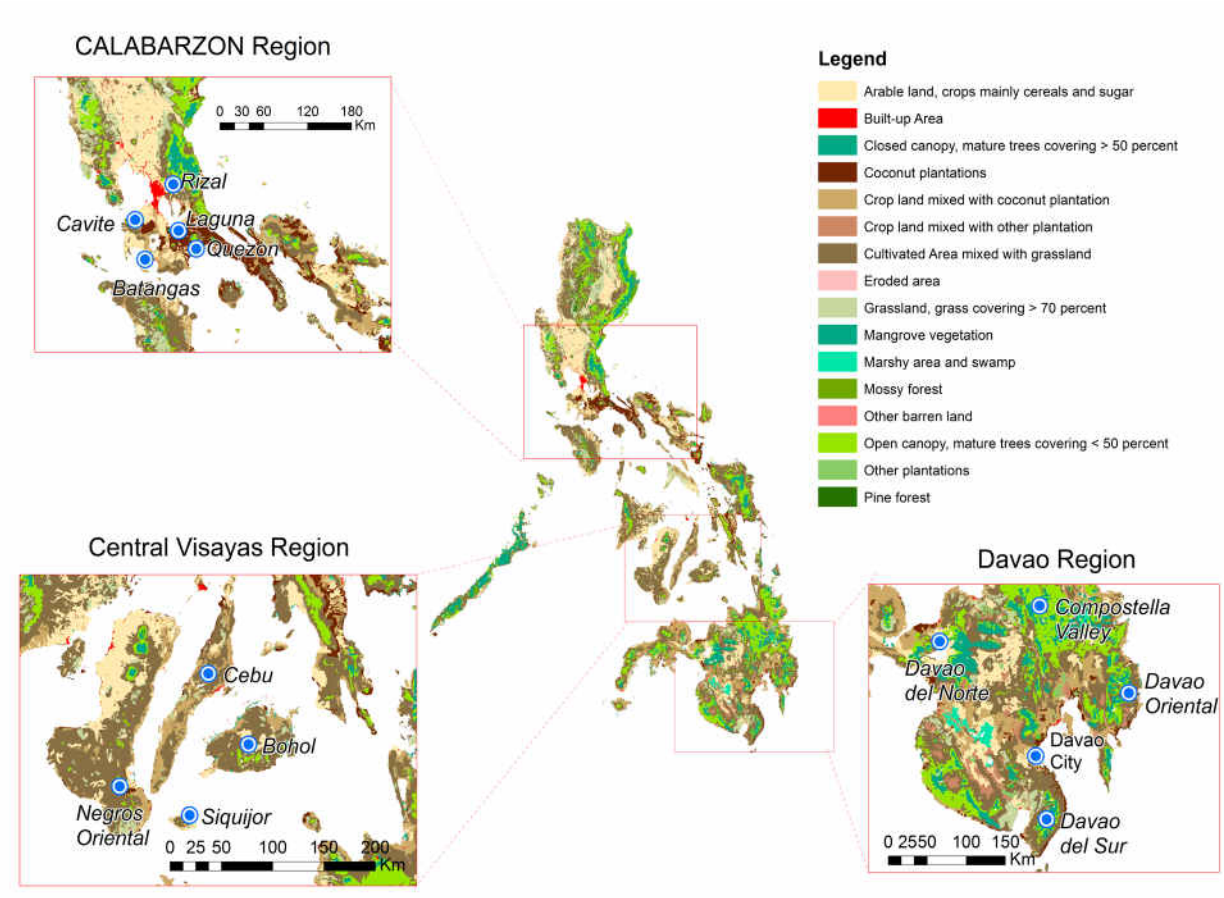

FIGURE 1. Philippine map showing the location of the different case study regions.

in Calabarzon are Infanta, Quezon and Batangas. ***Central Visayas*** region lies at the centre of the Philippine archipelago between the two main islands of Luzon and Mindanao. It is the sixth smallest region in the country with a total land area of 1.58 million hectares. The population is also relatively small at 6,800,180. The climate of the region is tropical-monsoonal. The survey in Central Visayas region was conducted in Bohol and Cebu. With the exception of Bohol, the topography of Central Visayas is rugged and is characterised by highlands dominating the interior of the provinces, with narrow strips of arable land lining the coast. Davao region is located on the south-eastern portion of Mindanao with a total land area of 2,035,742 hectares and has a population of 4,468,563. Agriculture is the main economic activity in the region and banana is the primary agricultural product. While the region's economy is predominantly agriculture-based, it is now developing into a centre for agro-industrial business, trade and tourism. Aside from its forestland and fertile fields, the region is famous for its rich mineral resources. The study sites for the survey in Davao region were mainly Davao City and Davao del Norte.

2.2. Data Collection and Analyses

Household surveys were conducted with 234 farmers in the case study regions (i.e. 112 in Calabarzon, 60 in Central Visayas, and 58 in Davao) in 2013. More farmers were surveyed in Calabarzon where the population is twice as large as in the other regions (Table 1). The surveys were conducted by the authors, who consulted the local government officials to get permission for the survey and information on the locations of the farmers. We selected farmers who are producing major feedstock for bioenergy in the Philippines like coconut, sugarcane, corn, rice (for agricultural residues), etc. The questionnaire was constructed based on four types of information on (1) socio-economic characteristics, (2) sources of information on bioenergy, (3) knowledge and opinion on bioenergy, and (4) preferences on bioenergy feedstock. Socio-economic characteristics include gender, age, education, and locations of domicile and work. Sources of information on bioenergy identify the level of importance for the media (television, newspaper), internet, family and friends, work colleagues, neighbours, public officials, academe/science, and business partners. Knowledge and opinion on bioenergy are answers to the following questions: *(i) Are you familiar with the term "bioenergy" (also known as biofuels)? (ii) Is your work related to bioenergy? (iii) In your opinion, is bioenergy good or bad for your country? (iv) Do you think the use of biomass from food crops for bioenergy production increases food prices and thus affects food security (i.e. food affordability and availability) in your country?* Preferences on bioenergy feedstock provide rating (i.e., very low, low, high, very high, and do not know) on the potential contribution of the food crops (and non-food) for the sustainable production of first (and second) generation bioenergy.

We applied factor analysis, in particular principle component to identify the most important variables across all four

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types of information, i.e. those with largest contribution to the variance (i.e. difference or spread) in farmers' responses to the survey questions. Only the most important variables were used as input variables to the cluster analysis, which followed a two-step approach—hierarchical and K-means clustering. In this paper, cluster analysis aimed to categorise farmers into clusters and determine the appropriate number of clusters, so that farmers within a cluster have common characteristics and farmers in different clusters have diverse characteristics. The results of the analysis were used to develop typology on farmers' awareness on bioenergy. The SPSS software was used for the factor and cluster analyses. More details on the methods applied in this study are available in Eugenio et al. (2016) and textbooks on data mining (e.g. Tan, Steinbach, & Kumar, 2005).

3. Results and Discussions

3.1. Factors and Their Regional Variation

Table 2 compares the different case study regions according to the most important variables identified from the factor analysis. Most farmers in Central Visayas are still very young, highly educated and mostly live in urban/sub-urban area. Farmers in Calabarzon are in their retirement age and live in rural areas, while farmers in Davao are in their middle and retirement age, and mostly living in rural areas. A large number of famers in Central Visayas consider many sources of information on bioenergy as important (Table 3). The source of information that is important for the farmers in the three regions is media (TV, newspaper). Internet is the least important source of information because most of the farmers live in farms where internet is not very accessible. Only media is considered most important by half of the surveyed famers in Davao. Perceptions on potential sources of bioenergy feedstock, for both first and second generation, tend to be similar across all three case study regions, i.e. high potential level, except for Calabarzon. Farmers in this region consider perennial grasses to have low potential as source of feedstock. Experts suggest however that second generation bioenergy feedstock (e.g. grasses) is more sustainable because they do not use food crops and thus not affect food security. Moreover, they can be planted in marginal areas or less productive land.

