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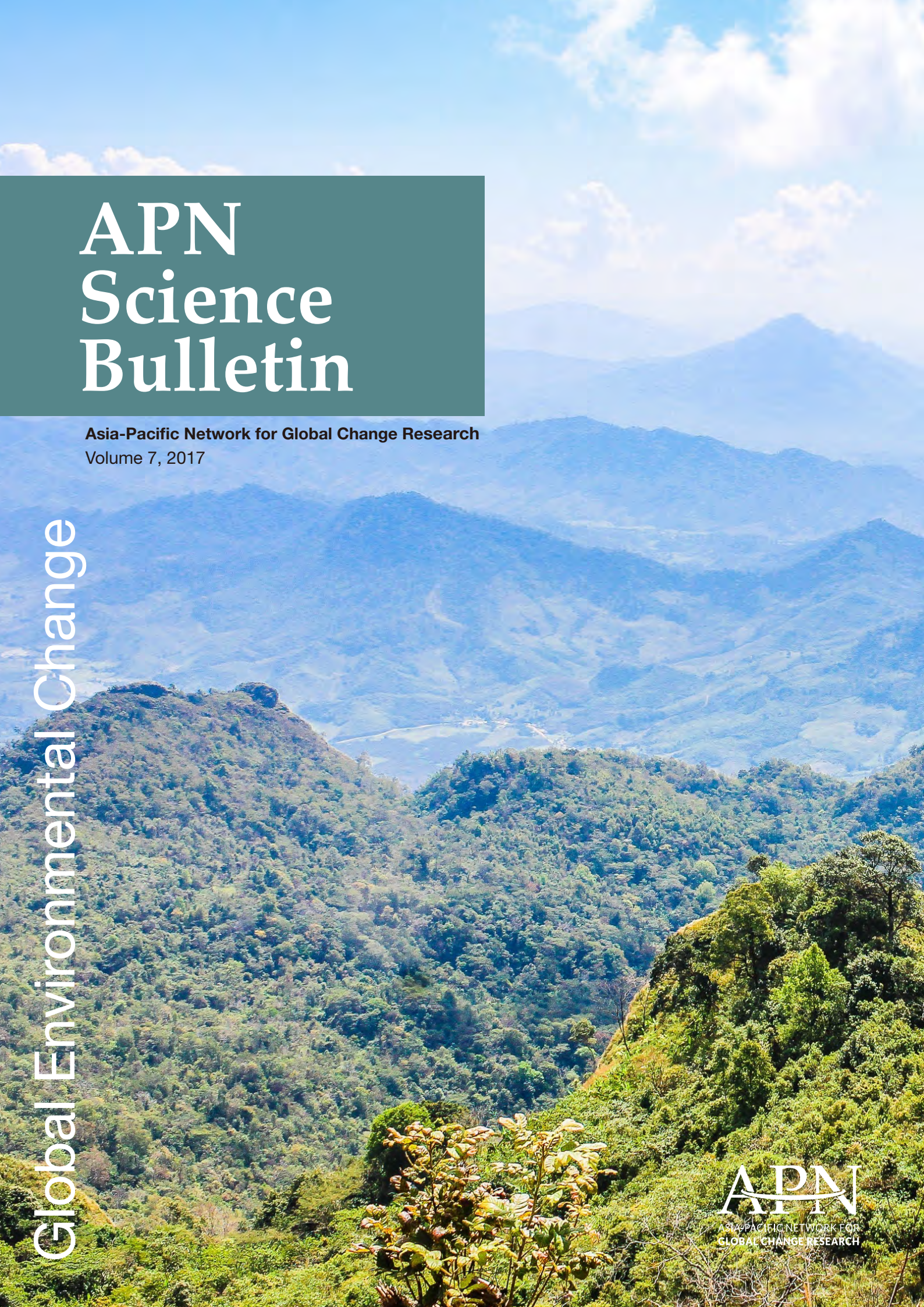

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Preface

On behalf of the editorial board, I am very pleased to present you with the seventh issue of APN's flagship publication, APN Science Bulletin, which features the results, outcomes and findings of a number of APN-funded projects on regional research and capacity development in global change and sustainable development. This publication serves as a record of recently completed activities by project teams who conducted activities for the benefit of developing nations of APN member states.

The APN Science Bulletin continues to evolve since it was first published in March 2011. We are continuing to facilitate a more rigorous, open and constructive peer-review during the process and the independent expert reviewers that make up the 2017 editorial board are listed in the front matter of the Bulletin. Our reviewers' contributions uphold the scientific rigour and relevance of the articles and I would like to express my heartfelt gratitude to them, and to the authors of the articles.

This year, too, APN has moved towards providing a web-based Science Bulletin so that the outputs of the projects that APN funds are able to reach as wide an audience as possible. The layout of the digitized version and the features available will allow each reader to target articles of particular interest using web-based features such as browsing by author or keyword, and full-text search. In addition to this, the reader is able to gather information on authors and other relevant work they have undertaken. Readers can also provide their comments and join online discussions under each article. As we digitize the APN Science Bulletin, the printed version will be phased out this year.

The articles featured in this issue are contributions from projects that were completed between 2015 and 2017 covering the period of APN's Fourth Strategic Phase (2015-2020). The articles comprise a range of topics considered as high priority by APN.

For example, some of the articles presented this year focus on an important element of global change and sustainability, which is resilience. These articles address issues such as the need to develop tools and indicators for assessing urban resilience by addressing multi-dimensional criteria; synthesizing key barriers to resilience in vulnerable communities in least developing countries; and developing resilience assessment tools for climate change adaptation in local communities.

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. On behalf of APN, we hope that the information contained in the 2017 Science Bulletin continues to pave the way to new and deeper collaboration and partnerships among like-minded scientists and researchers working on global environmental change and sustainability.

Linda Anne Stevenson

Head, Communication & Scientific Affairs Division

APN Secretariat

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Towards new weather and climate baselines for assessing weather and climate extremes, impacts and risks

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ABSTRACT

This project's goal has been to work with Southeast Asian institutions, archives, agencies and National Meteorological Services (NMS) to build capacities for improving and extending historical instrumental, documentary and palaeo databases of Southeast Asian weather and climate. The work plan comprised research into and cataloging sources of historical weather observations in archives and repositories globally and, the recovery (imaging and/or digitization) of the same where necessary and appropriate. These long datasets will contribute to the generation of high-quality, high-resolution historical dynamical weather reconstructions (reanalyzes). These will allow scientists and policymakers across the region to address weather/climate extremes, impacts and risks in ways and over time span not previously possible. The project launched officially at a workshop involving scientists, historians, and archivists, brought together with the aim of opening a multi-disciplinary dialogue on historical records and their modern-day application. The project has been successful in establishing a regional arm of the international Atmospheric Circulation Reconstructions over the Earth (ACRE) initiative: ACRE SE Asia. ACRE SE Asia is unique, as no other body exists in the region with the same remit or aims.

KEYWORDS

Climate, data recovery, dynamical reconstructions, historic weather, reanalyses

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1. INTRODUCTION

Initiatives to recover (sourcing, imaging, digitizing) historic datasets for generating more accurate long-term climate models have only gained momentum over the last decade, despite a long precedent of compelling arguments as to the value of historic weather observations (Le Roy Ladurie, 1972; Lamb, 1977). Although such work is relatively well established in Europe, the United States, China, and Japan; Southeast Asia currently has a dearth of data rescue initiatives with a long historical focus. The reasons behind this include a perception of the paucity of surviving data; the scattered nature of data due to shifts between colonial rule and independence and, later regime changes; a lack of local resources to develop data recovery projects. By way of example, the Southeast Asian Climate Assessment & Dataset (SACA&D) Digitisasi Data Historis (DiDaH) project, now completed, was limited by the fact that the bulk of observations recovered and digitized were in the post 1940s-50s period (apart from Indonesia in the South East Asian region) and, their data rescue was directed at National Meteorological Service (NMS) records only, with generally a heavy focus on temperature and precipitation data. ACRE SEA has a wider scope, with a longer historical timeframe (especially with a pre 1940s-50s observations focus) and broader record collection base, using archives, libraries, and online sources across the region and internationally. In fact, the SACA&D DiDaH project

is linked closely to the main ACRE initiative, with one of its last meetings being paired with the inaugural ACRE SE Asia workshop (as noted below in Section 2). Another project, completed in 2011, was the Asian Precipitation – Highly-Resolved Observational Data Integration Towards Evaluation (APHRODITE) project. Again, the data rescue component was limited to only daily rainfall data and gridded precipitation from 1951 onwards. A follow-up project, APHRODITE Water Resources began in 2014, also with a contemporary data focus. Finally, it is worth mentioning that the Japan Climate Data Project (JCDP) data rescue efforts are closely linked to ACRE, to the extent that a new chapter of the ACRE project – ACRE Japan – has been initiated. See http://www.met-acre.net/chapters.htm for more information.

Thus, the primary goal of the ACRE SEA project has been to launch and establish ACRE SE Asia as an umbrella body to build both capabilities and capacities within SE Asian institutions, agencies and NMS to improve and extend historical instrumental, documentary and palaeo databases of SE Asian weather/climate (Williamson, 2016, 2015). ACRE SEA is, therefore, an integral part of wider ACRE initiative, the major international data rescue effort. These objectives have been achieved by: establishing linkages between ACRE SE Asia and institutions and individuals engaged in data recovery efforts regionally (such as similar ACRE activities with ACRE China – part of the UK-Chinese Climate Science for Service Partnership [CSSP China]); establishing a dialogue between disparate groups with an interest in historical weather records e.g. historians and archivists as well as scientists; and generating publicity for data recovery through an official project launch multi-disciplinary workshop.

Newly digitized historical SE Asian instrumental weather observations will contribute to the mass of global weather data being used by the latest generations of high-resolution historical global dynamical weather reanalyzes (especially EC FP7-funded European Reanalysis of the Global Climate System [ERA-CLIM2] and the ACRE-facilitated 20th Century Reanalysis Project [20CR]). These new data, global reanalyzes and downscaled products (such as via http://www.metoffice.gov.uk/precis) will provide scientists and policymakers across the region with baselines with which they will be able to address weather/climate extremes, impacts and risks in ways, and over time spans, not previously possible.

The project's main objectives were to:

1. Build capabilities and capacities within Southeast Asian institutions, agencies and NMS to improve and extend historical instrumental, documentary and palaeo databases of SE Asian weather/climate.

HIGHLIGHTS

- Two-day workshop bringing together regional NMS representatives, historians, policymakers and applications users
- Establishment of a regional arm of the international Atmospheric Circulation Reconstructions over the Earth (ACRE) initiative and, a steering group for the same
- The contribution of newly digitized weather observations to the International Surface Pressure Databank (ISPD).
- Establishment of a new network of regional linkages of organizations and individuals working on historic weather observations, data recovery, and analysis in the region

2. Contribute to the generation of high-quality, high-resolution historical dynamical weather reconstructions (reanalyzes).

3. Hold a workshop bringing together regional NMS representatives, historians, policymakers and applications users.

4. Establish a regional arm of the international Atmospheric Circulation Reconstructions over the Earth (ACRE) initiative: ACRE SE Asia.

2. METHODOLOGY

The APN CAPaBLE funded component of this project ran from August 2013 to December 2015. The first year focused on developing an inventory of currently known weather data across the Southeast Asian region. This involved first-hand primary research in regional NMS archives and national archives, alongside making contact with people and projects involved in data recovery in Asia. Year One culminated in a project launch in the form of a two-day workshop at the National University of Malaysia in Kuala Lumpur. This was held in conjunction with, and support from, the Royal Netherlands Meteorological Institute (KNMI) Indonesian Agency for Meteorology, Climatology, and Geophysics (BMKG) Digitisasi Data Historis (DiDaH) workshop in Indonesia. The workshops were arranged one week apart so that core partners were enabled to attend both events. This ensured a seamless and coherent engagement between them. Workshop participants discussed the availability and collaborative use of long-term regional weather/climate databases for detailed assessments of observed climate variability and change; future plans to image and digitize published data; created targets for new data recovery and available proxy climate/weather data for inter-comparisons, and explored links with regional applications and policymakers. The workshop also invited participation from

historians and archivists in order to explore the potential of currently unused historic records for climate research (Allan, et al, 2015; Williamson, et al., 2015).

The second year saw a series of research meetings, archival and data recovery visits in Thailand, Vietnam, Singapore and the Republic of Korea to follow up on the workshop's outcomes; to catalogue and recover data where appropriate, and to discuss how newly recovered historical weather data could be fed seamlessly into ACRE-facilitated reanalyzes (Some examples of visualizations using ACRE-facilitated data can be accessed here). This connected with additional work undertaken by Williamson in Cambodia, Lao PDR, and the Philippines under ACRE China, part of CSSP China. Both funded years included a digitization component whereby pre-1950s weather data for the region were made available for the first time. The core project team comprised of Prof. Rosanne D'Arrigo, Lamont Doherty Earth Observatory (LDEO), Prof. Rob Allan United Kingdom Meteorological Office (UKMO), and Dr Fiona Williamson, National University of Singapore (NUS).

3. RESULTS AND DISCUSSION

Southeast Asian data uncovered during this project will be, where appropriate, assimilated into freely available 4D historical global dynamical weather reconstructions (reanalyzes) spanning the last 200+ years. A comparison of 20CR with three other reanalyzes is available here. Dynamical downscaling by Providing Regional Climates for Impacts Studies (PRECIS) team models will then take the reanalyzes output down to finer resolution (25 km to 100 m), for use by the climate science community, wide-ranging climate applications and services, policymakers, planners, environmental managers, educational and public needs across the SE Asian region (see ACRE structure). All of the above are considered necessary to provide the basis for the climate applications community, decision and policymakers across the region to access and utilize the new high-resolution databases, reanalysis outputs, and dynamical downscaling products.

Throughout the project, we have also been undertaking on-going work with DiDaH on bringing together historical instrumental weather observations with currently held contemporary data for the region in the SACA&D database. One benefit from this is that it raises the potential to extend the bevy of Expert Team on Climate Change Detection Indices (ETCCDI)-derived indices to much longer timeframes, making them even more valuable to the climatic variability, change, and applications research communities. At the same time, we have been creating our own database of sources for the

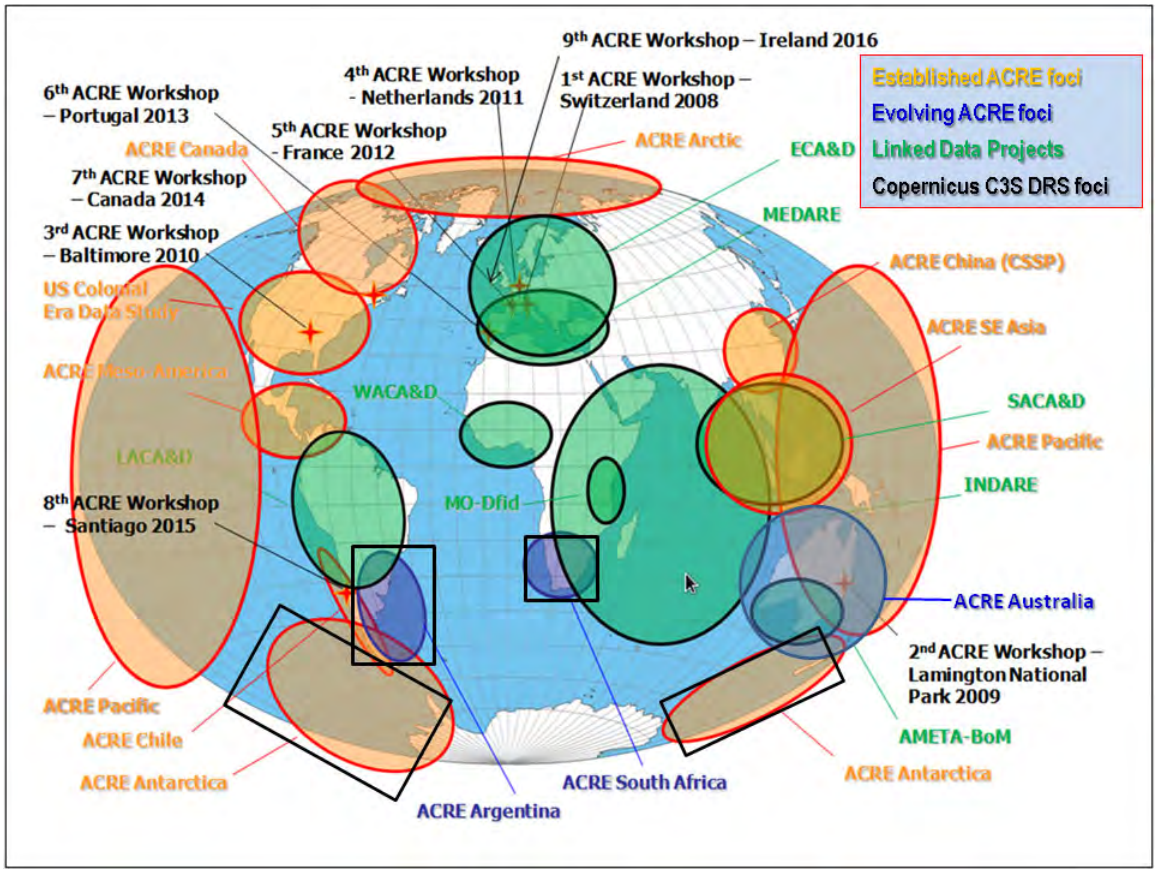

FIGURE 1. ACREs global reach.

region. This includes sources located in the region itself and data held externally either at European archives or by projects partners, e.g. Japan Agency for Marine-Earth Science and Technology (JAMSTEC), JCDP, the China Meteorological Agency (CMA) and the new ACRE Australia focus (Ashcroft et al., 2016). This has meant a process of uniting scattered data which in turn can be shared with original host countries-especially ex-colonial countries. As well as revealing gaps in knowledge and areas on which future research should be focused, the database has also revealed duplication, important in itself because this highlights the value of compiling such a database.

ACRE is the dominant initiative in climate data science as far as having a principal component that is both undertaking and facilitating the rescue of historical weather and climate data, and thus the major server of long surface weather data records to all reanalyzes. Figure 1 shows ACREs global reach currently, and its linkages to other data rescue activities and the new EU Copernicus Climate Change Service (C3S) Data Rescue Service (DRS).

ACRE SE Asia is now an integral part of this global strategy, and efforts to build an international integrated database of surface meteorological observations (Thorne et al., 2017). Since submitting the original APN CAPaBLE proposal, the International ACRE Initiative has become an even more integral part of the expanding and enhanced (Met Office [MO]-University of Southern Queensland [USQ]) Collaboration Agreement (a partner in ACRE SE Asia). Thus, ongoing activity and project development by USQ already underway in SE Asia, linking climate analysis and agricultural production modelling, will require outputs and outcomes from the new ACRE SE Asia foci to be sustained. These activities will utilize and expand the data recovery and associated activities across SE Asia that is already an integral component of this USQ (soon to be MO-USQ) activity. ACRE SE Asia and MO-USQ will provide the basis to underpin ongoing wider climate applications, policy and decision support, delivery and usage of data and reanalysis outputs across the region.