Familiarity with bioenergy or biofuels is highest in Davao and lowest in Calabarzon (Table 3). However, work of farmers in Calabarzon is more related to bioenergy compared to Davao and Central Visayas. As for their perception on the impact of bioenergy on the economy, all or almost all farmers in the three regions consider bioenergy as useful. But they also think that it affects food security when biomasses from food crops are

Factors	Calabarzon	Central Visayas	Davao
Age			
< 30	6.03	37.93	11.67
31-40	16.38	44.83	20.00
41-50	12.93	6.90	31.67
51-60	33.62	10.34	26.67
> 60	31.03	0.00	10.00
Gender			
Male	50.86	51.72	58.33
Female	49.14	48.28	41.67
Domicile			
Urban/sub-urban	4.31	55.17	10.00
Mountain/forest	12.93	0.00	0.00
Farm/agriculture area	68.10	44.83	86.67
Riverside/coastal area	11.21	0.00	0.00
Education			
Primary/Grade School	25.86	17.24	43.33
Secondary	50.86	27.59	31.67
Undergraduate (Bachelor)	14.66	43.10	20.00
Graduate (Master/Doctor)	1.72	12.07	5.00

Note: The values represent the percentage of farmers for each factor category (i.e. age, gender, domicile, and education) and sum up to 100% for each region.

TABLE 2. Regional comparisons of socio-economic characteristics, in percent.

Category	Calabarzon	Central Visayas	Davao
Source of information			
Work colleagues	45.69	65.52	41.67
Family & friends	47.41	63.79	45.00
Academe/science	55.17	56.90	36.67
Public officials	55.17	56.90	45.00
Neighbours	31.03	67.24	41.67
Media (TV, Newspaper)	56.90	75.86	51.67
Business partners	23.28	56.90	41.67
Internet	18.97	39.66	35.00
High potential for production			
Sugar-rich crops	52.59	100.00	85.00
Perennial grasses	42.24	96.55	85.00
Starch-rich crops	58.62	100.00	85.00
Fast growing trees	52.59	96.55	85.00
Oil-rich crops	74.14	98.28	85.00
Agriculture/forest residues	58.62	100.00	85.00
Energy source- Bioenergy			
Low	5.17	1.72	10.00
Medium	20.68	12.07	5.00
High	39.66	50.00	30.00
Very high	28.43	36.21	41.67
Do not know	6.03	0.00	13.33
Knowledge on bioenergy			
Familiar with bioenergy	43.10	55.17	68.33
Work related to bioenergy	30.17	0.00	5.00
Food security	57.76	87.93	63.33
Bioenergy is good for economy	98.28	100.00	100.00
Work Region	49.57	24.79	25.64

Note: The values represent the percent of farmers who have chosen or answered "yes" for the item/question in each category. For example, 45.69% of the farmers in Calabarzon answered that work colleagues are sources of their information on bioenergy.

TABLE 3. Regional comparisons on the knowledge and sources of information on bioenergy, in percent.

used for bioenergy production. The number of farmers who think that there is a link between bioenergy and food security is largest in Central Visayas. Farmers in the three regions also assessed the potential contribution of bioenergy in comparison with other energy sources (i.e. renewable energy and fossil fuel) in promoting economic growth in the country. Central Visayas gave the highest potential for bioenergy and Davao the lowest relative to other renewable resources. Most of the surveyed farmers were male, except for Calabarzon where the gender of farmers is almost equally distributed (Table 2). Female should have knowledge or awareness on bioenergy because they take part in farming decisions and are also part of country's economic growth or development.

3.2 Clusters and Their Typologies

Four clusters of farmers were identified from the cluster analysis. Based on the responses of the farmers in each cluster on the survey questions, we analysed the profiles of the clusters to give some indications on the typologies based on the level of awareness. These typologies, which we describe as unaware, low awareness, moderate awareness and high awareness, are as follows:

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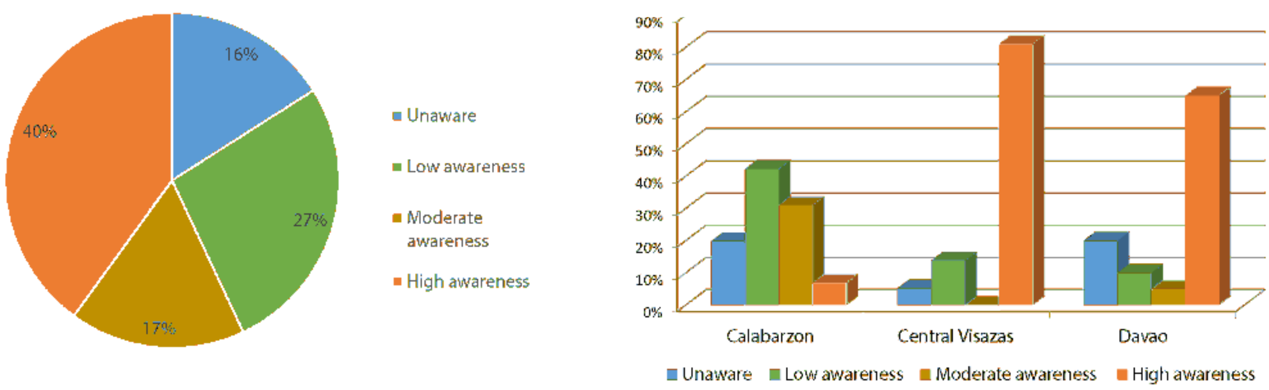
consists of farmers whose age is near to retire, residence is mainly rural area and most important sources of information on bioenergy are other farmers. They think oil-rich crops have high potential contribution for the sustainable production of bioenergy. They have low familiarity with bioenergy and consider their work as not related to bioenergy. On the other hand, they believe that bioenergy does not affect food security but they are not sure if bioenergy can contribute to economic growth. The level of awareness of farmers in this cluster can be considered extremely low and can thus be characterised as "unaware".

- **Cluster 2** consists of farmers who are middle aged, live in rural areas and highly educated. Media (e.g. television and newspaper) and internet are relatively important sources of information by the farmers in this cluster. They consider feedstock from non-food crops such as perennial grasses, agriculture and forest residues to have very high potential contribution to sustainable bioenergy production. The largest proportion of farmers who think the potential for these non-food crops is high or very high belongs to this cluster. They are very familiar with bioenergy although their work is not related to it. They believe that bioenergy will affect food security, but nonetheless it has very high potential to support economic growth. As compared to the farmers in other clusters, those in this cluster can be considered very informed and thus have a typology of "high awareness".
- **Cluster 3** consists of farmers whose age is close to retirement, residence is in rural areas, and most important sources of information are family and friends. They consider only oil-rich crops to have high potential as feedstock for bioenergy production. They are not familiar with and consider their work as not related to bioenergy. Famers in this cluster have thus very close characteristics with those in cluster 1. However, in contrast to cluster 1 farmers, they believe that bioenergy has high potential for the economy, but at the same time it will affect food security. These farmers can thus be considered to have a typology of "low awareness".
- **Cluster 4** consists of farmers who are in retirement age and already retired, educated, and live in rural areas. The neighbours are relatively important source of information for the farmers in this cluster. They consider fast-growing trees to have average potential as feedstock for bioenergy. They are most familiar with bioenergy and largely think that their work is related to bioenergy. Moreover, they consider bioenergy to have average potential for economic growth. Regarding food security, opinion of farmers in this cluster are rather mixed, with half of the farmers thinking bioenergy will affect food security and the other half is of opposite opinion. The level of awareness of the farmers can thus be considered moderate or typology corresponding to "moderate awareness".

Figure 2 shows how the farmers are distributed among the four typologies. The largest number of farmers has a typology of high awareness (40%), followed by low awareness (Figure 2a). Farmers with high awareness are found predominantly in Central Visayas, followed by Davao (Figure 2b). Few farmers are unaware in Central Visayas. Davao has the least number of farmers who has low awareness. Calabarzon is where the greatest number of farmers who have low and moderate awareness. Farmers who are unaware or have extremely low level of awareness are almost equally distributed in Calabarzon and Davao.

4. Conclusion

This study presented the analysis of awareness of farmers on sustainability of alternative bioenergy feedstock. The results showed that there is variation on farmer's awareness¬¬ in the case study regions in the Philippines. Central Visayas has the greatest number of farmers with high awareness typology, while Calabarzon has the least number of farmers with this typology. Farmers with high awareness is largest in Central Visayas because many farmers are still in their young age, age that still have the time and interest to explore or learn new ideas; highly educated, where they have supplementary knowledge from their schools/universities; and mostly reside in urban area where information reaches farmers ahead of time. In contrast, many farmers in Calabarzon and Davao mostly reside in rural areas and in their retirement age or already retired. These characteristics make them rather indifferent to the issues



a) b)

FIGURE 2. Distribution of farmers by (a) typology and (b) region.

of bioenergy and should be taken into account in designing strategies to build their awareness.

In addition to the socio-economic factors, sources of information have significant effect on farmer's knowledge on bioenergy. The most important sources of information by the farmers with high awareness in Central Visayas are media and internet. Farmers in this typology, although their work is not related to bioenergy, consider non-food crops to have potential to contribute to the sustainability of bioenergy production. Farmers should have an understanding on this issue in view of the fact that they are in the primary sector that is involved in supporting production of bioenergy feedstock. Considering the low level of awareness of the farmers in the two other regions (i.e. Calabarzon and Davao) particularly among female respondents, it is important to provide them the necessary information and training. Farmers should be well informed on the sustainability of feedstock for first and second generation to ensure that bioenergy promotes rural development and does not cause food insecurity. The Philippine government's current blending targets of 10% for bioethanol and 5% for biodiesel are planned to be increased to 20% in year 2025 (Corpuz, 2013). To achieve these targets, policy should not focus on meeting the targets by importing biofuels but by encouraging farmers to produce the required feedstock. This will require capacity building programmes that enhance and spread awareness among the farmers.

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Upscaling the Application of Low-Carbon and Energy-Efficient Technology in the Construction Sector

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HIGHLIGHTS

- Ecological impacts of construction sector will rise with urbanisation in South Asia.
- Use of low carbon technologies in affordable housing will reduce the impact.
- Policies and codes and guidelines including green mandate should be developed.
- Technical capacity building of government will aid in implementation of policies.
- Knowledge dissemination on the benefits of these technologies is essential.

ABSTRACT The construction sector of India, Nepal and Pakistan are currently seeing a boom in the construction sector owing to growing economy and rapid urbanisation. The growth of the sector has critical environmental implications. Apart from its energy footprint, it also has a high resource footprint. The sector also has linkages to several other industries such as cement, steel, paints, tiles, and fixtures manufacture etc. While extraction of these materials and manufacturing of the final products itself contributes greatly to the emissions released, inefficient technologies result in a larger emission increase, making the use of these materials both resource and energy intensive. In this study, focus has been laid on low-carbon and energy-efficient materials and technologies in the building sector that are presently in use in South Asia. The study thus highlights that the adoption of such materials and technologies requires multi-level interventions that range from public policies, awareness generation, capacity building and skill development to the use of financial incentives for the upscaling of such technologies.

KEYWORDS *low carbon; energy efficient; unsustainable urbanisation*

1. Introduction

1.1 The Construction Sector of South Asia

The construction sector is crucial component and indicator of a country's development. It is the second largest employer after agriculture in India, and accounted for 8.2% of its GDP in 2011–2012 (Planning Commission, 2013). The sector grew at a rate of 18% per annum from 2004–2007 in Pakistan (Neilson, 2010). Along with the social and economic implications, the construction sector has a critical role to play in environmental implications as well. Being an energy-intensive sector, it contributes to around 10–24% of total national greenhouse gas (GHG) emissions in India and Pakistan (Parikh et al., 2009). Besides energy, this sector is also very resource intensive. Cement, concrete and bricks are the most sought after materials in construction. They are produced using inefficient technologies that consume large amounts of coal and release high carbon emissions. The sector has an adverse impact on agricultural yield exerting pressure on food security due to conflicts of use

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of fertile top soil between agriculture and brick making, aggregate mining and sand dredging of rivers for concrete, mortars and plasters.

Economic growth and the geographic reconfiguration of the demands for housing and infrastructure towards urban and peri-urban areas have fuelled the growth in construction activities. However, the urbanisation process has occurred rather rapidly and haphazardly, bringing South Asia to the forefront of an enormous socio-economic shift without adequate thought and planning for defining its environmental future. It has also led to the desperate clamour for more and better urban housing, causing a frenzy of construction. The urban housing requirements range from 18.78 million in India to 1 million in Nepal range from 1 million (Varsha et al., 2015). Apart from the housing shortage, reconstruction due to disasters and extreme weather events along with renovation and aerial expansion of buildings will result in increased demand for materials from the construction sector. For example, floods alone have led to the collapse of over 2 million homes since 2010 in Pakistan. Further, according to estimates by the United Nations Development Programme (UNDP), the earthquake that occurred in Nepal in April 2015 resulted in “immense” damage to 500,000 to 600,000 homes across Nepal (UN, 2015).

Given this context, the impacts of unsustainable urbanisation and the expanding construction sector are high on the global sustainability agenda. Considering the scales of the impacts on environment, it is imperative that the construction sector embeds the concept of sustainability and green economy in its development trajectory.

There are viable opportunities for greening the sector, however, in order to translate the opportunities to tangible benefits, several interventions in the form of public policies, awareness generation, capacity building and skill development, and appropriate financial tools are imperative. This study thus attempts to analyse and highlight the key barriers and drivers that enable the adoption of low-carbon and energy-efficiency materials and technologies and mainstreaming of the same in the overall construction sector.

2. Methodology

The research study caters to this urgent need to increase awareness about the environmental consequences of a massive development of current building practices. It aims to show the way forward for the generalisation of clean technologies in the social housing space, and ultimately, in the housing sector as a whole.

With a focus on low-carbon, resource- and energy-efficient options, a literature study and technology and institutional mapping and profiling has been done for each selected country, namely India, Nepal and Pakistan. A case study approach has been adopted to analyse good practice applications and of conventional applications in each country situation, so as identify the drivers and barriers in the mass scale adoption of these construction materials and technologies (see Table 1).

In addition, a stakeholder mapping process was conducted to identify the key gaps that hinder the adoption of these technologies, thus helping in the formulation of conclusions on the push and pull factors that are essential for the mainstreaming of these materials and the technologies in South Asia.

The regional research also looked at economic, technological, and regulatory and policy frames in the different country situations and attempts to strengthen regional global change research by identifying key gaps and areas for integrative research. While the country situations differ, a common analytical frame binds the overall study.

Analysing policy thrusts and national commitments towards transformation of the sectors helped in identifying the drivers for change within the institutional mechanisms, financing systems, incentives and partnership arrangements and define the critical elements of the ecosystem for promoting low-carbon development pathways. It also examined barriers with respect to technology know-how, regulatory mechanisms, capacities of stakeholders and market promotion. The analysis resulted in identifying strategies that can be employed to successfully mainstream low-carbon options both within the sector as well as draw lessons from other sectors.

Analysis Frame for each country:

- Policy guidelines and regulatory frameworks
- Institutional mechanisms and synergies across institutions
- Partnerships
- Investments/ financing
- Capacities

Country	Prevalent Low-carbon and Energy-efficient Materials & Technologies		
India	Fly ash bricks	Bamboo	Prefabricated concrete slabs
Nepal	Hollow Concrete bricks (HCB)	Bamboo	Compressed stabilised earth blocks (CSEB)
Pakistan	Vertical shaft brick kilns (VSBK)	Bamboo	Hydraulic lime

TABLE 1. Selected case studies on low-carbon and energy-efficient materials and technologies.

3. Results and Discussions

The results from the regional case studies reveal that pathways to sustainability in construction do exist. Cleaner and alternate technologies have been developed that can substantially reduce the ecological footprint of the sector.