ACRE SE Asia is also now being supported through its linkages to the ACRE China component of the Climate Science for Service Partnership China (CSSP) – a bilateral partnership between the UK Met Office, the CMA, the Institute of Atmospheric Physics (IAP) at the Chinese Academy of Sciences, and other key institutes within China and the UK. This is a 3-year project from 2015-2018, during which time adjunct research work will be undertaken on building a database of sources Southeast Asian historical weather observations and work will be extended to include Taiwan, Macau, Myanmar, and the Philippines. It is anticipated that information currently stored in European repositories can be reunited with ex-colonial countries where applicable, and more data sharing initiatives can be enacted. There was a major workshop held in Beijing in August 2016 under the auspices of ACRE China, in which ACRE SE Asia collaborators attended and presented (Williamson et al., 2016) and another in Hong Kong in March 2017. In addition, monies are being sought to enable specific data recovery projects for early 20th century hard copy meteorological observations (imaging and digitization) held in the NMS in Lao PDR and Cambodia. Williamson will also continue research into sources of historical data for the region, by individual research, and by working with regional partners, to facilitate this. One important area of work is raising funds for two recovery projects, to rescue hard copy data currently held in storage at the Department of Meteorology and Hydrology (DMH), Vientiane, Lao PDR and Ministry of Water Resources and Hydrology (MOWRAM), Phnom Penh, Cambodia. In both cases, neither country currently has the resources or capabilities to recover this documentation and vital data stands to be lost without a recovery project.

In terms of moving forward, this research contributes weight to a compelling argument for the value of a global, publicly-accessible, integrated database and portal for historical weather data. The World Meteorological Organization (WMO) International Data Rescue (I-DARE), the European Commission Seventh Framework Program (EU FP7) European Reanalysis of the Global Climate System (ERA_CLIM2), C3S DRS and Indian Ocean Data Rescue (INDARE) projects are prime examples of efforts to address such needs, but what is required is a truly international 'one-stop' database and portal for such material (Thorne et al., 2017). This will be a major topic discussed during the second half of the 9th annual ACRE Workshop in Ireland in June 2016. The ACRE SE Asia project has also highlighted the importance of open data sharing policies to which not all countries subscribe. This current deficiency leads to gaps where data does exist but is not allowed to be shared. ACRE is strongly placed to work with the international data/data rescue community on this issue.

More work needs also to be undertaken as direct and indirect consequences of this two-year project. Directly, it would be useful to consider, or to take part in, initiatives to encourage open data sharing regionally. Indirectly, the project has shown that a great deal of data does exist for the region that still needs to be collated. The project needs to be extended across Southeast Asia and, in particular, European archives and NMS repositories need to be mined for information. The project recommends an extension to Myanmar, Lao PDR, Cambodia, and the Philippines. A critical step forward would also be to seek

funds for large recovery projects on new source data.

4. CONCLUSION

This two-year project has achieved the following objectives. To:

1. Build both capabilities and capacities within Southeast Asian institutions, agencies and NMS to improve and extend historical instrumental, documentary and palaeo databases of SE Asian weather/climate.

2. Contribute to the generation of high-quality, high-resolution historical dynamical weather reconstructions (reanalyzes).

3. To hold a workshop bringing together regional Meteorological Department representatives, historians, policymakers and applications users. This workshop was successfully held in May 2014 at the National University of Malaysia. It brought together people from disparate fields — across the humanities and sciences — to frame a dialogue on historical data sources, their recovery, and usage in addressing modern challenges.

4. To establish a regional arm of the international Atmospheric Circulation Reconstructions over the Earth (ACRE) initiative: ACRE SE Asia.

The outcomes and outputs of this project will address the needs of decision-makers and users of climate services in the region and, globally. It will contribute to the ability of these less developed countries to develop and understand their own data recovery capacities, preserve an invaluable resource for the global climate user and research community, and add to the knowledge of a region that is particularly sensitive to climate risks now, and in the future. ACRE is currently investigating sources of funding to enable continuing this important project.

ACKNOWLEDGEMENTS

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Towards an integrated approach to urban resilience assessment

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ABSTRACT

As climate change advances, more cities across the world are coming to realize the essential need for resilience-oriented planning. This article summarizes findings of a research project on developing tools and indicators for assessing urban resilience. A mixed-methods approach is taken to investigate various issues related to development and implementation of integrated resilience assessment tools. This includes an extensive review of a vast body of literature published on urban resilience, content analyses of existing assessment frameworks, and employment of methods such as checklist surveys and "structured interview matrix" to use the knowledge of experts in the field. Based on the literature review several criteria are identified that can be used for developing assessment tools suitable for informing decision-making process. Examination of a selected number of assessment tools shows that most of them fall short of appropriately addressing these criteria and further improvements are required. This study argues that resilience is a multi-dimensional concept. The five dimensions identified here are, namely, environmental, social, economic, physical, and institutional. It is emphasized that various criteria related to these dimensions should be appropriately addressed during various planning, absorption, recovery, and adaptation stages of disaster risk management.

KEYWORDS

urban resilience, assessment framework, climate change, disaster risk management, mixed-methods approach, structured interview matrix.

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1. INTRODUCTION

Throughout history, cities have often been able to endure and recover from climatic and non-climatic shocks and stresses (Vale & Campanella, 2005). However, due to unprecedented urbanization and climate change, the scale of these stresses and disruptions has increased and is expected to increase even further in the future (Field et al., 2014). Increase in frequency and intensity of disruptive events can overwhelm even the most robust urban systems and limit their coping capacity. Advances in the understanding of the potentially dire impacts of climate change has resulted in the widespread use of the resilience concept in science and policy circles (e.g. Resilience Alliance, ICLEI, C40 Cities, etc.). It has also given rise to the emergence of various initiatives around the world that intend to enhance resilience of cities and communities (for further information see Sharifi (2016)). These initiatives are initiated and operationalized by

HIGHLIGHTS

- Resilience thinking improves the capacity for disaster risk management.
- Assessing urban resilience can facilitate a better-informed decision-making process.
- Factors related to the assessment of urban resilience are identified.
- Assessment tools should reflect the multi-dimensional nature of urban resilience.
- Urban resilience assessment should address the issue of context-specificity.

various entities including national and local governments, Non-Governmental Organizations (NGOs), and donor organizations. More recently, there has also been an increasing trend in the development of initiatives that are centered on partnerships between different cities and communities; the Global Resilience Partnership and the 100 Resilient Cities program are two examples of these partnerships.

The ubiquity of the resilience concept can be attributed to its broad scope and the fact that it can be utilized to frame various issues related to climate- and non-climate-induced disruptions in urban areas. Further knowledge about resilience and its assessment can provide better understanding of transformative approaches that need to be taken in order to develop cities that contribute to climate stabilization and to achievement of the Sustainable Development Goals (SDGs) .

The literature on urban resilience is immense and still growing (Cutter, 2015; Fox-Lent, Bates, & Linkov, 2015; Tyler & Moench, 2012; Sharifi, 2016). A number of issues related to social, economic, environmental, physical, and institutional aspects of resilience have been addressed in the literature (Cutter, 2015; Fox-Lent, Bates, & Linkov, 2015). More recently, there has also been an increasing interest in the development of assessment tools that capture the complexity of the resilience concept and make it more tangible for the public and policy makers (Cutter, 2015; Fox-Lent, Bates, & Linkov, 2015, Sharifi, 2016, Sharifi &Yamagata, 2016b). Resilience assessment can also help communities identify their shortcomings and develop action plans to address them. It can also provide learning opportunities through actively engaging different stakeholders throughout the process (Sharifi, 2016).

The main aim of the study is to review literature on urban resilience assessment and identify different issues that should be considered for the purpose of developing integrated resilience assessment tools. Other objectives are to identify various resilience principles and characteristics that should be integrated into urban planning and also to develop a framework for evaluation of existing resilience assessment tools. The study is important as existing assessment frameworks are often fragmented and fail to provide a comprehensive picture of urban resilience assessment. Furthermore, although many assessment tools exist, analyses of their strengths and weaknesses are still scarce. The research project aims to fill these gaps.

The research methods and materials are discussed in the following section. Section three presents the main findings and discusses their implications for urban resilience assessment. The final section summarizes the main points discussed in the study and highlights several areas for future research.

2. METHODOLOGY

The broader research project was developed based on a mixed-methods approach. Here, only those methods used to obtain the results presented in this study are explained. Before explaining the research methodology, it is essential to clarify what is meant by the term 'resilience' in this paper. Resilience is a contested concept and various definitions can be found for it in the literature (Sharifi, 2016). The definition provided by the National Academies was adopted for this research project. It defines resilience as "the ability to prepare and plan for, absorb, recover from, and more successfully adapt to adverse events" (TNA, 2012, 14).

As one of the main objectives of this study was to identify a comprehensive list of criteria that can be used for assessing urban resilience, an extensive literature review was conducted. A broad review protocol was developed in order to include criteria related to various aspects of urban resilience. As a result, research from various fields including, but not limited to, urban planning, disaster management, sociology, economy, environment, infrastructure, governance, water, and energy was included in the study. Further details about the review protocol can be found in Sharifi and Yamagata (2016a) and Sharifi (2016).

In addition to identifying resilience criteria, the review was also designed to extract a set of measures that can be used for development and evaluation of urban resilience assessment tools. A framework for assessing suitability of resilience assessment tools was developed based on these measures. This framework was later used to critically analyse the selected existing resilience assessment tools. Thirty six tools were selected for this purpose. Content analyses of manuals and other documents related to these tools were conducted to find out if they comply with the measures outlined in the framework.

As resilience is a normative concept, any research related to it should also involve participatory methods to obtain knowledge from a diverse array of stakeholders. Although it is intended to engage stakeholders from different sectors in the project, until this stage this has mainly been limited to researchers and few key actors from NGOs. A four-day workshop was organized at The University of Tokyo in December, 2015 . Over 30 participants attended this workshop. A call for applications was distributed several months before the workshop in order to ensure participation of qualified people from different countries . This workshop provided the opportunity for various researchers and practitioners

from different countries to share their knowledge and actively participate in discussions related to urban resilience assessment. During the third day of the workshop the participants were assigned the task of identifying different urban form criteria that enhance resilience of communities.

On the last day participants were engaged in an exercise to discuss answers for four major questions that were identified cooperatively (by the participants) based on the presentations and discussions from the first three days of the workshop. Structured Interview Matrix (SIM) which is a technique that has been used by several researchers to map community assets in a participatory process was used for the purpose of this exercise (T L. O'Sullivan, Corneil, Kuziemsky, & Toal-Sullivan, 2015; T. L. O'Sullivan, Kuziemsky, Toal-Sullivan, & Corneil, 2013). The exercise was conducted in three stages as follows: first, an interview matrix was developed to divide the participants into four groups and assign a specific question to each group (three groups had 4 members and one group had 5. For the purpose of consistency, two members of the latter group were paired). Each participant was engaged in "one-on-one" interviews with a participant from the other groups to collect answers for the specific question. Each interview was conducted in about five minutes and the responses were written down by the interviewer. The process was repeated until each group collected 12 unique answers for its question (each participant answered to three unique questions from the other groups). The facilitator guided the participants on how to complete the interview matrix. Following the completion of this stage, the groups reconvened to discuss and elaborate on the findings and add their own input. Each group was tasked to identify three main findings for its assigned question. A plenary discussion was organized at the last stage in order to discuss the questions and findings with all participants (T. L. O'Sullivan et al., 2013, 240). This exercise provided an opportunity for all participants to express their opinions and actively engage in discussions.

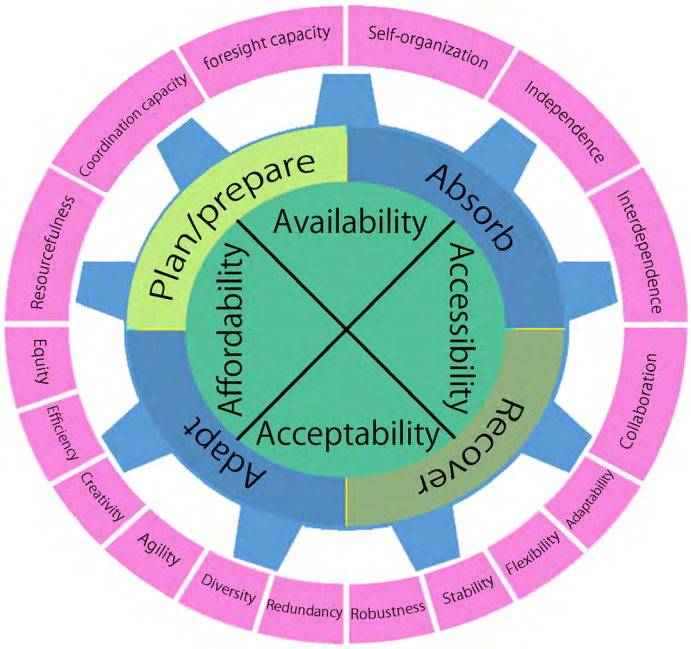

FIGURE 1. Different factors related to the assessment of urban energy resilience. Items of the pink band should be considered during planning, absorption, adaptation, and recovery phases in order to ensure availability, accessibility, acceptability, and affordability of urban energy. Adapted from Figure 2 in Sharifi and Yamagata (2016a).

3. RESULTS AND DISCUSSION

3.1 Different dimensions, criteria, and qualities related to urban resilience

As discussed above, the project aims to create a database of criteria related to different aspects of urban resilience. Criteria related to general urban resilience and urban energy resilience have already been identified (Sharifi & Yamagata, 2016a). For general urban resilience, a total number of 122 criteria have been identified by the authors and categorized into five groups, namely, environmental, social, economic, physical, and institutional. Complete list of these criteria can be found in Table 5 of Sharifi (2016).

Also, 196 criteria related to urban energy resilience were extracted and divided into five categories, namely, infrastructure; resources; land use, urban geometry and morphology; governance; and socio-demographic aspects and human behaviour . Further analysis of these criteria showed that they provide various sustainability benefits (in terms of availability, accessibility, affordability, and acceptability), and can also enhance resilience abilities in terms of planning, absorption, recovery, and adaptation (Sharifi & Yamagata, 2016a).

Review of the extensive resilience literature also revealed that there are various qualities (principles) that should be met in order to appropriately achieve urban resilience. These qualities are namely, robustness, stability, flexibility, resourcefulness, coordination capacity, redundancy, diversity, foresight capacity, independence, interdependence, collaboration, agility, adaptability, self-organization, creativity, efficiency, and equity (Sharifi & Yamagata, 2016; Tyler & Moench, 2012). Possible linkages between these qualities with sustainability dimensions and resilience abilities have been explored (Sharifi & Yamagata, 2016). Figure 1 shows these linkages in a simplified way.

3.2 Framework for evaluating suitability of urban resilience assessment tools

The evaluation framework includes six main criteria. These are briefly explained below; further information can be found in Sharifi (2016). 'Comprehensiveness', as the first criterion, implies that various resilience dimensions and criteria should be integrated into the assessment framework. 'Cross-scale dynamism' and 'temporal dynamism' are the next two evaluation criteria and should be considered in order to be able to track changes and influences over time and across space. The fourth criterion is related to addressing 'uncertainties' using methods such as modelling and scenario-making in the assessment process. According to the fifth evaluation criterion assessment tools should be developed and implemented through 'participatory' approaches that can enhance accuracy and applicability of the assessment results and provide learning opportunities for both citizens and local authorities. Finally, 'action plans' should be developed based on assessment results (Sharifi, 2016). These components are shown in Figure 2.

FIGURE 2. Criteria for evaluation of resilience assessment tools (Adapted from Sharifi (2016)).

3.3 Examination of performance of the tools against the evaluation framework

Thirty six assessment tools were selected and evaluated using the framework displayed in Figure 2 . In terms of comprehensiveness, it was found that more work is needed in order to provide a balanced account of different resilience dimensions. Analysed tools have, on average, paid more attention to the institutional dimension at the expense of other dimensions. As can be seen from Figure 3, it is particularly necessary to better acknowledge the significance of the environmental dimension (Sharifi, 2016). Average percentage distribution of the frequency of the criteria related to the five resilience dimensions is shown in Figure 3.

Results showed that assessment tools do not perform well in terms of reflecting cross-scale and temporal dynamism in their framework. Regarding the issue of scale, selected tools are mainly focused on the status quo of the focal scale. Community as the focal scale affects, and is affected, by other scales (upper and lower) and

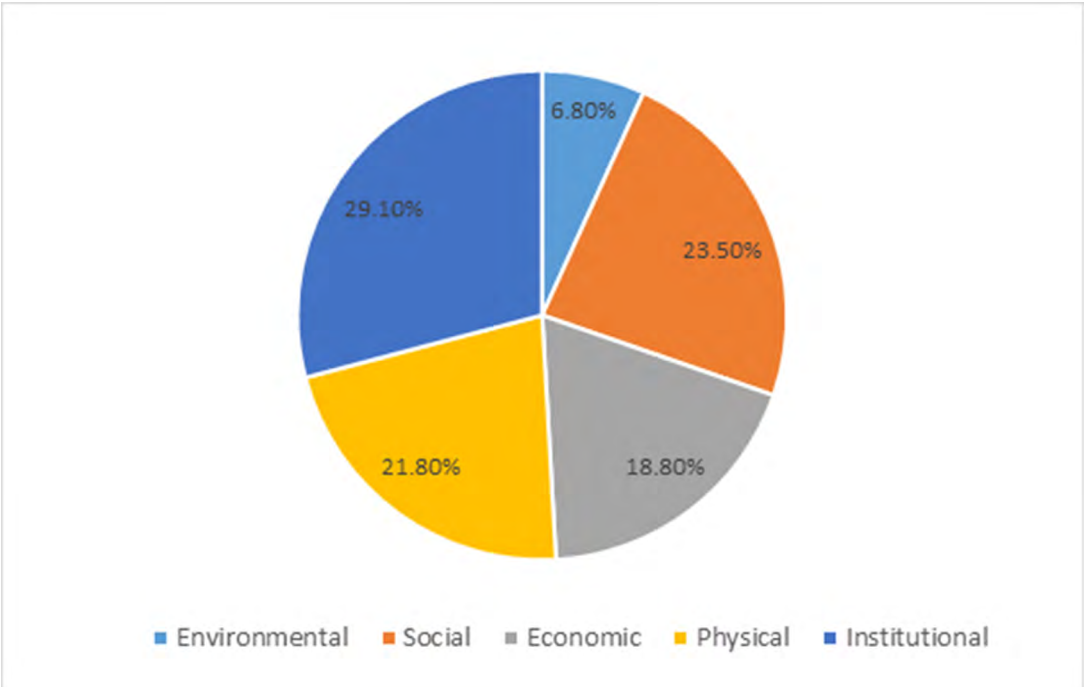

FIGURE 3. Average distribution of resilience criteria in selected community resilience assessment tools (Adapted from Sharifi (2016)).

this should be taken into account. Regarding the issue of temporal scale, assessment tools are mainly focused on the assessment of baseline conditions. In order to better address uncertainties, more work should be done with respect to developing alternative future scenarios, adopting an iterative approach, and utilizing modelling and simulation in the assessment process.

Limited success has been achieved in terms of taking participatory approaches (the fifth evaluation component). Further improvements are needed, particularly regarding engaging stakeholders in the process of developing assessment tools. The same arguments apply to performance with respect to development and implementation of action plans (Sharifi, 2016).