In the case of vertical shaft brick kilns (VSBK) in Pakistan, it was found that there was a 30–50% reduction in energy consumption (SKAT EEBP, 2010). While the VSBK is an example of an efficient use of technologies, the use of fly ash bricks is an example of resource efficiency, where the residue of thermal power plants is used to produce building bricks. In India, 163.56 million tonnes of fly ash was generated in 2012–2013 (Central Electrictiy Authority, 2014). Fly ash is now increasingly being used as a resource material rather than a waste. In this regard, fly ash has gained popularity in the manufacture of building materials like bricks, blocks, tiles etc, thus acting as an appropriate alternative to clay based conventional building materials. Fly ash bricks have a low environmental footprint as compared to the clay bricks produced by conventional technologies as greenhouses gases are not emitted during their production as well as conserve top soil. Further, alternative building materials, like micro-concrete roofing tiles, stabilised concrete earth blocks and prefabricated roofing elements can reduce the resource consumption by 25–30% (DA-CDKN, 2013). Energy consumption can also be reduced by 30–80% in new and existing buildings by commercially viable technologies (UNEP SBCI, 2007).

Further, what has been key to this study is the role of stakeholders. In the case of Nepal as seems to be the case for both India and Pakistan as well, it has been evident that policy and regulatory frameworks play a vital role in the mainstreaming of low-carbon construction materials and technologies. For example, compressed stabilised earth blocks (CSEB) are made from a mix of dry inorganic soil, non-expansive clay, aggregate and sometimes a small amount of cement, thus making them a viable alternative to fired bricks. Attempts have been made to introduce CSEB in Nepal since the past decade; however lack of awareness among the end-users has been the main reason for its failure. Hence, strategies for adoption of this material include financial incentives like subsidies, voluntary green building certification systems, building codes etc.

Similarly in the case of fly ash bricks a policy push has been the major driver for the accelerated uptake of the technology in India. The notification numbered S.O. 763 (E) of Ministry of Environment, Forests and Climate Change and the Fly Ash Mission of Department of Science and Technology, Government of India, have played a crucial role in the uptake of the technology through technology demonstration, easy access to fly ash and mandatory use of fly ash bricks in construction.

Case study: Bamboo House India (BHI)

BHI is a social enterprise striving to create a chain of bamboo showrooms across the country to promote and market bamboo based products under one roof,, starting from bamboo pen to bamboo housing structures. It works through a hybrid model with a “for-profit” component and a “non-profit” component. “For profit” activities involve sourcing, designing, retailing, exhibiting and developing markets and “not-for-profit” activities are handled by the “Bamboo Artisan Welfare Society” involving skill training and upgrade, design development as well as capacity building. The organisation is taking an initiative of opening showrooms for bamboo products, artifacts, materials etc. BHI is also encouraging artisans to come up with bamboo-based materials by providing them with interest-free loan for their orders.

Stakeholder	Role
Government	• Streamlining policies to promote the use of low-carbon and energy-efficient construction technologies • Introduce low-carbon materials and technologies in the Schedule of Rates • Encourage preferential procurement by government departments • Ensure quality of materials through eco-labelling / rating systems • Strengthening implementation processes and mechanism • Increased coherence and integration among departments
Private Sector	• Partnerships for strengthening supply chain through aggregation • Enhanced access to finance to provide an impetus to micro-entrepreneurs • Incubation services for commercialisation of technologies • Encourage public-private partnerships for commercialisation of technologies
Civil Society Organisations	• Awareness • Training and capacity building

TABLE 2. Analysis of stakeholders and their roles in upscaling low-carbon and energy-efficient construction materials and technologies.

A broad analysis of all the case studies has helped in the identification of all the stakeholders that play an essential role in creating an enabling environment for the adoption of low-carbon and energy-efficient materials and technologies.

Table 2 provides a clear understanding of the key stakeholders; their roles as facilitators in adopting low-carbon construction materials and their mainstreaming into the construction sector.

Given that the role of all stakeholders is crucial, the study through the analytical frame seeks to further highlight the key drivers that result in up scaling low-carbon and energy-efficient materials and technologies in South Asia.

4. Recommendations

4.1 Policy and Regulatory Norms

The intent to introduce and promote "green" and "low carbon" in the construction sector is gathering focus in India, Pakistan and Nepal. Policies and initiatives of India like the National Housing Policy, the 12th Five Year Plan (2013–2017) and the National Action Plan on Climate Change advocate the use of alternate technologies in construction. However, the translation of the mandate to policies and schemes has been minimal. Outdated policies like the Housing Policy of Pakistan (2001) and absence of codes and guidelines are one of the major barriers in the promotion of low-carbon construction technologies.

To remedy this, guidelines should be developed to include the aspects of low-carbon construction in policies and schemes. The scope of Schedule of Rates should be expanded to accommodate low-carbon building materials. This would enable the government departments to use low-carbon construction techniques and technologies in their construction. Preferential procurement for low-carbon materials would also encourage their use.

The set of codes and standards and monitoring mechanisms that ensure the efficiency and quality of the building materials used is also rather weak. A quality control system should be set in place that is in the form of eco-labelling/rating systems for materials and products. While ensuring quality is essential, it is also crucial to allow flexibility in the design and applicability of these materials. Materials and design should be selected on the basis of local geographical conditions, climate and availability of local materials. Encouraging the streamlining of indigenous, locally produced material, will result in significant economic regeneration within the select communities.

Adaptation and mitigation measures should also be incorporated into local municipal planning and service delivery to promote low-carbon construction practices. Taking carbon considerations into account in risk reduction, relief and reconstruction would also contribute to the potential "greening" of the disaster risk management plans. This is an important dimension for recognising the benefits that a low-carbon economy can bring to developing countries (Urban, Mitchell & Villanueva, 2010). However, there needs to be an institutionalised, collective effort made to mainstream these materials and technology into housing policies, instructional guidelines etc. for widespread usage.

4.2 Technology and Capacity

Currently, the construction sector suffers from lack of appropriate technologies and the support by efficient technology transfer. While research on the development and promotion of low-carbon construction technologies is being conducted by several research institutes, laboratories and civil society organisations in India, there is a glaring lack of any kind of academic and research work in Pakistan. Innovation of low-carbon and energy-efficient technologies is essential for the transformation of this sector. Several aspects need to be addressed for the successful adoption of these technologies. They include collaborative research, technology demonstrations, access to information and capacity building of workforce.

Successful adoption of technologies like the VSBK, HCB, CSEB, and use of bamboo in structural applications can be seen in small pockets across South Asia. While these technologies are available, limited information about the benefit of these technologies, its viability in the local context, and the operation processes hinders its growth. There is a dire need to launch campaigns generating awareness among regulatory agencies, builders/architects, end users and the general public.

The lack of technical capacities is one of the largest barriers facing the sector. Policies should focus on addressing this by organising technical training of masons and engineers on a regular basis. Capacity building of officials for the proper implementation of these policies should be promoted (TARA, 2014).

4.3 Market and Finance

The disaggregated nature of this sector throws up challenges with respect to strengthening the supply chain of materials and services. Continuous supply of construction materials can be ensured by setting up micro enterprises. Fiscal incentives and priority financing for small and medium enterprises should also be initiated to facilitate setting up green building material production facilities. Most of the investors are concerned about a quick return on investment, thereby depending upon traditionally available technical knowhow and manpower. New and low-carbon construction technologies are negatively perceived. Partnerships with banks and other financial institutions should be explored to facilitate easy access of finance to the entrepreneurs.

Quality is a key component in the aggregation of green construction services. Standardised curriculum and a system for certified skills for masons and artisans will go a long way in monitoring and assuring quality.

4.4 Partnerships

Research and development is essential for promoting low-carbon and energy-efficient technologies. However, the research on these technologies remains confined to the research laboratories and institutions, out of bounds for common entrepreneurs. It is essential to strengthen commercialisation of appropriate technologies through propagating incubation services. Such services can act as intermediary between the laboratories and research institutions, and entrepreneurs. Apart from technologies, incubation services can also include other softer aspects of construction like design and processes, capacity building, etc.

It is vital to promote public-private partnerships. In such partnerships, the services are delivered by the private sector, while the responsibility of providing service rests with the government. Public-private partnerships would not only help in commercialisation of low-carbon technologies, it would also aid stricter implementation of these policies.

User acceptance of these technologies is the key to its acceptance. However, popular public perception is that low cost means low grade. There is also lack of readily accessible and reliable information comparing alternative structural materials and systems, the benefit of these technologies, its viability in the local context, and the operation processes hinders its growth. Awareness generation targeting users is the need of the hour.