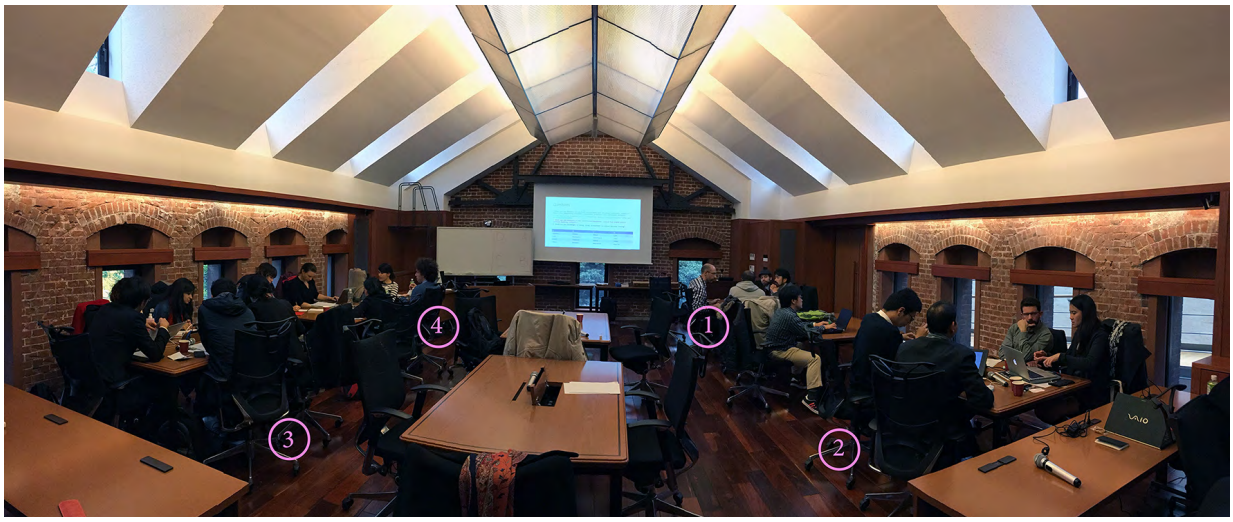

FIGURE 4. Participants were divided into four groups to take part in the activity designed based on the SIM technique.

3.4 Results of the SIM exercise

During the workshop the participants were asked to complete a checklist survey on the linkages between criteria related to urban form and resilience. The objective of the activity was to clarify how each criterion is related to different disruptive events such as flooding, hurricane, earthquake, drought, power outage, etc. It was also intended to calculate the relative importance of each criterion. This exercise helped participants engage in debates on issues such as synergies and trade-offs between the criteria. It was found that more time would be needed to complete the exercise. Therefore, further research on this topic is necessary in the future

The SIM session was cantered on answering the following questions by the participants:

1. What elements of the built environment influence resilience and how is urbanization process related to resilience?
2. How is urban resilience framed in the context of adaptation, recovery, and sustainability?
3. What institutional elements contribute/detract from building resilience?
4. What would be the main challenges regarding development and implementation of assessment tools and integrating the results into the decision-making process?

Participants were divided into four groups as shown in Figure 4. The exercise provided an opportunity for participants from different related fields to share their knowledge and learn from one another. The major points that emerged from this activity are briefly explained here. Regarding the elements of the built environment that are most related to resilience, participants listed many elements, including, robustness of the infrastructure, accessibility of facilities, urban typology and morphology, density, and street layout. It was discussed that other socio-economic issues should also be considered in addition to these physical elements. On the second question, it was emphasized that resilience, adaptation, recovery, and sustainability are interrelated concepts. Any resilience planning approach should pay attention to the interplay between these concepts. Also, potential synergies and trade-offs between these concepts need to be further investigated. Main themes with respect to governance and institutional elements included the necessity for a flexible system that features both bottom-up and top-down approaches, and the need for dealing with the issues of multi-level governance and interlinkages between different entities. Participants also emphasized the significance of transparency and accountability for resilience planning. The issue of trade-offs was again raised. Participants also mentioned the need for context-specific resilience planning and warned against developing general and prescriptive assessment tools.

In response to the last question, various challenges were identified. These include, but are not limited to, access and availability of data needed for resilience assessment, difficulties related to communication and dissemination of results, the boundary issues and multiplicity of factors that should be taken into account in order to define the optimal unit of analysis, and problems related to context-specificity and standardization of the assessment process.

4. CONCLUSION

Resilience is a topic of interest to planners and policy makers as they prepare to meet the consequences of climate change. This article reports on a research project focused on developing criteria and indicators for assessing various aspects of urban resilience. It was discussed that resilience is a multi-faceted concept and any effort to assess it should pay attention to environmental, social, economic, physical, and institutional dimensions. A framework for evaluation of resilience assessment tools was developed that emphasizes the significance of meeting six criteria: comprehensiveness, cross-scale dynamism, temporal dynamism, uncertainties, participation, and action planning. Evaluating selected tools using this framework showed that they are still far from being optimal.

The study also reported on activities that involved participation of researchers from different fields. It was emphasized that resilience assessment should fit the local needs and be capable of informing decision making process. The assessment process should enable a wide range of stakeholders to better understand the complexities of the urban system. This process should be appropriately integrated into the planning system. Such an integration will also be essential for implementation of assessment findings. The SIM activity proved very useful for facilitating discussions between participants with various backgrounds. It provided the participants with the opportunity to share their knowledge and experience.

This study emphasizes that further research is needed to gain better understanding of the synergies and trade-offs between various resilience criteria. It is also necessary to conduct more investigations on the relationship between resilience and related concepts such as vulnerability, mitigation, and sustainability.

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The International Conference on Regional Climate — CORDEX 2016

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ABSTRACT

The project, which facilitated the attendance, interaction, and training of early-career scientists from developing nations in the Asia-Pacific region at the International Conference on Regional Climate – CORDEX 2016 (ICRC-CORDEX 2016) was a great success. The conference, held in Stockholm, Sweden 17-20 May 2016, was jointly organized by the Swedish Meteorological and Hydrological Institution and the World Climate Research Programme (WCRP). About 90 participants, 46 of whom were from the Asia-Pacific region, were supported financially to attend the conference. The project provided Asia-Pacific region scientists with the opportunity to attend the conference and interact with the 300+ scientists from 38 nations. Participation via web streaming and Twitter made it possible for the community at large to participate and interact remotely with the conference and its participants. ICRC-CORDEX 2016 offered a platform for further capacity development, training and knowledge exchange for developing nation scientists together with the opportunity to expand existing or build new, collaborations. The conference emphasized the added value, vulnerability, impact and assessment issues, as well as the use and future of regional climate information and CORDEX results as well as the CORDEX goal to build the capacity of regional climate science in developing and transition nations.

KEYWORDS

Added Value, CORDEX, Impact and Adaptation, International Conference on Regional Climate, Vulnerability

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1. INTRODUCTION

1.1. CORDEX Background

Policy and decision makers need information about climate, climate change and impact and vulnerability assessments at the right scales and communicated in an understandable way to ensure that the knowledge is used effectively for adaptation, mitigation and risk management. The understanding of the response of regional and local climate systems to global climate and the influence of the regional and local systems on the global system is the focus of the Coordinated Regional Climate Downscaling Experiment (CORDEX) community. To predict future changes and analyze past changes and trends, earth-system/climate system models are primary tools. Since global scale models are too coarse to resolve

HIGHLIGHTS

- APN-funded early-career scientists were active participants at the conference
- CORDEX-2016 supported APN goals of enhancing regional cooperation and capacity.
- CORDEX-2016 promoted APN cooperation with other global change and networks.
- CORDEX is substantively advancing climate science for societal needs.

the questions that decision makers encounter daily, advanced downscaling methods are required to translate this coarse global scale information into finer and more adapted regional and local information.

The World Climate Research Programme (WCRP) initiated the worldwide effort, CORDEX, in 2009 to address these issues. CORDEX compliments the corresponding CMIP global scale effort that aims at supporting climate assessments such as those undertaken by IPCC, and advancing global climate simulations.

1.2. ICRC-CORDEX 2016

The International Conference on Regional Climate–CORDEX 2016, held in Stockholm, Sweden 17-20 May 2016, was jointly organized by the Swedish Meteorological and Hydrological Institution (SMHI) and the World Climate Research Programme (WCRP), and attracted over 300 participants from 38 countries. The attendance of about 90 participants was made possible through the financial support from conference sponsors such as APN. For the community at large, remote participation and interaction with the conference and its audience were made possible via web streaming. Twitter question and answer sessions were also available.

The conference offered a platform for scientists, policymakers and the full spectrum of potential end-users of climate information from around the world to interact with the CORDEX research communities from all continents and thus to discuss and develop research on high resolution climate information and its applications to vulnerability, impacts and adaptation (VIA) at the appropriate regional and local scales. It laid the ground for enhanced cooperation and exchange. The participation of early-career scientists from around the world and particularly from developing nations is key to the future success of fostering capacity development, training and knowledge exchange and offering an opportunity to expand or build new collaborations.

2. METHODOLOGY

WCRP, SMHI and CORDEX continuously work with capacity building on multiple scales and are engaged in training the next generation of climate experts. For this reason, the conference had a special focus on the active participation of students and early-career scientists, many of whom are active in regions highly vulnerable to

CORDEX2016 GROUP photo

climate change and variability.

To ensure worldwide representation in this major international climate conference, much effort was put into fundraising for travel support. WCRP, SMHI, APN and other conference sponsors joined their efforts in providing support for aspiring early-career scientists and students to attend the conference, which served as a forum for them to initiate new partnerships in their research/education and to gain insight into the challenges of regional climate science and applications on multiple scales, and gain perspective on policy-making implications.

Grant funds were assigned based on financial need, scientific background and scientific quality/relevance/impact of submitted abstracts. Priority was given primarily to early-career scientists, post-graduate students and researchers who received their highest degree in 2011 or later, and scientists from emerging and developing economies. The second priority was given to students pursuing their graduate studies (MSc, PhD).

About 120 applications were received, 46 of which were from the Asia-Pacific region. A review process to evaluate these applications was carried out by a panel of experts representing the CORDEX domains and areas of expertise within the CORDEX community. From the total pool of applicants, the evaluation panel identified 90 eligible applications. Thirty-five of the selected recipients were from the Asia-Pacific region and fourteen were supported directly with the grant from APN.

As part of the conference activities, a poster presentation competition was organized for students and early-career scientists. Scientific content and presentation skills of authors/speakers provided the basis for judgment. A group of independent judges chosen from the conference participants and with the appropriate scientific expertise performed the evaluation. The best posters were identified and recognized at the final summary plenary session. The three award winners out of the 48 that entered the competition received a "Best Poster Award" certificate and a complimentary handmade glass bowl.

> *"During my poster presentation, I got an opportunity to seek suggestions on improvement of my work design as well as through discussions, exchange knowledge and ideas to design further part of my work."*
>
> — Anubhav Choudhary, participant

> *"I got the chance to establish a network with some experts and institutions which are really [renowned] and inspiring."*
>
> — Jeeban Panthi, participant

> *The conference shall remain special for me as a means for gaining new skills and a great exposure to the international community.*
>
> — Mohit Prakash Mohanty, participant

RESULTS AND DISCUSSION

The conference brought together the international community of regional climate scientists and stakeholders with a particular emphasis on issues of added value, vulnerability, impact and assessment and the current and future use of regional climate information and CORDEX results. The first day featured an Opening Session with the participation of Jan Olsson, the Swedish Environment Ambassador, where a general discussion on challenges related to climate and climate change was discussed. In the following Plenary Session on CORDEX achievements and lessons learned, the future of CORDEX was the main issue. Two of the speakers were IPCC WGI and WGII co-chairs, who talked about IPCC needs and the best use of CORDEX. Distillation of climate information and how to communicate tailored messages at appropriate scales to users was a recurring theme during the entire conference period.

The following days were organized into four thematic parallel sessions: benefits of downscaling, includ-

ing added value and distillation issues; frontier downscaling tools, including human-climate interactions and empirical-statistical downscaling; impacts and applications, including extremes, coupled systems and the path from observations to models to applications; and domain-specific and cross-domain issues.

The final day started with the CORDEX co-chairs William Gutowski and Filippo Giorgi summarizing the status of CORDEX. There are several areas of progress: the CORDEX community worldwide continues to advance scientific understanding of regional climate and regional downscaling; the IPCC has a growing demand for information for regions; the interface between regional climate science and climate services needs further exploration for optimum use of climate research and experience; the added value of regional downscaling has been demonstrated and needs to be further communicated. As part of this progress, a set of coordinated CORDEX experiments that are expected to fill gaps and inhomogeneities within the CORDEX framework are being planned as a basis for further CORDEX work and as an input to the 6th assessment report of the IPCC.

Some issues to address within regional climate research/modelling also emerged. These include a shortage of observations and risk analyses; the benefits of higher resolution versus computational costs; how to coordinate modelling/modellers; the potential loss of information when averaging over ensembles of simulations, which smooths results; the distillation of climate information from data; and interaction and communication with users and stakeholders. Although CORDEX has contributed vastly to the development and production of regional climate data and information, there are still gaps in regional climate downscaling -both knowledge gaps and coverage gaps. To refine and add further to existing information, further development of models, infrastructure, tools and knowledge exchange are needed. The demand for uncertainty estimates, training and capacity building and more tailored information is continuously increasing. These developments call for more interaction with users. Lurking behind these issues are overarching questions such as: What are the limits of CORDEX as a science program? And when does CORDEX hand off its data and climate information to climate services organizations?

This four-day conference clearly demonstrated, through the broad international presence of speakers and poster presenters, the vast achievements of CORDEX and its relevance to VIA communities. CORDEX is a global framework, where scientists around the world cooperate to advance and coordinate climate science and application of regional climate downscaling. This has led to common protocols in the development of both high-resolution Regional Climate Model (RCM) and Empirical-Statistical Downscaling (ESD) projections, the intercomparison of these projections, and the development of accessible archives of the results.

Conference oral presentations, photos, and videos are accessible from the conference webpage. All plenary sessions were broadcast live via web-streaming, allowing those unable to attend the conference to remotely follow the presentations and discussions. A Twitter account was set up to allow remote questions to be forwarded to the speakers and audience in real-time. Poster sessions during two of the science days facilitated interaction amongst the participants, especially between students, early-career scientists (ECS) and senior researchers.

The programme also featured a special CORDEX-Asia and Australasia session "Regional monsoon hydrological cycle over Asia and Australasia", chaired by J. Sanjay, F. Tangang and J. Evans.

A special event for students and ECS' was organized to promote networking and mentoring for those beginning a career in regional climate research. The focus of this event was on science communication–or, as Asher Minns expressed it, "How you are heard instead of what you are saying". The students, ECS' and senior participants had the opportunity to actively participate and share thoughts and ideas and were invited to discuss and try to explain to their neighbours what their research is about in a simple and non-technical way. After the initial presentation and discussion, four early career scientists presented their experiences of science communication and gave suggestions on how to improve communication. Finally, a discussion on communication-related topics, including miscommunication and ECS communication opportunities followed.

The ECS' funded by APN participated actively at the ICRC-CORDEX conference during the poster sessions, oral presentations and at the early-career scientist side-event. The poster sessions provided a great opportunity for ECS' to showcase and discuss their own research and acquire new ideas, through engagement with other participants.

A few APN-funded early-career scientists were provided with the opportunity to give an oral presentation during parallel and plenary sessions. The conference also offered early-career scientists an opportunity to talk with their peers and senior scientists, resulting in a great expansion of their network internationally.

4. CONCLUSION

Our firm belief and conviction is that the conference was a big success in achieving the objectives to promote the CORDEX vision to advance and coordinate the science

and application of regional climate downscaling as well as the specific conference objectives. For instance, conference activities included demonstrating and sharing tools, knowledge, and methods for capacity development, sharing best practices and fostering discussions on communication with users and stakeholders. The conference also showcased high-resolution climate information and its applications to vulnerability, impacts, and adaptation by the full spectrum of potential end users of regional climate information. All this would not have been possible without the financial support from several contributors, among them APN. The conference also had good international visibility and, as witnessed by many participants, met well the goals of networking and research capacity development in all domains.

In addition to the students and early career scientists sponsored by APN, WCRP and SMHI sponsored a number of senior scientists from the Asia-Pacific region who greatly contributed to the success of the conference. Scientists and experts from the Asia-Pacific region gave oral presentations, displayed posters and participated in side events and workshops.

The breadth and depth of oral and poster presentations illustrated the relevance of and need for CORDEX on the climate change agenda. CORDEX contributions to impacts, vulnerability and adaptation applications in areas such as the WCRP Grand Challenges, where, for instance, the Food Basket regions where pointed out, are increasingly demanded as well as direct input to IPCC assessments and special reports.

The CORDEX scientific challenges with the aim to target specific regional fine-scale features will act as guidance for the next CORDEX phase. The statistical downscaling also needs to be more visible under CORDEX and integration of ESD groups has been initiated. As a good example of stimulating ESD activities, the CORDEX-Asia ESD group was established in November 2016 during the 4th workshop on the Southeast Asia Regional Climate Downscaling (SEACLID).

The sharing of information from CORDEX is developing and hopefully, in the future, all will be available on the common platform ESGF.

CORDEX Coordinated Output for Regional Evaluations (CORE) program's design and implementation will be a main task in the coming years. The CORE program would engage a succinctly structured core set of RCMs to downscale a core set of GCMs for each CORDEX domain and for a core set of scenarios. In the future, this could be incrementally enlarged with further models and simulations. The CORE program could potentially produce an atlas-like product that could be useful in many areas, such as IPCC assessments.

In summary this project contributed well to the APN goals to (a) support regional cooperation in global change research on issues particularly relevant to the region; (b) enhance capabilities to participate in global change and sustainability research; (c) support science-based decision-making; (d) strengthen appropriate interactions among scientists and policymakers; and (e) provide scientific input to policy decision-making and scientific knowledge to civil society and the public. More broadly, CORDEX-2016 supported the APN goal to cooperate with other global change and sustainability networks and organizations.

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A final word of gratitude goes to the CORDEX community and all of the participants, who made this conference an enjoyable and memorable event.

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Barriers, needs and potential solutions to reducing vulnerability to global environment change for least developed countries in the Asia-Pacific Region

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ABSTRACT

Least developed countries (LDCs) face a myriad of challenges, such as extreme poverty and immense pressure on natural resources that increase vulnerability to all forms of hazards. A synthesis on Global Environmental Change (GEC) and Sustainable Development in LDCs conducted in 12 Asia Pacific LDCs, built capacity and facilitated the integration of cross-scale information from local to international levels, to produce comprehensive outputs for policy needs. The aim was to synthesize material on major climate-related hazards and disasters and environmental challenges facing these LDCs, key barriers to reducing disasters, and identify underlying causes of such barriers while highlighting potential contribution of traditional locally based practices to reducing vulnerability. The synthesis benefitted from documented historical data, local experience, and a systematic review of grey and scientific literature. Results point to increased frequency and intensity of climate extremes taking a toll on lives and property and that, coastal zone and marine ecosystems are poorly managed and threatened by climate change. Key barriers to reducing disaster risk include governance, technical, financial, cognitive and cultural factors. Indigenous knowledge systems and local experience have the potential to enhance coping mechanisms where integrated into policy frameworks. Innovative, locally based mechanisms could assist LDCs in harnessing this potential.