5. Conclusion

In conclusion, it is evident that the construction sector is a disaggregated sector with complex interlinks among both the public and private stakeholders. But at the same time, one is able to identify the key agents of change whose cooperation as well as coordination can bring about a paradigm shift in the construction sector from a carbon intensive and resource inefficient sector to a more sustainable construction sector.

On one hand, the Government agencies need to work towards streamlining policies to include the "green" mandate, strengthen the implementation processes and mechanisms and increase coherence and integration among departments. On the other hand, the private sector needs to build partnerships so as to strengthen the supply chain as well as enhance access to finance to provide an impetus to micro-entrepreneurs. Finally, the civil society organisations also have a crucial role to play in generating awareness as well as building capacities towards the use of green construction materials. Thus the coming together of all these stakeholders with a universal goal of mainstreaming the use of low-carbon and energy-efficient construction materials and technologies will result in the transition to a green and more inclusive economy.

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We would like to thank Asia-Pacific Network for Global Change Research for their support. Increasing environmental impact of the construction sector is a growing concern for developing countries like India, Nepal and Pakistan, and this study afforded us the opportunity to explore and understand the issue.

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Bringing Early-Career Scientists to the Fore: Lessons Learned from International Geosphere-Biosphere Programme (IGBP) Landmark Synthesis Event

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HIGHLIGHTS

- Benefits go both ways when early-career scientists and organisations interact.
- Start early and connect often with organising partners and participants.
- Follow-up engagement is necessary, but outcomes from IGBP's effort remain to be seen.

ABSTRACT Large international conferences can offer a range of benefits to participants, such as access to new scientific ideas, an international perspective, and the opportunity to network and discuss ideas with peers from around the world. Young and early-career scientists, particularly from developing countries, may have limited access to funds to attend international conferences. The International Geosphere-Biosphere Programme (IGBP) took the opportunity to support and engage young and early-career scientists from developing countries while organising a legacy event at the American Geophysical Union (AGU) 2015 Fall Meeting in San Francisco to mark the end of the IGBP. This policy paper discusses lessons learned and outcomes from this effort.

KEYWORDS *early-career; developing country; IGBP; AGU*

1. Introduction

The International Geosphere-Biosphere Programme (IGBP) began the process of organising IGBP's landmark synthesis event in 2013. This event was intended to mark the end of IGBP and celebrate the handover of international, interdisciplinary research into Earth systems, land use, and other fields to the next iteration, Future Earth. The event would highlight IGBP's accomplishments over the past nearly three decades at the American Geophysical Union (AGU) 2015 Fall Meeting in San Francisco. The venue would bring together researchers from many disciplines and from all over the world.

The events would also be the perfect place to draw attention to one of IGBP's focuses: capacity building. The IGBP planned to bring young/early-career scientists from developing countries together, to give them the opportunity to network with their peers and meet established scientists in the IGBP and Future Earth communities. The experience of attending an international conference would offer these young scientists an opportunity to present their own work, and to bring back their new-learned lessons to their home institutions and colleagues.

These objectives and more were fulfilled with the assistance of an Asia-Pacific Network for Global Change Research (APN) grant, alongside other support. The main objective was to provide opportunities for collaboration and networking for young scientists from developing countries and with the newly emerging Future Earth community, in a forum within the larger AGU meeting, where APN grantees could present their work to their peers and the international scientific community.

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The ultimate outcomes of these efforts remain to be seen, but an immediate appraisal of the events in December 2015—IGBP's concluding celebration and the gathering of young researchers from developing countries at the AGU—shows they were successful, meeting the goals of the IGBP. Lessons learned by the IGBP, now closed, should prove useful to other organisations that wish to accomplish the following: capacity building, networking for the next generation, and fostering interdisciplinary work in developing countries and their scientific communities.

2. Methodology

IGBP implemented a number of measures to ensure that APN grantees participated fully and left the meeting having established collaborations.

2.1 Partnerships for Planning and Funding

IGBP began communications with AGU on the IGBP landmark synthesis event in 2013, two years before the event. In 2015, IGBP was given a place as an observer on the AGU Program Committee. A close working relationship developed to ensure that the event ran smoothly. AGU provided practical and administrative support to APN-funded young and early-career developing country scientists (further details in section 2.4).

IGBP worked closely with Future Earth, the home for the next generation of interdisciplinary science research efforts, to develop and deliver a range of activities associated with the IGBP landmark synthesis event, namely the IGPB/Future Earth Young and Early-Career Scientists' Workshop, the Bella Gaia performance (2.3.3) and the Future Earth booth at AGU. IGBP reached out to its wide network of partners, as well as those involved in IGBP projects past and present, to develop the programme for this event, to seek funding and to get further support for this event before and during the AGU.

In addition to the APN grant, IGBP also received financial support from NASA and the European Space Agency (ESA), for various aspects of the IGBP landmark synthesis event. The request process started in fiscal year 2014/2015.

2.2 Selection of APN Grantees

During 2015, IGBP undertook a selection process to identify aspiring young and early-career scientists from the APN region contributing to IGBP science. IGBP worked with its core projects to identify scientists in their networks that met the following criteria: undertaking research of interest to an IGBP core project, aspiring young or early-career scientists, and located within an APN region, Africa or South America. IGBP core projects proposed the names of 16 potential candidates from APN regions. IGBP invited these to submit a paper abstract and an up-to-date CV to IGBP for consideration. These were scored by members of IGBP and its projects based on the concept of the paper and its relevance to the project and AGU. Consideration was given to the applicants' CVs and the potential benefit the opportunity to attend AGU might afford the candidate. The top 11 abstracts were selected to receive APN funding to travel to AGU.

As a condition of the funding, grantees were required to submit a revised version of their abstract for talks and poster presentations at AGU. IGBP asked the participating projects to assist the successful grantees in the development of their submissions to AGU, which helped connect grantees to the wider community while further training them in how the scientific community does its work. In the end, a total of 11 scientists were selected for APN funding, and 10 submitted at least 1 and in some cases up to 3 abstracts to AGU. All 10 scientists were invited to present posters at the AGU 2015 Fall Meeting.

2.3 Creating Networking Opportunities

IGBP was keen to maximise APN grantees involvement and networking opportunities in AGU. This was done in part by requiring all grantees to submit abstracts. All those who submitted an abstract were invited to present in a poster session at AGU, allowing them a platform to meet peers and widen their scientific networks. Giving a poster at a meeting with more than 20,000 attendees meant they would meet with other researchers in the poster hall, even if they only spoke to the scientists with posters on either side of their own. The APN grantees were also invited to help staff the Future Earth booth at AGU, which was another practical way to engage them and also widen their networks.

In addition to their poster presentations, IGBP involved APN grantees in a number of ways, described in the following sections.

2.3.1 IGBP/Future Earth Young and Early-Career Scientists' Workshop

Grantees were invited to apply to attend a two-day workshop sponsored by IGBP and Future Earth, held at Stanford University (Palo Alto, California) directly before the AGU fall meeting in San Francisco.

Those wishing to attend the Young and Early-Career Scientists' Workshop had to submit a short statement outlining their research interests and motivation for participating. In total, 24 participants were selected to attend the workshop, of which 4 were APN grantees. IGBP funded a further 5 workshop participants from Africa and South America. The goal was to have a regionally diverse group of people participating in the workshop.

The Young and Early-Career Scientists' Workshop focused on principles and approaches that can be useful in providing guidance on implementing a co-design approach. The workshop was meant to engage the participants in Future Earth research and the scope of its programming. An important aspect of Future Earth is stakeholder engagement. To reflect this, Natasha Udu-gama, Director of Community Partnerships for AGU's Thriving Earth Program, joined the workshop to introduce participants to Thriving Earth Exchange (TEX). The platform focuses on natural hazards/disasters, natural resources, and climate change, and builds collaborative relationships between scientists and non-scientists to design and implement local solutions together.

The workshop's breakout sessions were meant to develop collaborative skills so that young and early-career scientists might learn to work "across boundaries of disciplines and society." The participants were chosen based on their geographical and also disciplinary diversity, including physical geography, ecology, atmospheric chemistry, sustainable and environmental governance, and development studies.

2.3.2 IGBP Celebration Banquet

All APN grantees were invited to the IGBP celebration banquet, which brought together around 150 scientists and agency partners who shaped IGBP over the past three decades. Key personnel from Future Earth were also invited. IGBP used the occasion as an opportunity to establish young developing-country scientists' interactions with the global environmental change community and senior personnel from Future Earth.

2.3.3 Bella Gaia Performance

All APN grantees were invited to attend the Bella Gaia performance, a live music and dance performance accompanied by images representing the Anthropocene. A post-performance panel discussion took place with representatives from IGBP, Future Earth, and AGU, which co-sponsored the event, and Bella Gaia's founder and others.

2.3.4 Promoting 100 IGBP Co-sponsored Sessions

The IGBP community was well represented at AGU with 100 co-sponsored IGBP sessions. These sessions were labelled as co-sponsored by IGBP so they were easy to identify. Highlights included sessions with an integrated and policy-relevant approach, such as "What's the Big Deal about the Anthropocene?" and "More Bang for Your Buck: How Does Coordination Add Value to Sustainability Science?" In some cases where panellists/speakers would not normally have attended this type of conference, IGBP provided funds to assist. IGBP provided APN grantees with a guide to the AGU conference that included details on the 100 sessions co-sponsored by IGBP; the aim was to introduce them to new ideas presented by established researchers from the global environmental change community.

2.4 Practical Support to APN Grantees

IGBP worked with AGU to identify and offer support to the grantees throughout the meeting. Practical considerations included helping developing country scientists register for AGU and submit their abstracts without paying fees. AGU set up a special registration portal online for each of APN and other developing country grantees to allow them to bypass payments, and the membership organisation invoiced IGBP directly for the fees.

APN grantees were provided information on the AGU International Buddy Program (http://fallmeeting.agu.org/2015/international-buddy-program/), which "connects first-time Fall Meeting attendees, whose first language is not English, with other experienced attendees who speak the same first language". The AGU International Reception, a free event on the first evening of the meeting, also provided support to international participants.

Further support for the APN grantees came through network building with each other: they stayed at the same hotel, were all invited to the IGBP celebration banquet where they were introduced to each other, and were all invited to the Bella Gaia performance and seated together. The grantees who attended the pre-AGU workshop had an additional opportunity to network with their peers and senior global environmental change scientists. These activities fostered international relationships and support among this cadre of young scientists from developing countries.

3. Results and Discussions

All the IGBP landmark synthesis event activities reflected the IGBP synthesis findings through a range of different approaches. Scientifically, panel discussions, AGU Union sessions, IGBP-project-led sessions, and posters were paired with the IGBP celebration banquet and Bella Gaia performance. The Future Earth/IGBP Young and Early-Career Scientists' Workshop as well as through information and discussions at the Future Earth booth further engaged all participants. Because the IGBP core projects identified the Asia-Pacific scientists whom they thought would benefit most from participating in the IGBP landmark synthesis event, the scientists' research naturally contributed to the IGBP synthesis and they participated in many of the above activities.

3.1 Importance of Early Planning and Partnership Development

Advanced planning helped ensure that APN grantees would be able to engage fully in IGBP's landmark synthesis event at AGU. It cannot be emphasised enough that these processes take time. IGBP began the process of finding funding more than two years before the event itself.

Relationship building was also instrumental to the success of this event. Close working relationships developed over years meant that AGU and IGBP worked together successfully on the many different practical and strategic aspects of this event, and Future Earth and IGBP successfully developed a suite of activities together.

With such planning, IGBP could support a total of 20 young and early-career scientists from developing countries to attend the AGU fall meeting and participate in the IGBP landmark synthesis events. Of these, 10 were funded via APN funding. IGBP found funding to allow an additional 9 developing country scientists to attend the IGBP landmark synthesis event from Africa and South America. Having multiple partners and time to accomplish these goals made this possible, including finding alternative funding from other partners for other unrelated activities to free up monies for the developing country scientists.

3.2 Encouraging Active Engagement

IGBP put in place mechanisms to ensure that all funded participants fully engaged in the IGBP landmark synthesis event and AGU to make sure they got the most out of the experience. Requirements to submit abstracts to AGU, invitations to the IGBP celebration banquet and Bella Gaia performance, the chance to participate in the Young and Early-Career Scientists' Workshop and also get involved in the Future Earth booth—all were designed to maximise their experience.

All but one recipient submitted a paper to one or more sessions as a condition of their grant. (That person was sick at the time of the submission deadline.) The grantees had the experience of preparing an abstract for a high-level international meeting in collaboration with IGBP core projects scientists, and interactions with the international scientific community at a top-level scientific meeting.

All APN grantees who submitted a paper (or in some cases up to three) were invited to give a poster presentation at AGU. In general, very few abstracts are accepted as oral sessions at AGU, and poster sessions are the normal mode of communication for the majority of AGU attendees. This opportunity allowed the APN grantees to interact with peers interested in their subject matter and to build new contacts and networks while learning about scientific communication and participation in the scientific process.

For those invited to attended the two-day Young and Early-Career Scientists' workshop, participants received training and time to think about related global environmental change subjects, including marine protection, urban resilience, rural sustainability, and human and environmental health interactions. They also learned about co-design and co-production, the current modes of creating knowledge in international, multidisciplinary research efforts. The participants also gained experience in working in teams as they developed case studies with their colleagues. Future Earth has already contacted the scientists' as part of their Future Earth Open Network initiative.

3.3 Necessity of Follow-up Engagement

After IGBP formally closed in December 2015, following up on APN grantees' experiences of AGU has not been possible. However, through informal communications, participants expressed their appreciation for this opportunity and their enthusiasm for what they had learnt at AGU.

Questionnaires were conducted in advance of AGU to establish how the APN scientists would communicate their experience of AGU to their peers. The 10 APN grantees expressed their plans for presenting scientific talks to their academic colleagues after returning home from AGU, organising scientific collaborations and meetings at their own institutions, and encouraging students to publish and communicate their results. Some were also very interested in promoting communications via social media to heighten public awareness of the issues they study. They all looked forward to international collaborations, and to collaborating across disciplines, and hoped that the introductions made at AGU would lead them to this kind of transdisciplinary, multifaceted work at an international level.

While it remains to be seen whether they have succeeded in these goals, IGBP hopes that having taken the time to think about and respond to this survey, in addition to experiencing an international conference with the global environmental change research community, will keep these goals in mind for these young researchers, and ultimately benefit their communities, both civil and scientific.

Future Earth asked participants to complete feedback forms following the Young and Early-Career Scientists' workshop, with overwhelmingly positive responses. Out of the 20 evaluation forms completed, 8 said that the workshop was excellent and 12 said that the workshop was good. All said they would recommend the workshop to colleagues. Among their assessments, they greatly appreciated the diversity of backgrounds and nationalities, as well as the gender balance achieved by the organisers. Responders also appreciated that the workshop was oriented toward concrete projects, stakeholder perspectives, and broader research approaches.

Future Earth was given contact details for all the APN grantees and followed up with them after AGU to invite them to give feedback on and act as "ambassadors" for the Future Earth Open Network, an online digital platform meant to connect the global sustainability science research community.

4. Conclusions

Over the past three decades, IGBP as an organisation was active in enhancing multidisciplinary scientific research, informing social policy and clarifying such important issues as the Anthropocene. IGBP considered the Landmark Synthesis Event at the 2015 AGU Fall Meeting in San Francisco to have been a success and a suitable celebratory closure to its nearly 30 years of work in global environmental change, on many levels.

Part of that success came in the introduction of young scientists from developing countries to the next generation of global change research and the researchers who will continue the IGBP legacy. Sufficiently early planning and meaningful interactions with partner organisations contributed immensely to the success of the program and the achievement of the objectives of bringing researchers from all levels together to further research in global change.

Now that IGBP has closed its doors, the organisation will be unable to follow up to see what happens as a result of this project. Nevertheless, taken as a freestanding experience, the efforts made in service of these scientists and related organisations seem to have been a success.