KEYWORDS

Asia-Pacific least developed countries, Capacity building, Climate extremes, Global environmental change, Indigenous knowledge, Marine and coastal zone management

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1. INTRODUCTION

The changing global environment is impacting sustainable development throughout the globe, with some of the worst impacts on LDCs. Of all the countries in the world, LDCs have the lowest Human Development Index ratings (UNDP, 2015). Several international frameworks have recognized the need for special treatment of LDCs, for example, the 2015 United Nations Framework Convention on Climate Change (UNFCCC) Paris Agreement and the Sendai Framework for Disaster Risk Reduction 2015-2030 (UN, 2015a; UNISDR, 2015). However, this recognition has not reduced the significant capacity constraints that result in acute susceptibility to disasters in these countries (Dube & Sivakumar, 2015; UN, 2015b). Although vast information on global environmental change is generated at regional and international levels, policymakers in LDCs continue to rely on scanty and incomplete information, partly because available infor-

mation lacks immediate local context for an effective application (Seitzinger et al., 2015).

The objective of this LDCs study was to synthesize material on major climate-related hazards and disasters and environmental challenges facing the Asia Pacific LDCs, key barriers to reducing climate disasters, and identify underlying causes of such barriers while highlighting potential contribution of traditional locally based practices to reducing vulnerability. In doing so the synthesis also sought to build capacity among scientists and policymakers in LDCs and facilitate the integration of local information with relevant GEC science outputs generated by various international organizations, to produce updated and consolidated outputs that can better address the challenges faced by LDCs. This study was conducted as part of the International Geosphere-Biosphere Programme (IGBP) second major international synthesis of key policy-relevant areas within GEC research from which a theme on GEC and Sustainable Development: Needs of LDCs was selected with a focus on the Asia Pacific (APAC) LDCs (Seitzinger et al., 2015).

1.1. Asia Pacific LDCs

There are 14 APAC LDCs, nine in Asia and five in the Pacific; among these are Small Island Developing States (SIDS). A significant proportion of APAC LDCs population live in degraded areas, for example, up to 39.3% in Cambodia in 2010, and under severe multidimensional poverty, e.g., 21% in Bangladesh for the 2005-2014 period, which exacerbates vulnerability (UNDP, 2015). In general APAC LDCs lie along zones of potent hydro-meteorological hazards that have in recent years been enhanced by climate change (Dastagir, 2015). Together with high population growth, poor planning and inefficient management of resources, these events give rise to frequent disasters that have a potential for serious impacts on communities (IPCC, 2012). The APAC region accounted for 40% of all recorded global disasters from 2005 to 2014 (UN, 2016). APAC LDCs suffer high exposure to hazards and elevated risk from disasters; for example, Vanuatu, Bangladesh, Solomon Islands and Cambodia are among the top 15 most exposed countries worldwide (UNESCAP, 2015). Despite their vulnerability, APC LDCs have a great potential wealth of indigenous knowledge that has not been fully tapped to contribute towards addressing the vulnerability (Dewan, 2015; Basak et al, 2015; Rahman & Rahman, 2015a; Jahan et al, 2017).

2. METHODOLOGY

The synthesis commenced in 2009 under the guidance of IGBP and targeted LDCs scientists through a wide consultative process within the IGBP community, its partners, and other regional and international environmental research initiatives. This culminated in a preliminary set of focus areas and a planning workshop in September 2010 from which the synthesis focus areas and participants were finalized and synthesis methodologies established.

HIGHLIGHTS

- Asian LDCs suffer high exposure to hazards and elevated risk from disasters.
- Environmental changes impair key resources such as coastal and marine ecosystems.
- Weak governance systems and lack of focus on adaptive capacity needs are barriers.
- Indigenous adaptation mechanisms are potential solutions being lost or overlooked.
- Asian LDCs lack capacity for generating long term, up to date and locally relevant scientific information to guide policy.

The study covered drought, floods, coastal zone management and the marine environment, with a focus on barriers to reducing disaster risks and the potential of indigenous/local knowledge to minimize vulnerability. It extended over Bangladesh, Nepal, Bhutan, Afghanistan, Yemen, Myanmar, Cambodia, Lao PDR, Kiribati, Vanuatu, Solomon Islands and Samoa, as determined by the participating scientists who were at liberty to collaborate beyond APAC LDCs to enhance networking and build capacity.

The synthesis relied on building on existing knowledge and skills of LDCs scientists, shared experience, learning by doing, and training, for instance, on producing peer-reviewed publications (Dube & Sivakumar, 2015). The primary data source was a literature review that assessed published and grey literature of theoretical and case studies, policy reviews and documented adaptation practices with some material from popular media. The document searches were conducted using various search strings relying on academic databases such as ISI Web of Knowledge, Elsevier, EBSCO, and Wiley. Whilst grey literature utilized Google Scholar, Google, ProQuest and also targeted websites e.g. specific websites related to LDC- SIDS and included consultation with experts (Kuruppu, & Willie, 2015). In addition, direct linkages with the science community in the region and beyond through institutional visits, workshops, and seminars were made in different countries (IGBP, 2015). Informal meetings with various stakeholders including policy makers and selected community leaders and field observations were also used to gather data (Miah, 2015; Miyan, 2015). The data sourcing and communication techniques used facilitated cross-validation of sourced information and allowed synthesizing and integrating information

established under different styles of knowledge creation, e.g., indigenous knowledge from a community, conventional scientific knowledge, and knowledge from practitioners. Details of protocols used to gather information are outlined in ten papers published in a special issue of the Journal of Weather and Climate Extremes volume 7, March 2015.

3. RESULTS AND DISCUSSION

The result of the efforts described in section 2 was interdisciplinary evidence produced from the 12 LDCs across geographic and temporal scales and of a cross-sectoral nature. A special issue of the journal Weather and Climate Extremes (Dube & Sivakumar, 2015) and policy briefs in English and in one of the Bangladesh local languages were produced, and an information dissemination workshop communicated the final results to varied stakeholders (SADMC, 2015; SADMC & IUBAT, 2015). These activities also served as a capacity-building process and formed a foundation for sustainability beyond the project. Key scientific findings of the synthesis established from assessing information from 12 LDCs follow below.

3.1. Barriers to Reducing Climate-Enhanced Disaster Risk

The results on barriers to reducing climate-enhanced disaster risk showed that the most common barrier was governance, followed by technical, cognitive and cultural, and financial issues (Table 1; Kuruppu & Willie, 2015). These barriers are products of interrelated processes and therefore solutions to these will be interlinked. The section below expands on these barriers and others under different themes, highlights needs and elucidates potential solutions.

3.2. Drought

Nearly all APAC LDCs experience frequent moderate-to-severe droughts of all types. For example, out of the 34 provinces in Afghanistan, 14 experienced drought conditions in 2011 which affected nearly 2.6 million people (Huffington Post, 2011). About 80% of APAC LDCs population depend on traditional agriculture. However, production of staples such as rice and wheat could decline by 8% and 32% respectively by 2050 due to drought (Miyan, 2015). Drought intensity is increasing, but the capacity to adapt is limited. Early awareness could reduce impacts, but drought forecasting and early warning are in their infancy because of lack of expertise and technology, as well as a scientific orientation that disregards

TABLE 1. Barriers to reducing climate-enhanced disaster risk (Kuruppu & Willie, 2015)

Barrier	Description of barriers
Governance	Governance from the local to the international level: i. Poor coordination between the tiers of government constrains engagement between national adaptation efforts and Local Government limiting the role of communities. This was most common with externally driven adaptation brokered by regional agencies with external donors on behalf of national governments. Disaster risk reduction initiatives need to focus on empowering local leaders through a participatory process. ii. Limited capacity to govern and fully engage international forums. ii. Limited capacity to govern and fully engage international forums.
Technical	Limited data available on climate and other biophysical resources due to lacking capacity to generate and manage this data.
Cognitive-cultural	Failure to incorporate community traditional knowledge, rituals, cultural values and norms and religious believes. Several studies reported declining trend in traditional knowledge as a barrier to adaptive capacity.
Financial	International adaptation funding for LDCs is inadequate, unpredictable, complex to access and administer and inequitable. Limited in-country capacity to access and manage funds, e.g., in rural areas. Some LDCs SIDS, e.g., Tuvalu, found it difficult to compete with larger LDCs in accessing funding. A common theme was the inequalities in power relations between LDCs and donor countries. Capacity-building efforts are needed to address this persistent barrier.
Other	The vulnerability of the major natural resources on which livelihoods were dependent, e.g., water, agriculture, biodiversity, fisheries and coastal zones.

TABLE 2. Examples of potential traditional practices established mostly for Bangladesh for integrating with conventional approaches to reduce disaster risk in APAC LDCs (Basak, Basak, & Rahman, 2015; Dewan, 2015; IGBP, 2015; Miyan, 2015; Rahman & Rahman, 2015a,b; SADMC, 2015; SADMC & IUBAT, 2015; Jahan et al, 2017).

Traditional and/or local practices	Description potential traditional/local practices
Forecasting heavy storms	Assessed clouds, intensity of thunderstorm and wind, extent of rainfall in upper catchments, position of stars, temperature and also behaviour of insects, birds and animals.
Household level pre-flood preparations	i. Built on elevated ground with multi-purpose ponds around the house that act as sources of portable water and for fish and aquaculture. ii. Used protective windbreaks plants, e.g., coconut, areca nut and fishtail palm. However, traditional mud houses are vulnerable to destruction by floods. iii. Food reserves, e.g., puff rice (Muri) and flat rice (Chira), for period of floods and also had measures for livestock.
Household level response to floods	i. "Vela" – a float used for transport during floods. ii. Shelter from floods included "Matcha" – elevated surface made out of bamboo or woods – or relied on "Vela" to live on until safe. iii. Medicinal e.g.s: green coconut water used to rehydrate the victims of waterborne diseases like diarrhoea, cholera and dysentery.
Traditional Farming practices	i. Adjusted crops and cropping with climate to reduce drought impacts. ii. Practices such as permaculture, mulching, and traditional harrowing followed by powdering the soil to protect evaporation deserve to be documented and shared for wider practice. iii. Rice known as "Jola Rice" has proved to be resilient to even severe floods.
Water conservation	i. Water reserves from rain water harvesting reduce heavy reliance on underground water, which lowered the groundwater table and increased the risk of arsenic contamination. Other water conservation approaches include traditional flood-plain management.
Traditional Farming practices	i. Adjusted crops and cropping with climate to reduce drought impacts. ii. Practices such as permaculture, mulching, and traditional harrowing followed by powdering the soil to protect evaporation deserve to be documented and shared for wider practice. iii. Rice known as "Jola Rice" has proved to be resilient to even severe floods.

indigenous knowledge systems (Table 1 and 2). Climate modelling to better understand the Asian Monsoon in light of climate change and for different agro-ecological zones could support region-specific drought adaptation plans (Dastagir, 2015). Inter-country water protocols could help to reduce human-induced drought conditions. Measures such as the use of drought-resistant crop varieties, water-efficient irrigation systems, switching to dry-season cropping or in extreme cases tree crops, all need to be considered (Karim & Rahman, 2015). Indigenous practices could fill some gaps, for instance in Vanuatu and Samoa traditional practices such as openly sharing crop varieties and maintaining the genetic material in reservoirs in farmers' fields help enhance adaptation to drought. While in the Solomon Islands, erosion of traditional knowledge precluded the passing of this knowledge to the younger generations and consequently, increase in pests and disease of food crops was reported and this has led to heavy reliance on imported, processed foods (Kuruppu & Willie, 2015). Overall, scientific information that is integrated with indigenous and local knowledge for longer timeframes is required for better responses to drought (Miyan, 2015; SADMC & IUBAT, 2015).

3.3. Floods

All the APAC LDCs are affected by floods and historical data show that the scale, intensity, and duration of floods have increased. Bangladesh is a low-lying delta; combined with poor land use management, the

result is that 80% of the country is affected by floods, causing millions to suffer every year, particularly the most vulnerable: nearly 32% of the total population of Bangladesh lives in slums (Dewan, 2015). Communities in APAC LDCs have been coping with flooding by using inherited wisdom and multi-generational practices that, for several reasons, including policies that downplay traditional knowledge systems, are rapidly being lost (Table 2).

3.4. Coastal Zone and Marine Environment

Government and NGOs in Bangladesh and Nepal have initiated a number of activities to minimize the adverse effects of floods, including flood forecasting and building awareness at the community level, training for preparedness and flood response, and assisting with emergency relief and post-flood rehabilitation. However, more regional forecasts are required and mandatory environmental impact assessments prior to construction of structures such as canals and water reservoirs, roads, and embankments could preserve natural water flows and reduce flood damage. The use of plants for flood control is constrained by reliance on non-adaptive exotic varieties (Table 2). Flood damage can be reduced by choosing plants according to the adaptation requirements of the species, corresponding to specific climate and physiographic conditions (Basak et.al. 2015).

An analysis of coastal infrastructure in the Bay of Bengal region, where over 50 million people reside, points to increased long-term waterlogging due to a combination of factors, including sea-level rise, increased tidal surges, cyclones, flooding, and erosion, which are linked to climate change and also poor coastal zone management (Vivekanandan et al., 2016). Withdrawal of water in upstream areas plus land degradation result in heavy siltation in the estuaries of the major rivers, the Ganges, Brahmaputra, and Meghna, negatively affecting fish productivity (Miah, 2015; Jahan et al., 2017). Poor maintenance and inadequate management of the polders have also contributed to internal drainage congestion and heavy external siltation. Further, investments in flood control in the form of embankments, roads, and highways block traditional navigation routes and water flows, and also have negative impacts on coastal zones. This is also the case with thick wind barriers that have been mounted along the coast, increasing the wind-speed and damaging the structures (Rahman and Rahman 2015a).

Although increased awareness has significantly reduced the death tolls during extreme events, practices noted above result from policies that are poorly informed by science and are not rooted in on-the-ground realities and lack community ownership (Dutta et al., 2016; Table 2). In this regard, the Forest Department in Bangladesh is considering a program of participatory mangrove plantation involving coastal communities.

Overall an integrated coastal policy involving the areas of rainwater harvesting, sanitation, controlled waterlogging, arsenic contamination, salinity, landslides, and erosion could contribute to the development of "smart" coastal cities that are more resilient to climate change-related hazards (Bajracharya et al., 2014; Rahman & Rahman, 2015b).

3.4.1. Fisheries and the Marine Environment

Marine fisheries provide livelihoods to millions of people in the Bay of Bengal, accounting for about 4.4% and 9.1% of the GDP in Bangladesh and Myanmar respectively (BOBLME, 2014). The Hilsa fishery is estimated to be worth over $USD 2 billion for Bangladesh, India, and Myanmar (BOBLME, 2014). But the Catch per Unit Effort shows a decline of up to 50% in terms of fish available (Miah, 2015; Dutta et al., 2016; Jahan et al, 2017). This is due to several factors, including changes in the marine environment, such as warming, shifts in salinity and pH plus the wider problem of ocean acidification, sea level rise, and changing currents, upwelling, and water mass movement, occurring together with poor harvesting methods plus overexploitation and the ever-increasing water pollution (Miah, 2015; SADMC, 2015). Change of migration patterns of spawning, growth, and production results in catch trends shifting to deep seas, but the local industry is ill-equipped for deep-water fishing (IGBP, 2015; Vivekanandan et al., 2016). Better management and environment-friendly practices could significantly reduce pollution (Habib et al., 2014; FAO, 2016).

Bangladesh and Myanmar account for 50–60 % and 20–25 % of the global catch respectively for the most harvested species Hilsa, (Jahan et al, 2017). Mechanisms to reduce pressure on Hilsa could include harvesting nonconventional seafood, e.g., seaweed and other fish species, but these need to be investigated (Miah, 2015). In Bangladesh, the government has created policy initiatives such as the Hilsa Development Trust Fund for sustainable production of Hilsa, but implementation remains a challenge. In Myanmar, the government has pledged through international conventions to put 10% of its marine areas under protection by 2020, but this might be too little too late. Because there are many interlinkages to the fishery, an in-country multi-agency structure is needed to monitor the implementation of the national Hilsa management plans (BOBLME, 2014; Miah, 2015; SADMC, 2015; FAO, 2016).

4. CONCLUSION

Governments and the international community are making efforts to reduce disaster risk in LDCs. However, country-level studies on extreme events for forecasting, early warning, and mitigation processes are required. Several barriers to adaptation that have a bearing on both national and international policy frameworks were identified. One major barrier was weak governance resulting in inadequate engagement of local governments and communities due partly to modalities of external funding and uninformed policies (Habib et al., 2014; Kuruppu, & Willie, 2015; Dutta et al., 2016). This results in failure to adequately incorporate cultural knowledge and local practices in plans to reduce disaster risk (Jahan et al, 2017).

Adaptation and disaster risk reduction need to be anchored on local conditions, experiences and traditional knowledge about extreme events such as drought and floods as well as coastal zone management and the marine environment (Jahan et al, 2017). To this end, it was demonstrated that most APAC LDCs have very strong local/traditional knowledge to combat disasters and manage environmental resources that are yet to be tapped (Table 2). By highlighting this, the synthesis has opened up scope for new research, e.g., regarding integration of traditional and conventional practices for long-term solutions to environmental change and how these can inform broader processes such as the 2030 Agenda for Sustainable Development. External support to supplement the limited financial and technical capabilities of LDCs will be valuable in advancing the noted research avenues. Moreover, the synthesis work also highlighted the pertinence for greater engagement and long-term support in building the capacities of local APAC LDCs scientists to lead and co-produce locally relevant information to support policy.

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Coastal forest management in the face of global change: Experience of four Asian countries

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ABSTRACT

The cross-country study examined community-based coastal forest management and policies on how integrating coastal forest management with human settlement planning and local livelihoods needs can strengthen community resilience towards climate change impacts confounded with other global changes like land use-land cover change, biological invasion and loss of biodiversity and economic globalization and planetary changes like tsunami. The study sites, the Philippines, Myanmar, India and Japan are located in coastal areas vulnerable to typhoons in the Northwest Pacific or cyclones in the North Indian Ocean. Unlike a seawall which only has a protective function, the study found that in all study sites coastal forests not only protect local communities from floods, tides and storms but also provide a range of ecosystem services serving the interests of both local and global communities. It is also found that in all the study sites: 1) Forests have been long conserved and created around individual houses and the entire village as well for livelihood security; 2) Apart from embracing the protective function of forests, local communities have developed house architecture providing some protection from flooding and windstorm; 3) Forest belt and embankment are often integrated to check windstorms and flooding. The study recommends that coastal forest policymaking must take into account indigenous knowledge and local concerns along with scientific knowledge and global concerns for coastal forest management.