Acknowledgement

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ONGOING PROJECTS

The Annual Regional Call for Research Proposals (ARCP)

Capacity Development Programme (CAPaBLE)

Climate Adaptation Framework (CAF)

Project Reference	Title	Countries Engaged	Elib URL
ARCP2015-01CMY-Miyata	Toward CarboAsia: Integration and syntheses of terrestrial ecosystem flux data in tropics/subtropics and croplands in Asia by activating regional tower-based observation networks	Bangladesh, China, India, Indonesia, Japan, Malaysia, Philippines, Republic of Korea, Thailand, Viet Nam	http://www.apn-gcr.org/resources/items/show/1882
ARCP2015-02CMY-Ailikun	Coordinated Regional Climate Downscaling Experiment (CORDEX) in Monsoon Asia	Australia, China, India, Nepal, Republic of Korea	http://www.apn-gcr.org/resources/items/show/1883
ARCP2015-03CMY-Li	Assessing spatiotemporal variability off NPP, NEP and carbon sinks to global grassland ecosystem in respond to climate change in 1911-2011	Australia, China, Mongolia, USA, Uzbekistan	http://www.apn-gcr.org/resources/items/show/1884
ARCP2015-04CMY-Tangang	Southeast Asia regional climate downscaling project (SEACLID)	Cambodia, Indonesia, Lao PDR, Malaysia, Philippines, Thailand, Viet Nam	http://www.apn-gcr.org/resources/items/show/1886
ARCP2015-05CMY(B&ES)-Salmo	Influence of mangrove biodiversity on accumulation of carbon and resilience to sea level rise: A comparative assessment among disturbed, restored and intact mangrove systems	Australia, Indonesia, Malaysia, Philippines, Singapore, USA	http://www.apn-gcr.org/resources/items/show/1940
ARCP2015-06CMY-Wu	Comparative analysis of pollution sources at the Hangzhou Bay and Mekong River mouths	Japan, Lao PDR, Thailand, USA, Viet Nam	http://www.apn-gcr.org/resources/items/show/1974
ARCP2015-07CMY-Babel	Developing an operational water security index, and its application in selected diverse regions of Asia	India, Thailand, Viet Nam	http://www.apn-gcr.org/resources/items/show/2013
ARCP2015-08CMY-Dey	Impacts of crop residue removal for biomass energy on soil function: studies to recommend climate adaptive agricultural waste management	Bhutan, India, Philippines	http://www.apn-gcr.org/resources/items/show/1947
ARCP2015-09CMY-Heath	Development of an evidence-based climate change adaptation toolkit to help improve community resilience to climate change impacts in Uttarakhand, India	Australia, Bangladesh, China, India, Nepal	http://www.apn-gcr.org/resources/items/show/1991
ARCP2015-10CMY(B&ES)-Liang	Coastal forest management in the face of global change based on case studies in Japan, Myanmar and the Philippines	Japan, Myanmar, Philippines	http://www.apn-gcr.org/resources/items/show/1964
ARCP2015-11CMY-Mishra	Climate change adaptation through optimal stormwater capture measures: Towards a new paradigm for urban water security	Japan, Lao PDR, Thailand, Viet Nam	http://www.apn-gcr.org/resources/items/show/1972
ARCP2015-12CMY-Sharp	Integrated solid waste management system leading to zero waste for sustainable resource utilisation in rapid urbanised areas in developing countries	Bhutan,Thailand, Viet Nam	http://www.apn-gcr.org/resources/items/show/1989
ARCP2015-13CMY-Zhou	Assessment of climate-induced long-term water availability in Ganges Basin and impacts on energy security in South Asia	Bangladesh, India, Nepal	http://www.apn-gcr.org/resources/items/show/1968

Project Reference	Title	Countries Engaged	Elib URL
ARCP2014-03CMY-Quynh	Carbon fluxes and emission from the Red River (Viet Nam and China): Human activities and climate change	China, France, Singapore, Viet Nam	http://www.apn-gcr.org/resources/items/show/1750
ARCP2014-08CMY-Prabhakar	Assessing community risk insurance initiatives and identifying enabling policy and institutional factors for maximising climate change adaptation and disaster risk reduction benefits from risk insurance	Australia, India, Japan, Malaysia, Philippines	http://www.apn-gcr.org/resources/items/show/1887
ARCP2014-09CMY-Gomboev	Boreal and tropical forest and forest-steppes in East Asia: A comparative study on climate impacts and adaptation	China, Mongolia, Russian Federation	http://www.apn-gcr.org/resources/items/show/1890
ARCP2014-10CMY-Shrestha	Runoff scenario and water-based adaptation strategies in South Asia	Bangladesh,India, Nepal, Pakistan, USA	http://www.apn-gcr.org/resources/items/show/1891
ARCP2014-11CMY-Yamada	Adaptation of solid waste management to frequent floods in vulnerable mid-scale Asian cities	Japan, Thailand, Viet Nam	http://www.apn-gcr.org/resources/items/show/1892
ARCP2014-12CMY-Sellers	Mega-regional development and environmental change in China and India	China, India, USA	http://www.apn-gcr.org/resources/items/show/1893
ARCP2014-13CMY-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	Indonesia, LAO PDR, Philippines, Republic of Korea, Thailand, USA	http://www.apn-gcr.org/resources/items/show/1894
ARCP2013-02CMY-Fortes	Seagrass-mangrove ecosystems: Bioshields against biodiversity loss and impacts of local and global change along Indo-Pacific coasts	Australia, India, Indonesia, Japan, Philippines	http://www.apn-gcr.org/resources/items/show/1593
ARCP2013-03CMY-Herath	Developing ecosystem-based adaptation strategies for enhancing resilience of rice terrace farming systems against climate change	China, Japan, Philippines	http://www.apn-gcr.org/resources/items/show/1594
ARCP2013-04CMY-Meinke	Improving the robustness, sustainability, productivity and eco-efficiencies of rice systems throughout Asia	Australia, India, Indonesia, Japan, Pakistan, Sri Lanka	http://www.apn-gcr.org/resources/items/show/1748
ARCP2013-25NSY-Shahid	Climate change vulnerability and adaptation in groundwater-dependent irrigation system in the Asia-Pacific region	Bangladesh, China, India, Indonesia, Malaysia	http://www.apn-gcr.org/resources/items/show/1896
ARCP2012-06CMY-IGBP	An International Geosphere-Biosphere Programme synthesis on global environment change and sustainable development: Needs of least developed countries	Afghanistan, Bangladesh, Bhutan, Cambodia, Lao PDR, Maldives, Myanmar, Nepal, Yemen	http://www.apn-gcr.org/resources/items/show/1597

Project Reference	Title	Countries Engaged	Elib URL
CBA2015-01CMY-Singhruck	Strengthening the adaptive capacity of local agricultural communities through the development of seasonal climate prediction system	Thailand	http://www.apn-gcr.org/resources/items/show/1952
CBA2015-02NMY-Pushpakumara	Scientific capacity development to strengthen informed-decision making for improved climate policy formulation and implementation in South Asian countries	Bangladesh, Bhutan, Nepal, Sri Lanka	http://www.apn-gcr.org/resources/items/show/2006
CBA2015-03NMY-Adiningsih	Building capacity for urban climate change adaptation in Southeast Asia	Cambodia, Indonesia, Lao PDR, Malaysia, Philippines, Thailand, USA, Viet Nam	http://www.apn-gcr.org/resources/items/show/2024
CBA2015-04NSY-Avtar	Developing a training module to monitor forest cover and deforestation using advanced remote sensing techniques under UN-CECAR framework in support of REDD+ MRV system	Cambodia, India, Japan, Sri Lanka	http://www.apn-gcr.org/resources/items/show/2000
CBA2015-06NSY-Silva	Escalating small hydropower development and aquatic biodiversity of mountain streams in Sri Lanka	Sri Lanka	http://www.apn-gcr.org/resources/items/show/2010
CBA2015-07NSY-Prasad	Biodiversity conservation in western Ghats, India: Capacity building in harnessing geospatial data management	India	http://www.apn-gcr.org/resources/items/show/2009
CBA2015-08NSY-Sharifi	Integrated, resilience-based planning for climate change mitigation and adaptation in Asia-Pacific cities	Australia, China, Japan, Thailand, USA	http://www.apn-gcr.org/resources/items/show/2011
CBA2015-09NSY-Comia	On-the-ground promotion of climate change adaptation strategies via establishment of local agroforestry learning laboratories in Southeast Asia	Indonesia, Philippines, Viet Nam	http://www.apn-gcr.org/resources/items/show/2005
CBA2014-01CMY-D'Arrigo	ACRE SE Asia: Towards new weather and climate baselines for assessing weather and climate extremes, impacts and risks over Southeast Asia	China, Indonesia, Japan, Malaysia, New Zealand, Philippines, Singapore,USA, Viet Nam	http://www.apn-gcr.org/resources/items/show/1912
CBA2014-03NSY-Cruz	Collaborative monitoring system for enhanced watershed management in the Philippines	Philippines	http://www.apn-gcr.org/resources/items/show/1948
CBA2014-06NSY-Hien	Scientific capacity building in climate change research techniques for non-governmental organisations in Viet Nam	Thailand, Viet Nam	http://www.apn-gcr.org/resources/items/show/1950
CBA2014-09NSY-Mathai	Training workshop and edited volume on “Green growth: Political ideology, political economy and policy alternatives"	Australia, Brazil, China, France, Germany, India, Indonesia, Japan, Nepal, Philippines, South Korea, Spain, Switzerland, Thailand, United Kingdom	http://www.apn-gcr.org/resources/items/show/1939