KEYWORDS

Coastal forest management, Disaster, Indigenous knowledge, Mitigation

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1. INTRODUCTION

Coasts are home to a large proportion of the global population, in particular in Asia. Coasts are experiencing the adverse consequences of hazards related to climate and sea level, and the impact of climate change is confounded with other global changes like land use-land cover change, biological invasion and loss of biodiversity and economic globalization and planetary changes like tsunamis. The tsunami-induced disasters following the earthquake of magnitude 9.0 in North-eastern Japan

HIGHLIGHTS

- Establishment of forests around houses and villages for protection and livelihoods
- Site-appropriate settlement planning in the face of coastal flooding and windstorm
- Integration of global and local benefits into coastal forest policymaking

on 11 March 2011 alerted the world of the inadequacy of conventional infrastructure (such as cement sea-walls) alone in protecting human life and property from natural disasters. Instead, "green infrastructure" of coastal forests, such as mangroves, beech forests, and plantations, should be included as part of an integrated approach to mitigate tsunami, storm surge, and climate change impacts induced disasters around coasts. Moreover, an integrated approach also offers a scope of synergizing local socio-economic and global environmental dimensions of sustainable development. Despite these benefits, in theory, there is little understanding about how the natural sub-system of forests and the human sub-system of settlement and infrastructure interact and how can they be integrated to adapt to climate change, in particular, from a cross-country comparative perspective (FAO, 2007; Alongi, 2008). Development of forest management systems complementing other ways of enhancing resilience such as sustainable agriculture, aquaculture, and fishery. First, the world after 1980 has lost mangrove forest, the keystone coastal forests from the point of biodiversity and ecosystem services, at a rate of 20 to 35% higher than other unique natural heritage of the planet like coral reef and tropical rainforests (FAO 2007) and >75% of global mangrove area is covered in just 15 countries (Giri et al., 2011). Second, mangroves are naturally endowed with a significant potential of climate change mitigation by virtue of their ability to keep pace with sea level rise (Alongi, 2008) and conversion of low biomass/carbon system like salt marshes to mangrove forests sequestering carbon at a rate as high as 1.74 Mg C/ha/year in recent decades (Alongi, 2012; Saintilan et al., 2014). In addition, mangrove forests provide regulating and supporting services, such as shoreline stabilization, coastal protection, water filtration and detoxification/pollution control, and habitat to unique biodiversity including numerous nutritious food and medicinal species. Third, the landless and poorest of the poor people in developing countries who depend on mangrove ecosystems for their livelihoods are often the most vulnerable communities to extreme events like tsunami, typhoons, and floods. Fourth, except for a few segments (Spalding et al. 2010), systematic management plans of coastal vegetation are lacking, and resource uses and regeneration practices guided by the indigenous knowledge and social network are still not intensively analyzed and documented

This article provides a summary of a cross-country (Philippines, Myanmar, India, and Japan) initiative aimed to (i) identify best practices of coastal forest management, integrating with planning of human settlements, agriculture, local livelihoods and climate change mitigation/adaptation, including indigenous knowledge; (ii) valuate barriers for up-scaling best practices, and effectiveness of coastal forest management policy through a bottom-up process; and (iii)recommend integrated approaches to harnessing forest regulating services in the planning of human settlements, agriculture and local livelihoods in coastal areas.

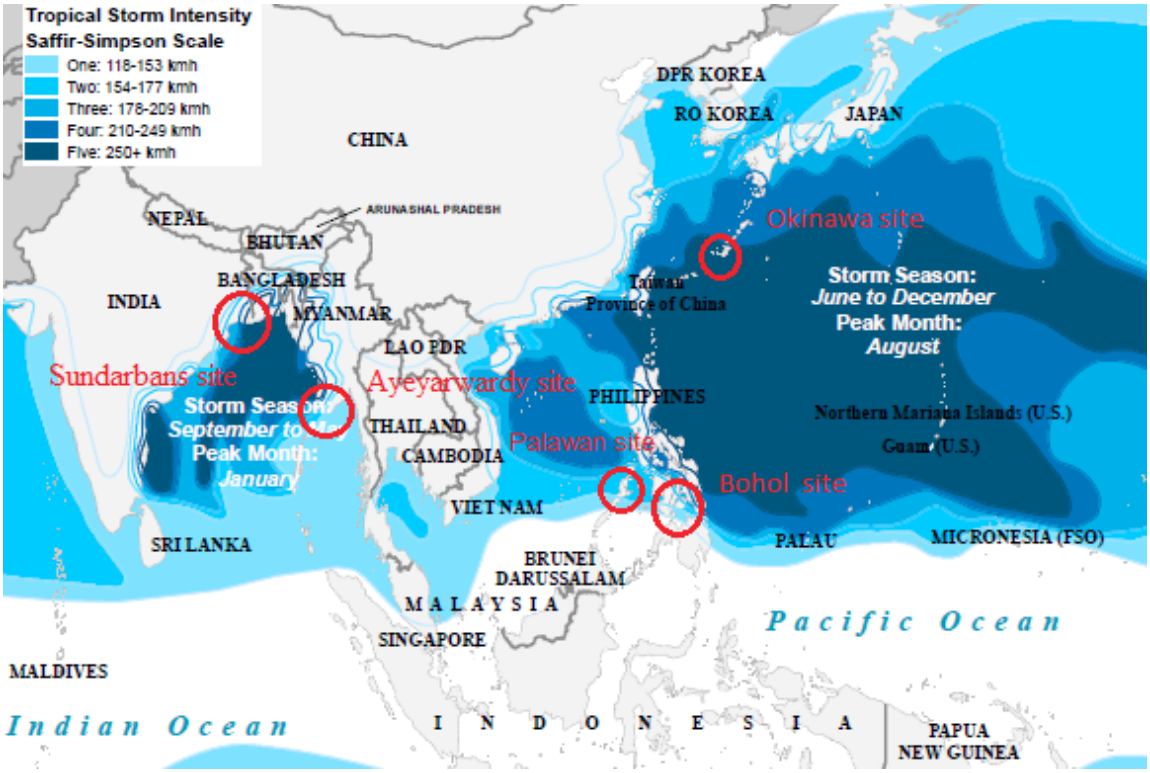

FIGURE 1 Location map of study sites based on the OCHA Relief Web map of Tropical Storm Risk in Asia-Pacific.

2. METHODOLOGY

2.1. Study Sites

In order to compare lessons and experiences in management of coastal forests, especially mangrove forests, across Asia, the project selected two clusters of coastal communities vulnerable to typhoons in the Northwest Pacific, one each in the Philippines (Bohol and Palawan Province) and Japan (Okinawa Prefecture), and one cluster in Myanmar (Ayeyarwady Delta) vulnerable to tropical cyclones in the North Indian Ocean as study sites. The project was also enriched with an associated case study in Sundarbans, India around the Bay of Bengal, also vulnerable to tropical cyclones in the North Indian Ocean. Mangrove forests are dominant in the study sites of the Philippines, Myanmar, and India.

2.2. Study Components and Methods

Community-based assessment of natural resources, management practices, and policy analysis were the key components of the study. The study carried out in 2014–2016 took a cultural landscape/seascape approach to analyze land/resource-use linked differentiation of ecosystems, resource utilization/regeneration mechanisms, spatiotemporal dynamics of resources and livelihood and people's perceptions about climate change/sustainability/policy interventions. Covering three villages for intensive observations, the study comprised three activities: (1) detailed ground survey of biophysical resources and their mapping by integrating information obtained from ground survey, participatory discussions, satellite imagery, available topographic/thematic maps and geographic information system; (2) socio-economic survey through structured questionnaire, open-ended interview, and focused group discussions to elucidate indigenous knowledge, community based management practices and people's perceptions about livelihood, state interventions and environment/development problems; and (3) identification of good land/resource use practices synergizing multiple benefits from coastal cultural landscapes/seascapes (Sein et al, 2015). Through multi-stakeholder consultations and dialogues, the policy analysis reviewed existing policies influencing community-based forest management. This analysis vis-à-vis the findings from the community-based assessments enabled identification of opportunities for better coastal forest management.

3. RESULTS AND DISCUSSION

3.1. Adaptive Management and Best Practices

The community-based assessment of coastal forests found out that local people in all study sites have long made efforts to establish plantation forests and to conserve natural forests around individual houses as well as the entire villages for protection from windstorms due to frequent typhoons or cyclones. Extensive mangroves are conserved and actively planted by villages with support from the government agencies as well as NGOs on the windward side of the coastal villages in the study sites of Myanmar and Philippines to mitigate impacts of the strong southwest monsoon. Many villages maintain man-made and natural mangrove belts at their boundaries facing river and seafront in the study sites of the Ayeyarwady Delta in Myanmar and the Indian region of Sundarban on the Bay of Bengal. Trees are systematically planted and maintained in the form of forest belts at the village boundary since centuries in the study site of Okinawa islands, Japan. The forest belts are much denser

FIGURE 2. Forest belts of Garcinia subelliptica planted around Tarama village, Okinawa, Japan (marked in red circle)

at places facing the coast or the north to cope with frequent and strong winds in Okinawa (Chen, et al 2008).

In addition to the protection forest belts around the village boundary, each household maintains a home garden distinguished by high density of trees (coconut, bamboo, betel nut, mahogany, etc.) forming the top canopy and a range of annual/perennial/seasonal crops in the understory for protection from strong storms and intense sunshine together with production of economic products in the study sites of Myanmar and India. Likewise, Fukugi trees Garcinia subelleptica resistant to windstorm are planted as a forest strip encircling individual houses in Okinawa for protection from windstorms and provide shade (see Figure 2). Protection from the forest strips is often augmented by establishing stone walls close and parallel to them. As a traditional best practice, protection forests are maintained both as family-managed units aiming protection of a given household and as a community-managed unit for protection of the whole village from windstorms in all study sites.

Apart from embracing forests for protection, local communities have designed houses taking into account risks of flooding and windstorm. Building houses on the stilts above normal flood water level is a traditional way of coastal communities in both the Philippines and Myanmar sites to reduce the risk of damage due to tides and frequent flooding of low-lying areas (see Figure 3). From the past few years, the traditional wooden stilts are being increasingly replaced by a concrete structure for its longer life, low maintenance costs and stronger resistance to flooding and windstorm. On the contrary, traditional houses in Okinawa are often built below the ground level in man-made depressions to minimize adverse impacts of windstorms (see Figure 3). Nevertheless, raised houses on stilts in the Ayeyarwady Delta of Myanmar and the Bohol Island of the Philippines is not a feature of Indian region of Sundarbans. Here, in almost all settlements, houses are either far away from the river/seafront (beyond high tide) or by the side of an earthen embankment (opposite side of embankment facing river) lined by bricks and augmented or not by belts/strips of forest plantations. The embankment is high enough to protect from tides and floods but has succumbed at times to extreme flood events.

Sometimes, biological and physical methods are integrated to reduce risks of flooding (see Figure 4). Mangroves (Avicennia spp.: air-drop) are maintained towards riverfront, and Casuarina, Tamarix gallica, and Acacia are planted on the embankment as in the study site of India. Along the coasts of Okinawa, concrete seawall and structures are built to mitigate coast erosion. In the past and even today, monastery serves as cyclone shelters as their stilts are much taller than those of ordinary houses in the study site of Myanmar (See Figure 5). Cyclone shelters of the concrete structure on the tall stilts are also now established in schools. Early warning system is also important for local people to move to cyclone shelters in time when the coastal hazard is forthcoming. Therefore, local communities in study sites integrate both forests and physical structures in the protection of their houses and farms.

The man-made mangrove forests are the source of a range of economic products including fish, molluscs, crabs, honey, fuelwood, timber and thatching material and thus play very important roles in local livelihood in

FIGURE 3. Traditional houses are surrounded by forested home-gardens/strips in study sites of Myanmar and Japan.

FIGURE 4. Forest belt and embankment are often integrated to reduce risk of flooding in the associate study site of Indian Sundarbans.

Myanmar, the Philippines and India in addition to their protection function. Sustainable use of forests is critical for coastal communities in Myanmar, the Philippines, and India. Coastal communities manage natural regeneration of nipa palm yielding high-quality thatching materials and nutritional fruits in the tidal zone and cultivate coconut, areca nut, and many other useful trees in tree-crop mixed home gardens developed on a higher ground beyond the reach of high tide in Ayeyarwady delta of Myanmar. Most home gardens are integrated with fish and crab ponds such that the ponds get enriched with run-off and lateral subsurface flows from the gardens, while irrigation from pond water reduces water and nutrient stress in home gardens. Ongoing efforts of mangrove rehabilitation contribute to both local livelihoods (such as the production of timber and fuelwood, non-timber forest products, and fish, crabs, and molluscs) and coastal protection. On the contrary, the man-made forest belts in Okinawa are mainly created for the protection of houses and farms from strong winds and for cultural values of Fengshui that recognizes a closed landscape as an auspicious one. Nowadays, these traditional man-made forest belts have become attractions for cultural tourism.

3.2. Issues and Options for Coastal Forest Management

Traditional coastal communities evolved livelihood systems that met their subsistence needs by utilizing resources in the sea/river and mangroves in different stages of succession at the sea-land interface. Further, these sea-facing ecosystems with biological and physical modifications are used as a shield to protect crops/livestock husbandry/aquaculture in the inland area from storm surges and flood. Such systems, common across countries, have location specificities and have been impacted in divergent ways by economic globalization, socio-political conditions, technological advancements and global environmental changes; a land/resource use

FIGURE 5. Monastery and school raised on the tall stilts could serve as cyclone shelter to cope with risk of floods in the study site of Myanmar.

or landscape architecture traditionally considered the "best" earlier may not be the best one at present or in future. Thus, as seen in the Okinawa site, expansion of urbanization, industrialization, advanced technologies and outmigration after second world war reduced beach plantations and Garcinia subelleptica groves around individual dwellings led to decline in natural capital (carbon stock and biodiversity) and huge investment of physical and financial capital in modern engineering methods of protection from wind and cool temperatures. Though mere restoration of traditional forest cover may enhance biodiversity and mitigate climate change and enhance local livelihood from income from ecotourism in such unique cultural landscapes, lack of policies and proactive role of local government are the major bottlenecks in inducing such changes even in a developed country like Japan (see Figure 6).

FIGURE 6. Garcinia subelleptica groves/belts are major attractions to tourists but management guidelines have not yet evolved in Okinawa, Japan.

In the Philippines, Tagbanua people utilized only dead trees for charcoal and fuelwood for a belief that healthy mangroves were necessary for sustaining fish production accounting in many locations >80% of direct use value (Carandang et al., 2013). Huge dead wood is available as a result of frequent downing and uprooting following typhoons observed around Palawan and nearby islands ravaged by Typhoon Haiyan, a category 5 storm, November 2013. However, deadwood alone could meet the needs at a time when mangroves were extensive and population pressure was low. This "best practice" in low population- subsistence economy is no longer tenable in the present scenario when natural intact forests have almost vanished, income needs of people have dramatically increased, policy supports more efficient income opportunities from plantations and a higher resilience potential of mosaic of forest, farm and aquatic ecosystems than dependence solely on forest resources is getting more and more acceptance. Thus, leasing degraded state forest land to people in Community Forestry programme and incentives to private companies to extend financial support for plantation since the 1990s is a good practice synergizing local concerns for immediate income and long-term global environmental benefits. However, the outcomes can be further improved by developing silvicultural practices enabling simultaneous enhancement of multiple functions of plantations, demonstrating them and facilitating their widespread adoption. Research is needed to determine sustainable limits of wood removals.

Homegardens in Ayeyarwady Delta of Myanmar and Sundarbans of India exemplify the potential of indigenous knowledge in establishing a land use as productive and rich in species and regulating services as natural forests by identifying micro-sites where salinity and water stagnation are avoided by a combination of physical, biological and ecological techniques. This traditional land use synergizing local livelihood concerns with global biodiversity conservation and climate change mitigation concerns, however, has been stagnant or declining in the absence of policies encouraging indigenous innovations and scientific research complementing/supplementing indigenous knowledge. Unlike widespread occurrence of home gardens, cultivation of Piper betel (betel leaf) is an indigenous innovation confined to only a couple of islands in Sundarbans. Betel cultivation has enhanced both social bonding (linkages within the farming community) and bridging (linkages between farmers and distant traders and consumers) enabling high profits from a perishable commodity produced solely by recycling and managing local resources and ecological processes. The high productive potential of betel garden is maintained by using sediments from fish ponds as manure and irrigating it by the water flushed out from these ponds for high fish production. Exposure to new management and production systems in areas visited primarily for the purpose of trading the local product like

betel resulted in the cultivation of Sesbania rostrata to serve the twin purposes of reducing salinity and nutrient enrichment without any external financial or technical assistance.

People do understand detrimental impacts of over-grazing by livestock and intensive pruning for fuelwood, susceptibility of grazed/trampled/pruned trees to pests and pathogens, encroachments of degraded forests, and deforestation due to shrimp farming but find themselves helpless in restoring degraded lands and sustainable intensification of resource uses in intact forests due lack of required technical knowledge and investment capacity. The system of Regeneration Improvement Felling developed in Myanmar favouring mixed economic species over weedy growth developed for government forests is a good practice of coupling of concerns for income/material benefits among local people and the global concerns for biodiversity conservation and enhancement of regulating service. Such systems have two times higher carbon stocks and plant species diversity than monospecific plantations established after clear felling and hence need to be encouraged through community forestry.

In situations like Sundarbans where deforestation/forest degradation was not so rampant, bonafide residents enjoyed rights of free subsistence uses of forest resources even after the land was taken over by the government in the 1950s and incentives for honey marketing necessitated fostered maintenance of healthy forested landscapes. Government authorities (i) organized groups of local people for honey collection from state forests, (ii) reduced the risks from the tiger by allowing collection only in groups, and (iii) secured income to farmers by procuring the products and then marketing it at no costs to farmers. Nonetheless, attention has not been paid to enhancement and replication of many good traditional practices : (i) integrated management of a highly heterogeneous landscape comprising paddy fields, fish ponds, home gardens, betel gardens and mangroves; (ii) lunar cycle of collection of fish, crabs and shrimp larvae; and (iii) creation of temporary ponds on river bank to collect dead wood/debris from mangrove forests in tidal flows, a labor-intensive but ecologically efficient way of meeting fuel needs. Coexisting with these good practices are unsound practices, like burning faecal pellets of goat, the dung of cattle (in the form of a cake) and coconut shells; the resource can be better used as manure.

Valuation of a species and process depends on the socio-ecological scenarios. Thus, palm Nypa fruiticans is a highly valued species in Myanmar but not in Sundarbans region of India because of better economic development alternatives. As this palm requires open areas for proper growth and reproduction, its high production is possible only at the expense of tree and herbaceous species and thereby reduction in carbon stocks.

3.3. Policy Dimensions

Policies in all the countries changed with changing imperatives of ecological, economic and social development. However, often different issues are dealt by different policy instruments at different times leading to confusions and contradictions. The Philippines government provides many incentives to Community-Based Forest Management (CBFM) but mangrove CBFM participants and other forest developers cannot avail them because of prohibitions enforced on felling through RA 7161 (cutting ban for all mangrove species especially for firewood purpose). It is necessary tore-zone coastal areas for local benefits (wood utilization and tourism) and global benefits (carbon offset and strict protection of biodiversity). Community Forestry Instruction (CFI) in Myanmar are heavily dedicated to technical efficiency and ecological functions of forests leading to neglect of livelihood enhancement function of forests and thereby adoption of unsustainable forestry practices by local people to secure better albeit short-term livelihood. It is urgent to formulate a proper land use plan for the Ayeyawady Delta for continued conversion and degradation of mangroves. Although windbreak function, biodiversity conservation and cultural dimensions of Garcinia subelleptica groves/strips are well recognized in Okinawa, a local conservation ordinance is still not in place to regulate the management, especially cutting of old Garcinia subelleptica trees. Regional recommendations such as greenbelts with a minimum of width of 100 m, but preferably up to 500 m or 1 km at the open coast, and 30-50 m along riverbanks and lagoons, and >10 m on islands, creeks, and channels (Macintosh et al 2002; Ashton et al., 2004) should be analyzed in the local contexts, appropriately modified and adopted. There is a need for harmonizing multiple and divergent dimensions of forests and livelihood in a simplified, unified, clear and holistic national policy and guidelines on coastal zone management.

The study recommends that coastal forest policy-making must take into account indigenous knowledge and local concerns along with scientific knowledge and global concerns for coastal forest management. The globally recognized approach(es) ICZM (Integrated Coastal Zone Management) or ICRM (Integrated Coastal Resources Management) or ICM (Integrated Coastal Management) should be considered and followed.

4. CONCLUSION

Coastal landscapes are undergoing a variety of changes. With enormous variation in environmental and socio-economic conditions and interactions between

forest, farming, aquaculture and sea/river systems, coastal forest management needs to be addressed as an integral component of cultural landscape/seascape rather than as a sectoral and independent activity. Further, forest conservation and restoration should be integrated at a regional scale. A participatory forestry is a good approach but, apart from empowering people by leasing land and granting funds, there is also a need of mobilizing people to apply and enhance indigenous knowledge unlike the present approach of following top-down prescriptions. Unlike a seawall which only has a protective function, coastal forests not only protect local communities from floods, tides, and storms but also provide a wide range of vital ecosystem services for global and local communities. Recognising multiple values of coastal forests, local communities have long conserved and planted forests around their houses and villages. Coastal forest policymaking must take into account local benefits and indigenous practices beyond global benefits and scientific knowledge. It is also necessary to further improve guidelines for rehabilitation and management of coastal forests for a wide range of ecosystem services.

Early, high and secured income from any occupation remains the top priority of people in poor countries. There is a need for setting out long-term participatory research to design management plans harmonizing local concerns for income/livelihood enhancement with global concerns for enhancing/conserving biodiversity and regulating and supporting functions of coastal ecosystems. Apart from participatory research in a given area, regional cooperation on research and capacity building may hasten the process of replication and further improvement of the known good practices within ICZM (Integrated Coastal Zone Management) or ICRM (Integrated Coastal Resources Management) or ICM (Integrated Coastal Management) frameworks.

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Riverine carbon flux from the Red River system (Viet Nam and China): a modelling approach

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ABSTRACT

The Red River (Vietnam and China) is a good example of a large Asian river basin, strongly impacted by climate change and human activities. Previous studies showed the increasing influences of human activities and climate on hydrology and suspended solids transfer of the Red River. In this study, using the Seneque/Rivershtrahler model, carbon transfer and outgassing from this river under natural and human pressures were calculated for the present and prospective scenarios for the 2050s. The results showed that the model successfully simulated seasonal and temporal variations of carbon concentrations of river. A riverine organic carbon (OC) export of 327 GgCyr-1 for the year 2014 was calculated for the Red River at Son Tay site. Due to the high allochthonous OC inputs from both point and non-point sources, the Red River system is a heterotrophically polluted system. The 2050s scenario results showed that an increase of 24% in OC concentrations for the whole Red River in the future will occur in response to large increases in the urban populations and that this system will remain a strong source of CO2 to the atmosphere in the future.

KEYWORDS

Carbon flux, Climate change, Human activity, Red River, Riverstrahler, Seneque

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1. INTRODUCTION

Tropical rivers which contribute 66% of freshwater outflow, 73% of sediment loads and approximately 61% of terrestrial net primary production, have a critical role in the total global fluvial carbon flux (Huang et al., 2012). However, for many large Asian rivers, river water discharge and sediment loads have been altered dramatically over the past decades as a result of reservoir impoundment, land use, population, and climate changes. It is known that changes in land use (deforestation and agricultural intensification) have resulted in accelerating soil erosion (Tian et al. 2014; Vanwalleghem et al., 2017), leading to increase in sediment loading (Bagalwa et al., 2015) whereas reforestation and dam impoundment can significantly reduce sediment loads (Lu et al., 2015; Strehmel et al., 2016). The changes in sediment loads of these

HIGHLIGHTS

- The Seneque/Riverstrahler was successfully applied to the Red River system
- Riverine OC export of the Red River at Son Tay site was 327 GgCyr-1 in 2014
- The Red River is a strong source release of CO2 to the atmosphere
- OC both point and non-point sources contribute to high heterotrophic situation of the Red River

river systems may affect their carbon fluxes to estuaries, coastal regions and even continental shelf areas (Galy et al., 2015; Tamooh et al., 2014).

The Red River (basin area: 156,450 km2) (Figure 1) is a typical example of South East Asia rivers strongly affected by climate and human activities. Previous studies focused on hydrology, suspended sediment load, nutrients and water quality of the Red River (Le et al., 2015; Dang et al., 2010). This study is structured around the Seneque/Riverstrahler model for relating the carbon transfer and outgassing of the whole Red River drainage network to human activities and natural conditions in its watershed. The model is tested and validated to describe the carbon transfer and emission in the system for the present situation and then is employed to explore scenarios of changes in human activities at the 2050s horizon.

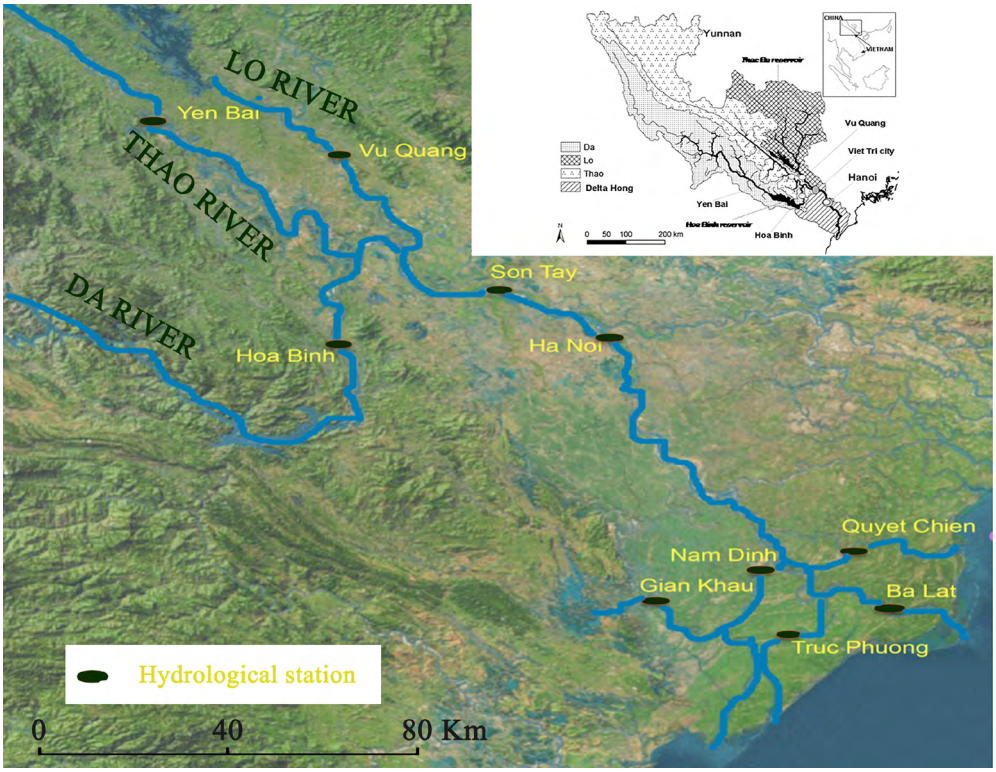

FIGURE 1. The Red River basin and observation sites (Le et al., 2005).

2. METHODOLOGY

2.1 The Seneque/Riverstrahler Model

The Seneque/Riverstrahler model (Billen and Garnier, 1999), a biogeochemical model (RIVE) of in-stream processes embedded within a GIS interface (Seneque), providing a generic model of the biogeochemical functioning of the whole river systems (from 10 to >100,000 km2), is designed to calculate the seasonal and spatial variations of water quality (Ruelland et al., 2007).

The model uses drainage network morphology, meteorological conditions, and land-use, point, and non-point sources, to calculate geographical and seasonal variations of the water quality variables at a 10-day time step (Figure 2). It was developed for describing nutrient transfer in large drainage networks in France (Billen et al., 2007), central Europe (Garnier et al., 2002), in Belgium (Servais et al., 2007), in Viet Nam (Le et al., 2010). Recently, the model has been adapted to investigate the transport of FIB in France (Ouattara et al., 2013) and in Laos (Causse et al., 2015). Here the model was applied to the Red River to simulate riverine OC concentrations and fluxes and to estimate the carbon metabolism.

In this study, the Seneque/Riverstrahler model was developed using the data from the Red River basin for the period 2008–2015. The river discharges at different stations were calculated by the model based on specific discharge measured at three upstream stations, separated into a base flow and surface runoff owing to the recursive digital filter of Eckhardt (2005), and the rules of dam operation.

2.2 Data Collection

The Red River: The three major tributaries: Thao, Da, and Lo, originate from Yunnan (China), then flow into Viet Nam, join at Viet Tri and form a large delta before flowing into the South Asian Sea.

Climate: The climate in the basin is influenced by the Asian tropical monsoon. There are two distinct seasons: the rainy season, from May to October and dry season occurs from November to April. The rainy season accumulates 85–90% of the total annual rainfall. The average daily temperature varied from 14–27 °C. Relative humidity was high throughout the year, averaging 82 – 84%.

Hydrology: The river discharge varies seasonally as a consequence of seasonal differences in rainfall. High flow (July to September) represent around 50–65% of the annual flow whereas the dry season flow accounts for 20–30% of annual flow. The daily river discharges at the outlets of the Thao (Yen Bai station), the Da (Hoa Binh

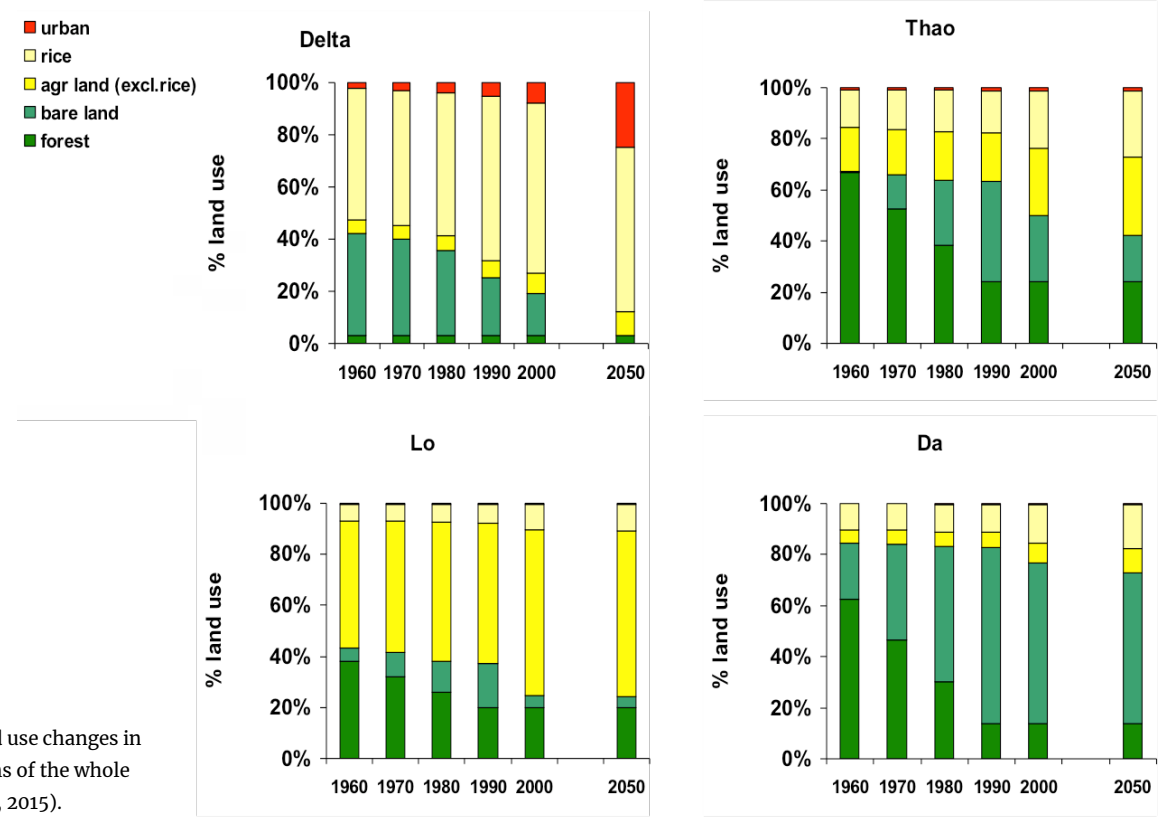

FIGURE 2. Trends of land use changes in the four major sub-basins of the whole Red River basin (Le et al., 2015).

station) and the Lo (Vu Quang station) and of the downstream Red river at Hanoi station as shown in Figure 1 averaged at 720 ± 159 m3. s-1; 1670 ± 284 m3. s-1; 1020 ± 227 m3. s-1 and 2500 ± 477 m3. s-1 respectively (MONRE, 1960 – 2015). The details of hydrological changes for the long-term period 1960–2010 was presented in Le et al (2015). There are four large reservoirs in the Red river basin in Viet Nam: The Hoa Binh and Son La across the Da River; the Tuyen Quang and Thac Ba across in the Lo River. Their characteristics were presented in (Le et al., 2015).

Land use: The forest area in the Red River delta has been quite stable for several centuries but the deforestation in the plateau and mountainous regions dramatically accelerated during the war years (the 1970s), followed by a period of rapid population growth and economic development (the 1990s). Economic development and structural change lead to considerable changes in land use with the expansion of planted forests and urbanization at the expense of rice paddies, mangroves and other non-production forests, and shrublands (Figure 3).

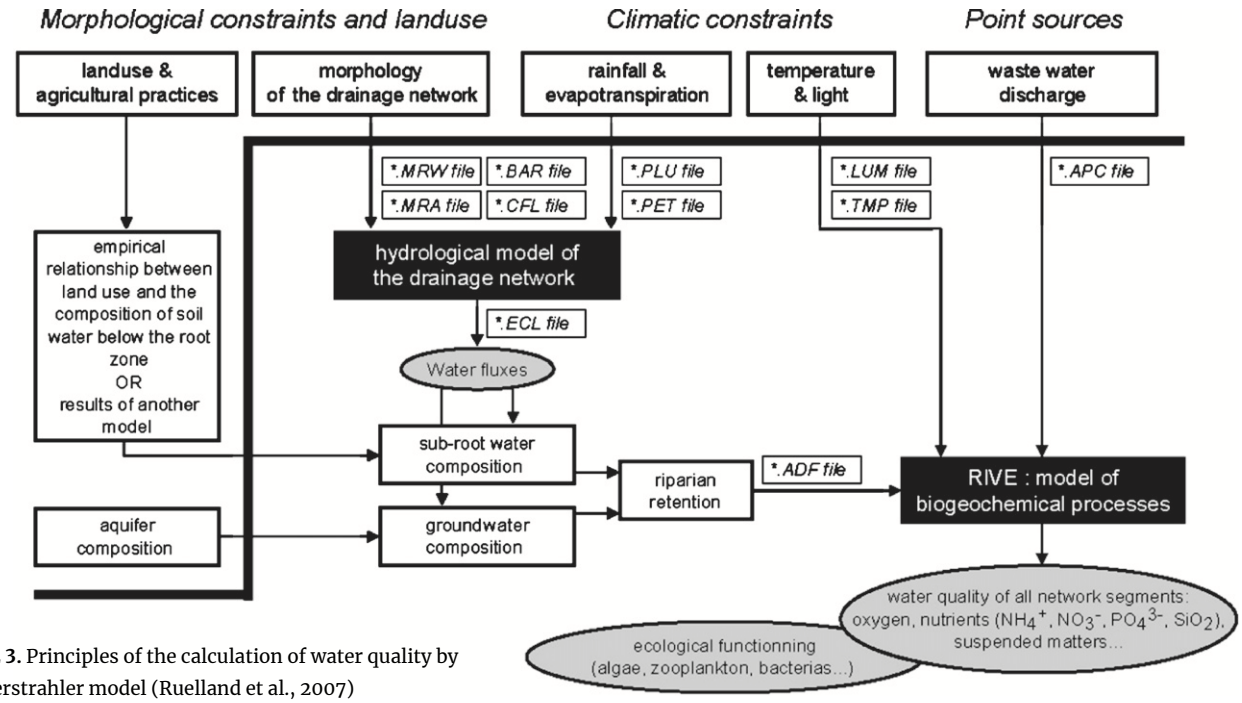

FIGURE 3. Principles of the calculation of water quality by the Riverstrahler model (Ruelland et al., 2007)

The GIS land use coverage information and the OC concentrations in small rivers, streams, and ditches drain of homogeneous land cover types were used to characterize OC concentrations in surface runoff and in base flow (Baric and Sigvardsson, 2007).

Population: Administratively, the Red River basin covers 25 provinces with a population of 32 million people. At present, about half of the inhabitants in the Red River basin live in rural areas with the rest living in cities, towns, and townships. However, the process of urbanization is accelerating due to rural exodus. The population density in the urban areas is expected to rapidly increase in the 2050s.

The OC point sources such as the discharges of domestic and industrial wastewater were taken into account in the model. Based on the census of urban population and industrial activities (Le et al., 2005), taking into account waste management type such as centralized wastewater treatment, direct discharge into rivers or agricultural recycling are adopted.

Validation data: In order to validate the modelling results, water quality data (including particulate organic carbon POC and dissolved organic carbon DOC) from the monthly monitoring surveys at the ten stations along the Red River (Figure 1) during 2008 – 2015 were used. Field sampling, laboratory analysis, and statistical analysis have been presented in (Le et al, 2017 a, b).

3. RESULTS AND DISCUSSIONS

3.1 Modelling Using Seneque/Riverstrahler Model for Present Situation

The Seneque/Riverstrahler model was firstly used for calculating river discharge at all sites observed. The modelling results were in good agreement with the observed values at all stations, as confirmed by the Nash and Sutcliffe values (1970) (≥0.7). Figure 4 gives a snapshot of the Seneque/Riverstrahler software for observation and modelling results of the river discharge at Hanoi station.