Project Reference	Title	Countries Engaged	Elib URL
CBA2013-02CMY-Hashim	Global environmental change and human health: Extreme events and urbanisation in the APN region	Australia, China, India, Malaysia	http://www.apn-gcr.org/resources/items/show/1769
CBA2013-16NSY-Dargantes	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	Cambodia, Indonesia, Japan, Philippines	http://www.apn-gcr.org/resources/items/show/1911

Project Reference	Title	Countries Engaged	Elib URL
CAF2015-RR01-CMY-Basnayake	Developing climate inclusive potential loss and damage assessment methodology for flood hazards	Australia, Nepal, Sri Lanka, Thailand	http://www.apn-gcr.org/resources/items/show/1975
CAF2015-RR02-CMY-Singh	Developing and promoting a people-centred approach to assess and address impacts of climate change induced loss and damage	Bangladesh, Cambodia, Myanmar, Nepal, South Africa, UK, Viet Nam	http://www.apn-gcr.org/resources/items/show/1978
CAF2015-RR03-CMY-Pereira	Integrating CCA, DRR and L&D to address emerging challenges due to slow onset processes	Cambodia, Japan, Malaysia, Myanmar, Philippines, Viet Nam	http://www.apn-gcr.org/resources/items/show/1949
CAF2015-RR04-CMY-Thomalla	An analysis of longer-term (5-10 years) recovery following major disasters in the Asia-Pacific region: Lessons for resilient development	Cambodia, Indonesia, Myanmar,Thailand	http://www.apn-gcr.org/resources/items/show/1969
CAF2015-RR05-CMY-Lasco	Assessing the linkages between climate change adaptation (CCA), disaster risk reduction (DRR), and loss and damage (L&D): Case studies in the floodplains of Cambodia, Indonesia, Philippines, Thailand and Viet Nam	Cambodia, Indonesia, Philippines, Thailand, Viet Nam	http://www.apn-gcr.org/resources/items/show/1945
CAF2015-RR06-CMY-Wang	Integrated flood modelling and pre-disaster loss estimation in Asian countries	China, Japan, Myanmar, Thailand	http://www.apn-gcr.org/resources/items/show/1976
CAF2015-RR07-CMY-Lotia	Methods toolbox for assessing loss and damage at local level	Germany, India, Nepal, Pakistan, Republic of Korea	http://www.apn-gcr.org/resources/items/show/1944
CAF2015-RR08-CMY-Chiba	Addressing non-economic losses and damages associated with climate change: Learning from the recent past extreme climatic events for future planning	Bangladesh, India, Japan, Philippines, Thailandwwww	http://www.apn-gcr.org/resources/items/show/1943
CAF2015-RR09-CMY-Huong	Climate change risk assessment and adaptation for loss and damage of urban transportation infrastructure in Southeast Asia	Cambodia, Thailand, Viet Nam	http://www.apn-gcr.org/resources/items/show/1951
CAF2015-RR10-NMY-Neef	Climate change adaptation in post-disaster recovery processes: Flood-affected communities in Cambodia and Fiji	Australia, Cambodia, Fiji, New Zealand, UK	http://www.apn-gcr.org/resources/items/show/2027
CAF2015-RR11-NMY-Siswanto	Developing high spatiotemporal resolution datasets of low-trophic level aquatic organism and land-use/land-cover in the Asia-Pacific region: Toward an integrated framework for assessing vulnerability, adaptation, and mitigation of the Asia-Pacific ecosystems to global climate change	China, Indonesia, Japan, Korea, Malaysia, Thailand, USA, Viet Nam	http://www.apn-gcr.org/resources/items/show/2030
CAF2015-RR12-NMY-Shaheen	Climate smart agriculture through sustainable water use management: Exploring new approaches and devising strategies for climate change adaptation in South Asia	Bangladesh, Cambodia, Pakistan,Sri Lanka, United Kingdom	http://www.apn-gcr.org/resources/items/show/2012

Project Reference	Title	Countries Engaged	Elib URL
CAF2015-RR13-NMY-Dautova	Developing life-supporting marine ecosystems along East Asia's coasts: A synthesis of physical and biological data regarding coral reef ecosystems for the science-based management and socio-ecological policy making in terms of global sustainability	Philippines, Russian Federation, Viet Nam	http://www.apn-gcr.org/resources/items/show/2033
CAF2015-RR14-NMY-Odeh	Monitoring grassland degradation in North/Central Asia: Deciphering the impacts of climate change and government policies at different spatial-temporal scales using remote sensing and expert knowledge	Australia, China, Mongolia, Uzbekistan	http://www.apn-gcr.org/resources/items/show/2034
CAF2015-RR15-NMY-Marambe	Building climate resilience in farming systems in sloping lands of South Asia	Bangladesh, Nepal, Pakistan, Sri Lanka	http://www.apn-gcr.org/resources/items/show/2035
CAF2015-RR16-NMY-Pham	Utilising geospatial technology to assess health vulnerability to climate change for rural population in Viet Nam and Philippines	Japan, Philippines, Viet Nam	http://www.apn-gcr.org/resources/items/show/2014
CAF2015-RR17-NMY-Arifwidodo	Understanding Urban Heat Island Effects to Urban Energy Consumption and Implications to Microclimate Adaptation and Mitigation Strategies for Planning Policy in Major Southeast Asian Cities	Indonesia, Philippines, Thailand	http://www.apn-gcr.org/resources/items/show/2029
CAF2015-RR18-NSY-Jacobson	Optimising climate change adaptation through enhanced community resilience	Australia, Cambodia, Viet Nam	http://www.apn-gcr.org/resources/items/show/2028
CAF2015-RR19-NSY-Monprapussorn	Integrated analysis of climate, land-use and water for resilient urban megacities: A case study of Thailand, Lao PDR and Viet Nam	Lao PDR, Thailand, Viet Nam	http://www.apn-gcr.org/resources/items/show/2036
CAF2015-CD01-CMY-Wijenayake	Enhancing Capacity of policy makers and practitioners in India, Sri Lanka and Nepal on Loss and Damage related to slow onset events in the region	India, Nepal, Sri Lanka	http://www.apn-gcr.org/resources/items/show/1980
CAF2015-CD02-CMY-Nhat	Capacity Building for National, Provincial Stakeholders and Local communities on Loss and Damage related to Disaster Risk Reduction and Climate Change Adaptation	Viet Nam	http://www.apn-gcr.org/resources/items/show/1953
CAF2015-CD03-CMY-Ibrahim	Building capacity for reducing loss and damage resulting from slow and rapid onset climatic extremes through risk reduction and proactive adaptation within the broader context of sustainable development	Cambodia, Malaysia, Viet Nam	http://www.apn-gcr.org/resources/items/show/1946
CAF2013-01SY-L+D(F)-Huq	Asia-Pacific Forum on Loss and Damage	Countries in the Asia-Pacific Region	http://www.apn-gcr.org/resources/items/show/1981

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