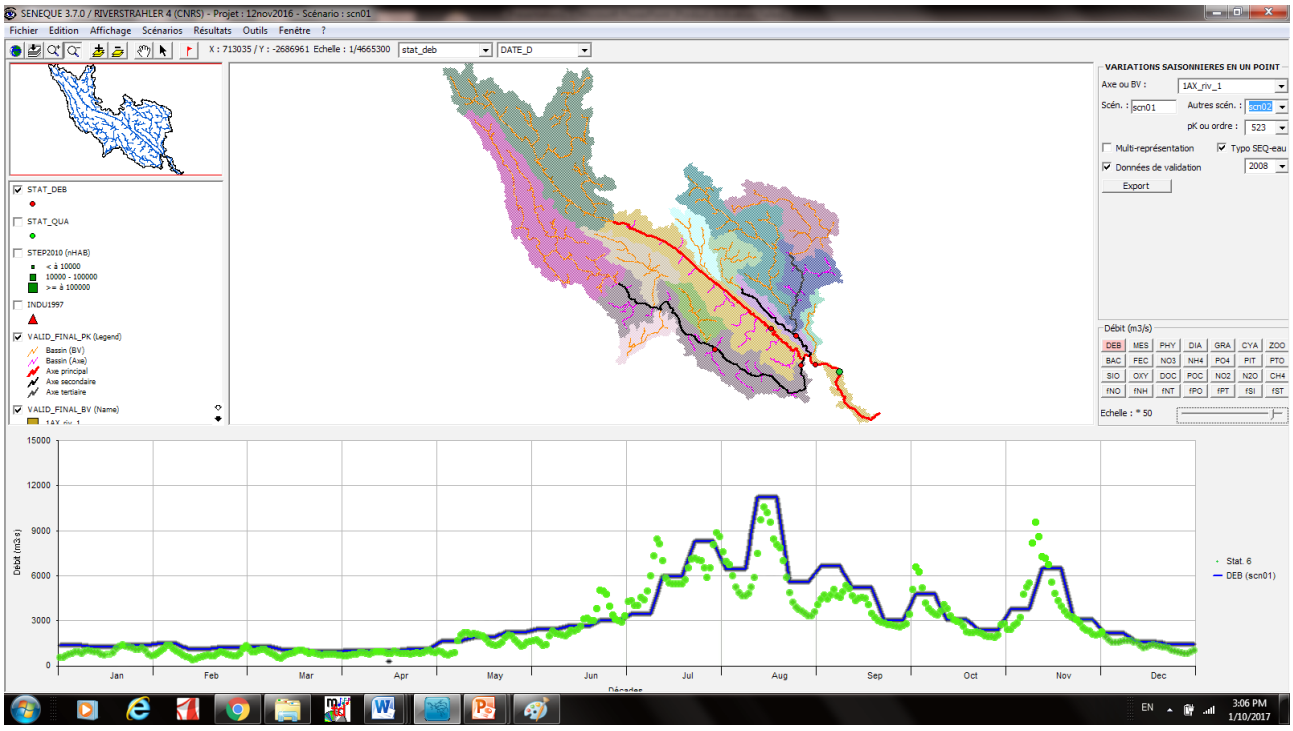

FIGURE 4. One of working screens of the Seneque/Riverstrahler software: observation (circle) and modelling (line) results of the river discharge at Hanoi station of the Red River.

The model was then used to calculate the concentrations of water quality variables, especially OC (POC + DOC). The modelling results were compared that of in-situ measurements and showed a rather good performance similar seasonal and temporal variations all sites, as confirmed by the Nash and Sutcliffe values of 0.6 (Figure 5).

The riverine OC export of the Red River at Son Tay site, estimated from the calculated OC concentrations and river discharges for the year 2014, was 327 GgCyr-1, equivalent to 2200 kgCkm2yr-1. This value was very close to the ones observed in 2008–2010 (Le et al., 2017a) and some Asian rivers such as the Yangtze, the Pearl and the Luodingjiang Rivers (China), the Godavari River (India), but much lower than the Ayeyarwady–Thanlwin River (Myanmar) (Table 1).

Using the model, the rates of primary production P and respiration R in the Red River for 2014 were

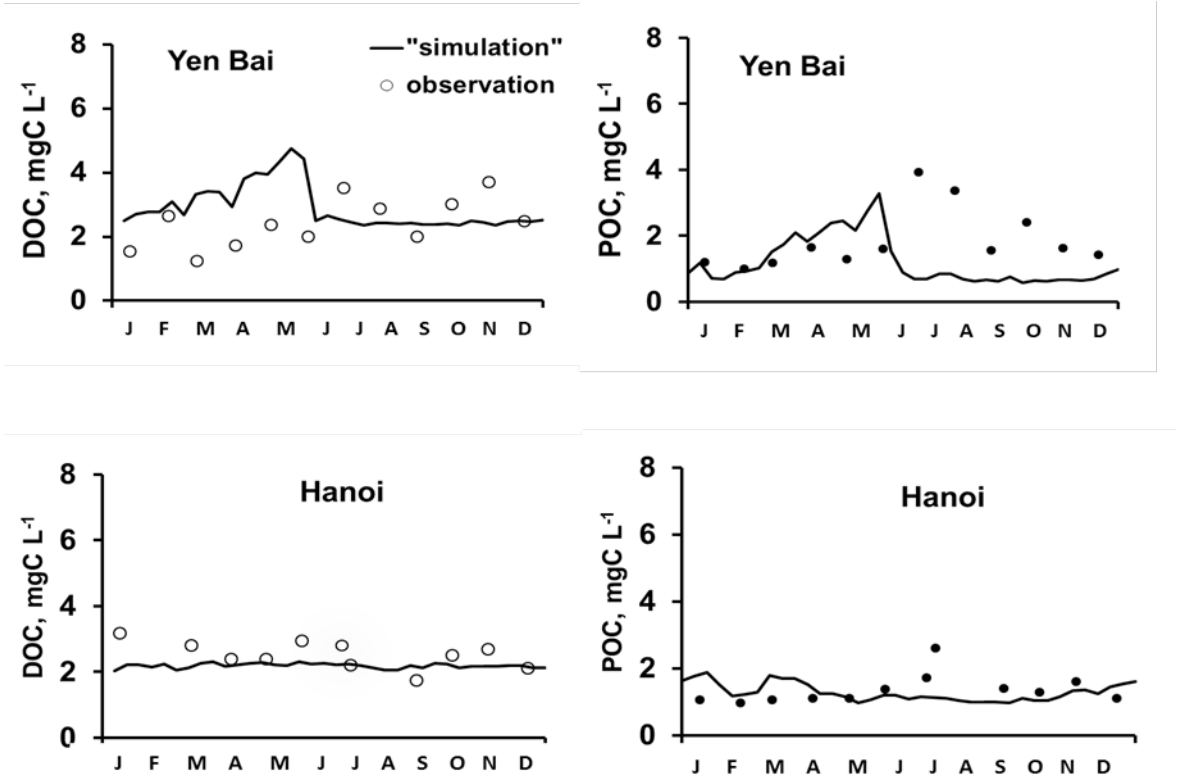

FIGURE 5. Modelling calculation and observation of POC and DOC concentrations at Yen Bai and Hanoi stations of the Red River for the year 2014.

determined. The results showed that respiration (270 GgCyr-1) was considerably higher than primary production (57.5 GgCyr-1). This means that the Red River is a significant source of CO2 to the atmosphere from outgassing across the water-air interface as many rivers in the World which is also noted by (Richey et al., 2002). This strong heterotrophic character of the Red River is due to the high allochthonous OC inputs from both point and non-point sources. Note that these results did not include CO2 outgassing from dissolved inorganic carbon from the watershed.

3.2 Exploring Scenarios

We used the model to predict future OC concentrations in the Red River system for a "business as usual" 2050 scenario based on the present hydrological data of the 3-year period 2012–2014 and future demographics and land use in the Red River system for the 2050 horizon.

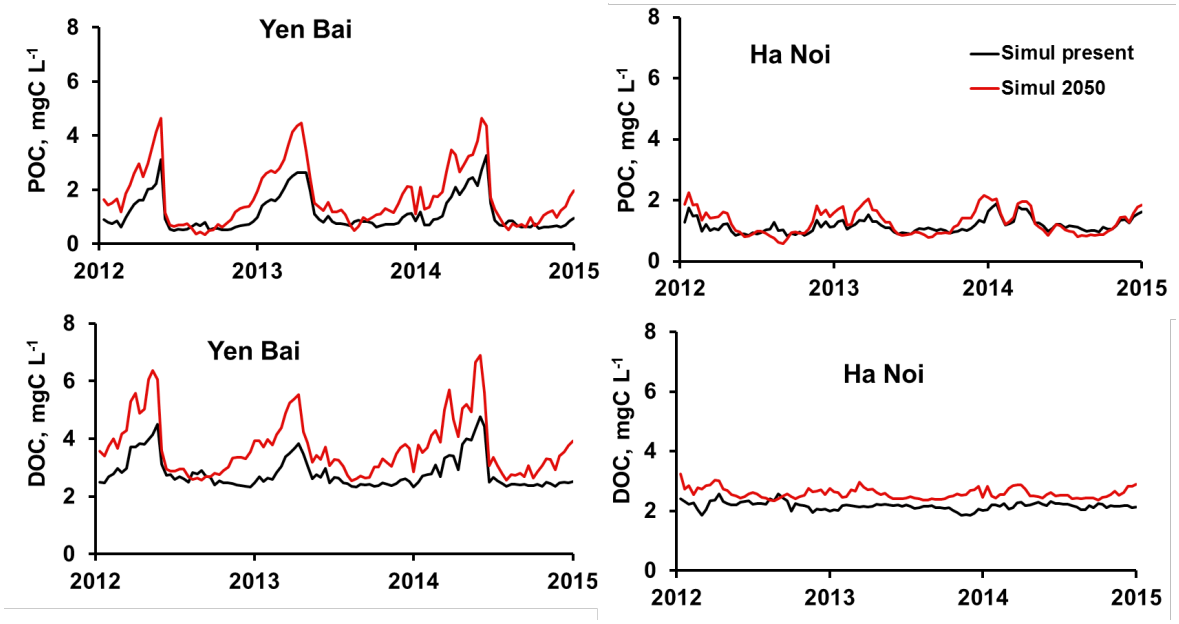

FIGURE 6. Modelling results for DOC and POC concentrations at Yen Bai (upstream) and at Hanoi (downstream) of the main axe of the Red River for present situation (in 2014) and perspective scenario (2050).

The scenario results showed that a limited increase of OC concentrations compared with the present situation at two stations Yen Bai and Hanoi (OC concentrations in 2050 scenario increased by 36% and 16%, respectively) was found (Figure 6). This was particularly the case in Hanoi even though the population is expected to triple by 2050. The reason may be due to the different stability of various components and sources for riverine OC inputs. Indeed, the study on the Haihe River (in China) showed that OC in a tributary, the Majia, was relatively stable by strong of OC in sediments and riverbank soils whereas it was complicated and influenced by humans and surroundings for another tributary, the Tuhai (Cao et al., 2015). Besides, this perhaps surprising result further underlines the difficulties that many developing countries are facing in terms of water quality. On the one hand, such a result can be considered as being relatively positive i.e. slightly increase in OC loads despite a large increase in population. On the other hand, it also means that water quality will not be improved in the future unless efforts are made to control diffuse sources in the basin. However, the setting up and running of such program requires extremely large investments, strong legislation, and effective education programs.

As mentioned above, with the high inputs of allochthonous OC from both point and diffuse sources, the Red River system was a strongly heterotrophic system, which means that the Red River was a strong source of CO2 to the atmosphere. As presently documented, the scenario for 2050 of OC would show that an increase of 24% in OC concentrations for the whole Red River will occur in the future, in response to large increases in the urban populations. Therefore, it appears that this system will remain a strong source of CO2 to the atmosphere in the future.

4. CONCLUSION

The Seneque/Rivershtrahler model was successfully applied to a large Asian river, the Red River for describing the natural and human impact on riverine carbon transfer and emission. In the present situation, the model successfully simulated the seasonal and temporal variations and the levels of riverine carbon concentrations for all the sites observed in the Red River system. An OC riverine export of 327 GgCyr-1 for the year 2014 was calculated for the Red River at Son Tay site. This value was closed with that some Asian rivers. Due to the high allochthonous OC inputs from both point and diffuse sources, the Red River system is a strongly heterotrophic system. The 2050s scenario results showed that an increase of 24% in OC concentrations in the future will occur in response to large increases in the urban populations and that this system will remain a strong source of CO2 to the atmosphere in the future.

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Community resilience assessment to support climate change adaptation in Cambodia and Viet Nam

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ABSTRACT

Rural communities throughout the Asia-Pacific are generally more exposed to climate-driven changes to their livelihoods than those in larger/urban communities. We developed and piloted a community resilience tool to be used to support climate change adaptation within existing development planning pathways. Our framework included 39 key questions based around outcomes related to (i) livelihoods and environment, (ii) infrastructure, (iii) community self-reliance, and (iv) climate and disaster management. In peri-urban Thuy Thanh (Vietnam), climate and disaster management were most concerning, with plan implementation funding the most limiting factor. In rural Vinh Hai, livelihood and environment outcomes were of most concern but again, plan implementation funding and information contributed to poorer outcomes. In rural Lvea Krang (Cambodia) community outcomes were most concerning, limited by ineffective collaboration, and plan implementation funding. In peri-urban Chamkar Samrong, all outcomes except climate and disaster management were of concern, with plan implementation funding and information the most limiting factors. Building resilience requires context-based consideration of desired outcomes and factors that affect them. Our assessment tool provides project managers with a comparably cheap means for monitoring the long-term effectiveness of uncoordinated aid donor projects in supporting community-based adaptation to climate change.

KEYWORDS

Adaptation, Assessment, Community resilience, Vulnerability

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1. INTRODUCTION

Climate change adaptation in Asia is particularly complex owing to interactions of geography, income, capacity and population change. The overwhelming majority of the population rely on subsistence agriculture, making them particularly vulnerable to both climate variability and change. For example, 80% of Cambodians depend on subsistence agriculture (mostly rice and fish) (Thomas et al. 2013). Forecast rice yield losses of 5% predicted by 2020 in Cambodia, combined with few opportunities for livelihood diversification, means that

HIGHLIGHTS

- Resilience assessment supports climate change adaptation using existing resources
- Factors limiting overall resilience are mostly dependent on context
- Limited resources and plan implementation commonly drove poor resilience outcomes
- Central Vietnam reported higher community resilience than Cambodia
- Links between climate change and development outcomes are often misunderstood

communities may experience severe and recurrent food shortages and debt if adaptation planning is not effective (Nuorteva et al. 2010, Sovacool et al. 2012).

Community vulnerability to climate change can be minimized through adaptation planning that builds on inherent community-based sources of resilience (Adger et al. 2011). Understanding such resilience is especially important in remoter areas where communities are largely self-reliant yet may or may not have developed high degrees of adaptability to climate-driven change (Nunn et al. 2014); an additional consideration is a degree to which such communities retain their levels of traditional coping in the face of encroaching globalization. Vulnerability comprises a community's exposure to risk and their sensitivity to impacts arising from risks (Adger et al. 2011). Community resilience is broader than vulnerability, including consideration of a community's assets and the dynamics by which they are able to and are limited in mobilizing those assets to address risk. Thus, it pays greater attention to governance and social dynamics that affect a community's development trajectory (Magis 2010). Understanding each community's assets and how they can be mobilised are critical in addressing the climate change-development nexus in comparatively poor rural communities (Friend and Moench 2013, Adger et al. 2011, Adger et al. 2013) yet this understanding is limited in the Asia-Pacific region and merits further investigation (Friend et al. 2014, Nuorteva et al. 2010). Some communities and practitioners (such as those we work with) feel that some current tools for assessing vulnerability (including measuring resilience) to climate change are narrow in focus and as such, are not easily integrated into multi-sectoral development planning.

Community resilience assessment has recently emerged as an area of focus in disaster management, promulgating tool development contextualized to the needs of different programs and the aims of specific projects (see Sharifi 2016, Sharifi and Yamagata 2016 and Ross and Berkes 2014). Many of these tools are broad in nature and detailed in anticipated analysis, sometimes failing to consider how climate change and development are inter-woven, instead focussing on disaster management at the expense of considering how communities actually change and adapt (Loring et al. 2016). Further, they are often very complex and detailed, and not easily applied without expert assistance to guide local scale adaptation. Improving tools for rapid measuring and strengthening the resilience of rural communities to climate change has the potential to (i) identify the existing status of resources and processes that could be mobilised to support adaptation to climate change and enhance community resilience, and (ii) inform national and sub-national planning by identifying communities most in need of interventions to enable effective and sustained adaptation. This project developed and piloted a rapid community resilience assessment tool addressing these knowledge gaps and identified opportunities to use community resilience assessments to enhance adaptation planning.

2. METHODOLOGY

Our methodology included three steps: (i) assessment framework development and revision based on expert feedback (2 months); (ii) assessment trialling in four communes (two in Vietnam and two in Cambodia) over a period of 3 months in each commune; and (iii) adaptation policy dialogues (one day each, one in Vietnam and two in Cambodia). In conjunction with United Nations Food and Agriculture Organisation (UN FAO), we also collected some household migration and food security data for Cambodia. For tool piloting purposes, communes (typically a cluster of 3-5 villages) for which climate vulnerability data and relationships existed were selected, including ones in both peri-urban and rural situations.

Participating Vietnamese communes included Vinh Hai (rural) and Thuy Thanh (peri-urban) in Tha Thien Hue province, Central Vietnam. In these communes, urban growth has encroached in rural areas while traditional agricultural livelihoods face increased impacts from more frequent typhoon and flood events as well as groundwater salinization. Thuy Thanh has 9,717 people and Vinh Hai has 13,019 people.

Cambodian communes included Chamkar Samrong near Battambang city (peri-urban) and Lvea Krang, a rural commune in Siem Reap Province, both in Northwest Cambodia. From unpublished remotely-sensed data, it is clear that over the past 16 months these areas have experienced increasing dryness and a concomitant decrease in the number of abnormally wet months. In combination, this affects food security with consequently high rates of out-migration to the capital (Phnom Penh) and to Thailand in search of work (Kingdom of Cambodia 2014). These two communes are home to populations of approximately 17,927 and 2,963 (respectively).

2.1. Assessment Framework Development

Starting in 2014, we reviewed ten community resilience assessment frameworks and indicators (excluding disaster resilience on the basis that it addresses climate crises rather than slow onset change) to develop a common indicator set. We then aligned indicators against a framework based on context, management inputs, planning, plan implementation and outcomes

(including livelihoods, infrastructure, community and climate and disaster management). This assessment structure is endorsed by the International Union for the Conservation of Nature (IUCN) to meet commitments to the Convention on Biological Diversity (Leverington et al. 2010). We developed a four-point qualitative scoring system for each of 39 questions with example high and low scores. Lastly, we revised our framework on the basis of expert feedback workshops with academics, climate change experts and NGOs, and policymakers – for example, adjustment to wording and indicators. Full details of the framework can be found in Jacobson and Nguon (2016) and Tran et al. (2016). Examples of questions and scores are provided in Table 1.

This framework structure provides a rapid and cost-effective assessment process. Qualitative assessments have been routinely criticised in monitoring and evaluation, irrespective of their ability to verify information needed for decision-making and a structured approach to planning in the absence of quantitative data (Hockings et al. 2009, Jacobson et al. in press). Where it does exist, quantitative information was incorporated into the assessment.

Component		Assessment question	Score justification	High score	Low score
Inputs	A	Do most community members have enough money after time of crisis/ stress?		Most people have strategies in place to maintain livelihoods during crises (e.g. setting money or food aside)	No-one has enough strategies in place to cope during crises
	B	Do most community members have sufficient social networks to support income security?		Most people have sufficient networks within the district to increase household income	Household income is decreasing and debt is growing for most families
	C	How easy is it for community members to shift to an alternative livelihood?		Community members can easily find alternative jobs or business opportunities in the area	It is difficult to find alternative income sources and most parents and or families must migrate for work
Planning	D	Is the planning responsive to community needs?		Commune and or provincial plans address these issue and it reflects the top priorities of the commune	Commune and or provincial plans do not address these issues
	E	Will land use planning reduce vulnerability?		Land use plans do reduce vulnerability from flooding, storms etc.	Land use plans increase vulnerability for many groups, not only the poorest or most marginalised
	F	Are there **sufficient resources** (financial, assets and knowledge) to **implement the most important activities** in plans?		We have all the resources we need for top priority activities that will build sustainable livelihoods	We have no resources to support sustainable livelihoods
Outcomes	G	How would you rate the **quality** of the **natural environment?**		The environment is high quality and it seems to be staying that way	The environment is medium to low quality and things are getting worse
	H	How would you rate the level of **economic development?**		Economic development is growing, as evidenced by jobs, housing quality and services available	Economic development is bad, evidenced by fewer jobs, less food, more debt and more migration

2.2. Assessment Process

The assessment was conducted as a workshop or focus group discussions with Commune Council, Village leaders and community groups in each of the four communes. In Cambodia, we also conducted a needs assessment and prioritization comparison. This included a needs prioritization ranking, a ranking based on access during climate-related hazards, and provided a valuable basis from which to discuss the appropriateness of existing resources for addressing different development outcomes under climate change (Jacobson and Nguon 2016). A survey of migration (including drivers and consequences) and food security was conducted in conjunction with UN FAO, and in one commune, a full independent Vulnerability and Needs Assessment was undertaken as part of the UN FAO project. In all cases, data (either previous existing studies or that which we had collected) were then summarized against community resilience assessment questions to use as prompts for discussion and assessment in workshops.

2.3. Adaptation Dialogue Process

The adaptation dialogue process (Jacobson et al. in press) enabled us to share and verify results and to identify innovative opportunities for adaptation utilizing existing resources. It included representatives from relevant provincial departments, NGOs, research organizations and aid organizations. The format followed: (i) an overview of activities and a discussion of climate impacts; (ii) an overview of key results; (iii) a presentation of the assessment

FIGURE 1. Example indicators for livelihoods and environment, and scoring guide

scores related to each outcome theme, with comments on score justification and issues by commune representatives attending meetings; and (iv) a discussion on how these issues might be addressed with prompting questions (including related provincial/NGO/University projects addressing issues identified, what would need to occur to enhance a particular score, whether existing planned activities are likely to improve scores, what can and cannot easily be changed about drivers of the issues). At the end of the process, we asked participants to summarize the most pertinent issues, to identify adaptation actions that could address them, and to determine who should be responsible for these.

3. RESULTS

3.1. Viet Nam

Thuy Thanh Commune results (Figure 2) indicate that responses to climate crises and slow-onset changes (e.g., sea-level rise) were perceived as the biggest problem for community resilience, one that was exacerbated by inadequate planning and a paucity of implementation funds. Some adaptation options identified included:

1. Improving understanding of climate change, including understanding the reasons for both insufficient stakeholder engagement in planning and perceived low levels of commune resilience and disaster preparedness. This would address poor planning scope scores for the climate and disaster management theme; and
2. Working more closely with vulnerable groups (e.g. elderly and poor) to understand and develop adaptive livelihood options. Participants felt that this would improve livelihood outcomes.

In Vinh Hai Commune, results (Figure 3) indicate that management of livelihood economic opportunities can be inferred (due to grading) as the biggest problem for community resilience, while funds to implement plans and inputs (including access to resources during times of crisis, social networks in crisis and the ability to change from one livelihood to another) were the most significant factors contributing to this. Based on scoring, this rural commune appeared better prepared for short-term climate impacts than the Thuy Thanh Commune, although long-term strategies to address livelihood alternatives are also needed. Some adaptation options identified included:

3. Improving understanding of vulnerable groups (e.g. very poor people, elderly), including developing more sustainable livelihoods, microfinance opportunities, and the level of support available to these groups during disasters. These groups were considered most affected by poor livelihood and environment outcomes scores;
4. Identifying and investing in livelihood diversification to sustain market-driven food production in the face of adverse climate events, to address poor livelihood and environment inputs and information score; and
5. Improving disaster preparedness, including the ability to survive for more than ten days without normal services or access (given the time it takes to receive support), i.e. the yellow climate and disaster management inputs and information score.

3.2. Cambodia

In comparison to the two communes in Vietnam,

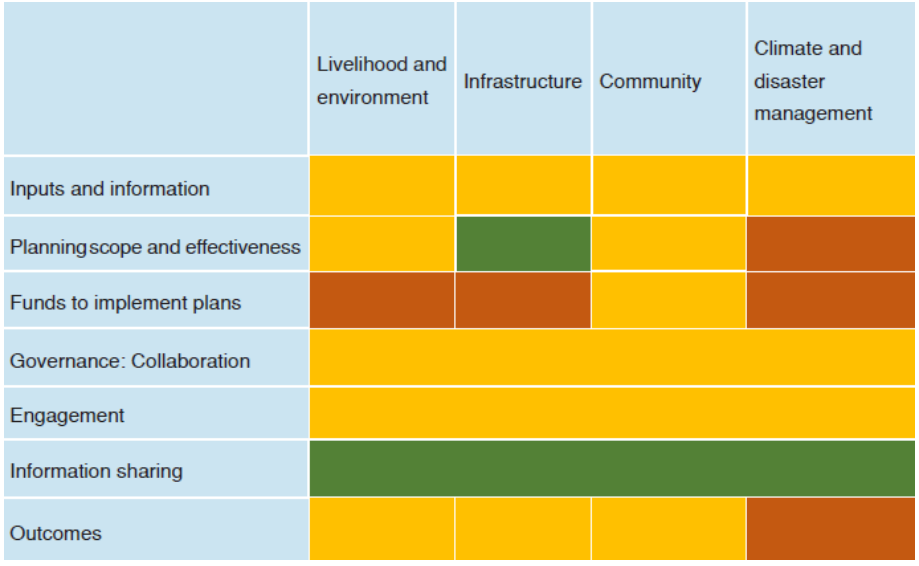

FIGURE 2. Thuy Thanh Commune resilience assessment summary. Green shading represents an element considered effectively addressed, yellow is mostly effectively addressed, whereas orange is poorly addressed.

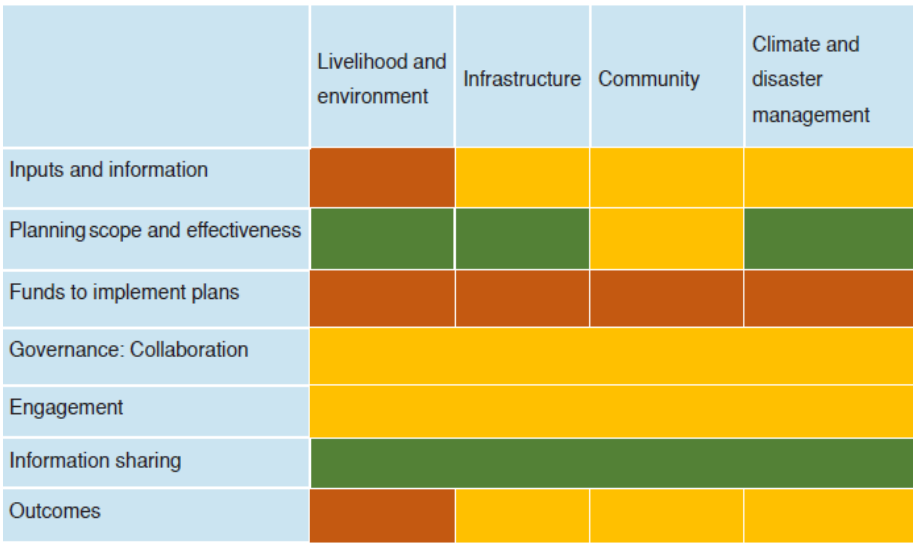

FIGURE 3. Vinh Hai Commune resilience assessment summary. Green shading represents an element considered effectively addressed, yellow is mostly effectively addressed, whereas orange is poorly addressed.

community resilience in the two commune in Cambodia was rated lower, largely because of issues with inputs, information, and resources for planning, and plan implementation. In both communes studied, management of climate crises and slower-onset changes (e.g. sea-level rise) were perceived as fundamentally challenging community resilience, compounded by a range of associated factors, such as funding to implement plans, information access and in some cases, planning scope (i.e. responsiveness to commune needs).

In Lvea Krang Commune, common cross-cutting factors including a lack of information for planning, community networks for coping with crises and reconfiguring livelihoods and addressing the needs of the most vulnerable people were issues, as was the quality of collaboration between community, government, and NGOs (Figure 4). Adaptation options beyond those being addressed by the UN FAO project (focusing on climate-smart agriculture, alternative livelihoods, and watershed management) included:

Study club (focused on school curriculum) for children from migrant households, given that they often have to work in fields to help feed their family due to labour shortages incurred because of climate-related food insecurity, and miss school as a result. This addresses some aspects of the poor community scores;

Improved water for drinking, sanitation and hygiene purposes, particularly in schools, as a result of climate-induced water shortages. This addresses some aspects of the poor community scores; and

Agricultural community (co-operative) for sharing information about market prices, coordinating planting to ensure markets are not saturated, coordinating use of irrigation among villages and commune, and enabling of access to climate-resilient rice seed varieties This addresses some aspects of the poor livelihood and environment scores.

Peri-urban Chamkar Samrong commune results (Figure 5) demonstrate that the commune faces a dual-development trajectory, with landholders closer to the city able to sell their land and invest in agricultural land with better water supply outside of the commune, and those living farther from the city who were unable to do so and whose land and livelihoods were thus more heavily impacted by increased frequency and severity of drought and foods, with few perceived livelihood alternatives. Our workshop participants suggested that in the last year alone, around half of agricultural lands (30% of

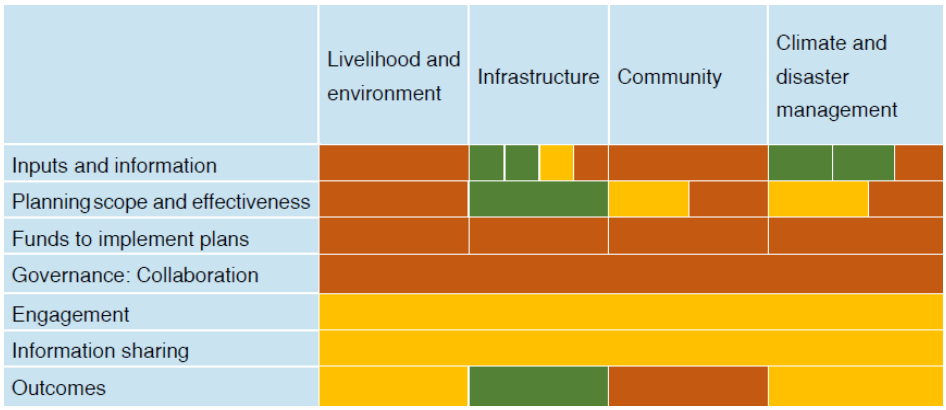

FIGURE 4. Lvea Krang Commune resilience assessment summary. Green shading represents an element considered effectively addressed, yellow is mostly effectively addressed, whereas orange is poorly addressed.

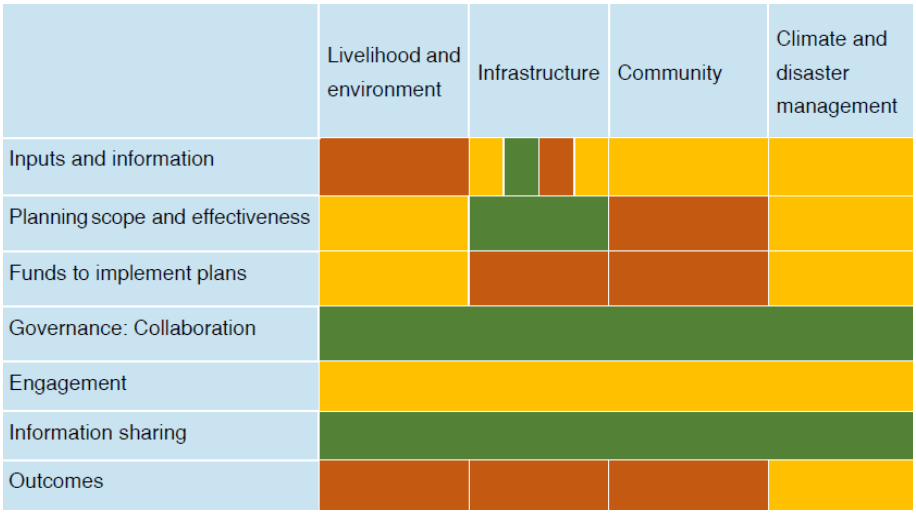

FIGURE 5. Chamkar Samrong Commune resilience assessment summary. Green shading represents an element considered effectively addressed, yellow is mostly effectively addressed, whereas orange is poorly addressed.

land area in village 1 and 2 within the commune) had been seized as collateral against microfinance loans, due to a drought that affected productivity and farmers' ability to repay loans. Collaboration and information sharing were less problematic here than for Lvea Krang, likely due to proximity to the city of Battambang that gave community members some potential cushioning from economic impacts of climate adversity through the provision of wage employment. Some adaptation options identified included:

6. Study club (as above);
7. Community gardens on school or NGO land, so that community members can learn about and grow alternative climate-resilient crops to increase food security and, with donor assistance, develop alternative livelihoods through microenterprises (e.g. herbal tea, compost development). This addresses some aspects of the poor livelihood and environment scores;
8. Climate-smart agriculture training (improve soil management and rice cropping practices to promote soil moisture retention and improve soil humus and fertility). This addresses some aspects of the poor livelihood and environment scores; and
9. Promote water and food storage for times of crisis, through commune and Department of Rural Development providing access to water storage containers and/or communal water tanks, and information about food storage in advance of floods and or drought. This addresses some aspects of the poor community scores.

4. DISCUSSION

The commonalities across all four communes are a lack of funds to implement plans and the general responsiveness of infrastructure planning. We did not identify any apparent patterns in results between peri-urban and rural communes. A larger sample size may indicate differences but our results suggest that every commune appears to face a mixed bag of issues, none exactly duplicating another, that affect its resilience. Our work has demonstrated that a policy dialogue approach is critical to identifying transformative approaches to adaptation (see Thomsen et al. 2012) that address urgent issues around community viability and contribute to long-term solutions for sustaining livelihoods. This supports the suggestion that successful climate change adaptation in Asia requires attention to be shifted from plan writing to the creation of spaces for informed dialogue (Friend et al., 2014).

In general, factors contributing to livelihood and community self-reliance were scored lowest. These include issues such as the ability to ensure income security in times of climate-related crises and to diversify livelihoods post-crisis, the responsiveness of planning to community needs and to reducing vulnerability, and building community networks and engagement during climate shock and stress events. Our tool has identified factors contributing most and least to resilience outcomes. Understanding how to build resilience is considered an emerging research agenda in integrated and advanced interpretations of community and disaster resilience (Davidson et al. 2016) but could include consideration of switching resources (time, planning and other) from areas scored positively to areas scored less positively.

Communities may not necessarily have conveyed or comprehended the inter-relatedness of climate issues in the scores associated with climate and disaster management components of the assessment tool. This is the

reason we included climate and disaster management as a development outcome, as well as incorporating elements related to climate impacts into other indicators (e.g. avoiding increased vulnerabilities as part of infrastructural development planning). The survey on climate-related household migration and social consequences undertaken in Cambodian case studies indicates likely climate-related household migration rates of 21-31%, resulting in labour shortages, issues for youth, instances of lower female safety, and in as many as half the cases, lower food security (Jacobson and Nguon 2016). These issues highlight the interconnected nature of climate change-related impacts. Lastly, a lack of espoused knowledge about the pathways through which climate change can impact all development could mean communities focus on short-term solutions rather than longer-term ones that ensure adaptation pathways remain open. Adaptation activities raised during our policy dialogue included a combination of both of these, for example, study club (a short-term solution), and climate-resilience agriculture (a long-term one).

Our results also highlight the need for greater attention to issues of climate change adaptation for marginalized groups, such as female-headed households, children and elders from migrant households, and poorer families. Little if any attention has been paid to these groups within resilience assessments, especially from the perspective of empowering them to engage in adaptation processes (Reed et al. 2014). A finer dissection of vulnerable group categories may lead to improved outcomes of development and climate change adaptation. While gendered perspectives on development are not new, gender/marginalization theory and its consideration in climate adaptation for agricultural development are comparatively under-developed (Carr and Thompson 2014). Reviews of community resilience assessment, e.g., Sharifi and Yamagata (2016) and Ross and Berkes (2014) do not include marginalization as specific components or indicators of resilience, although they do refer to 'equity' without contextualizing it. Where assessments do consider marginalized groups, they generally consider binary categorizations of marginalization; for example for women (as opposed to men), or for indigenous (as opposed to non-indigenous). They do not consider that members of one grouping may have less in common than they do with others in the opposing binary, i.e. richer women may have more in common with richer men in terms of their capacity to adapt than with poorer women. In our assessment, we asked specifically about whether planning reduced vulnerability and about the needs of the most vulnerable groups. The detailed discussion of these questions and subsequent poor scores lead us to conclude that understanding how best to address the needs of marginalized groups in resilience and vulnerability assessments requires greater attention.

5. CONCLUSION

This project has (1) contributed a rapid assessment tool for community resilience to climate change, and (2) demonstrated that assessments of the resilience of rural communities can help to identify the current status of resources and processes that can be mobilized to support adaptation to climate change. Our tool was sufficiently simple to be utilized as part of annual Commune Investment Plans in Cambodia and Vietnam. If implemented at a regional scale covering multiple communities (i.e., if its application was scaled out), results could be used to inform subnational planning by identifying communities that are most in need of interventions and by prioritizing adaptation efforts of different types. It could also be used as a systematic basis for targeting climate-related aid. Where resources exist, quantitative proxy indicators could be developed for framework questions. This would enable us to test the rigour of assessment scale in comparisons. The sensitivity of the tool to detect changes in resilience on the basis of adaptation activities must also be examined.

Our results highlight that building resilience requires context-based consideration of desired development outcomes and factors affecting the status of them. The third contribution of our work is to demonstrate how these can be captured in both assessment design and extension dialogue processes. A benefit of our assessment and policy dialogue process is that it could be used as a rapid approach to monitoring the effectiveness of aid projects designed to support community-based adaptation to climate change, e.g. as a companion to mid-term review; there are often many projects running simultaneously in any community, but a lack of coordination across projects sometimes exists. In this way, as illustrated by our policy dialogue workshops, community members are better able to express their needs and get the attention of their provincial, aid and NGO partners. Long-term use could also indicate whether adaptation path dependency is becoming an issue.

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