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Asia-Pacific Network for Sustainable Forest Management

and Rehabilitation

PROJECT PROPOSAL

Adaptation of Asia-Pacific Forestry to Climate Change – Phase II

Faculty of Forestry, University of British Columbia, Canada

June 18, 2015

Project title	Adaptation of Asia-Pacific Forestry to Climate Change – Phase II	
Supervisory agency	Canadian Forest Service	
Executing agency	Faculty of Forestry, University of British Columbia	
Expected project duration: 01/09/15 to 31/08/18 36 months		
Target area (project locations and context) China, Chinese Taipei, Malaysia, Myanmar, and Laos (maps are shown in Annex A)		
Total budget(USD) $899,200	**Expected APFNet grant(USD)** $499,200	**Conouterpart contribution (USD)** (in cash and in-kind) $400,000

Project summary:

The impact of climate change on the health and services provided by forest ecosystems is a major concern in the Asia-Pacific region. However, little progress has been made towards developing robust regional forest management strategies to tackle such challenges. A strong scientific basis and credible modelling tools are required to help local and regional forest managers develop and evaluate viable adaptation solutions to address this problem. The first phase of this project has made a solid contribution towards these objectives through the completion of six major outputs, including the development of tools and models and their application to five major tree species and three pilot sites. However, there is opportunity to expand and improve upon the tools and models developed in phase one in order to apply the outputs to a broader range of ecosystems and associated communities to further advance the capability of forest policy makers, statutory decision makers and forest managers to promote the management of forest resources in this region. In addition, there is opportunity to make these tools and their byproducts more widely available and more accessible for use by local practitioners through continued training, web tools and technology transfer. Together, these represent the main objectives of the second phase of this project.

Phase two of the project will expand our focus from temperate (China, Canada and Australia) to tropical and subtropical regions in Southeast Asia, where afforestation is active and/or forest ecosystems and dependent human communities are particularly vulnerable to climate change. Phase two will expand upon the outputs of phase one by downscaling both the spatial scale and temporal resolution of our high-resolution climate model (ClimateAP) and upscaling the application of ecological models from specific pilot areas to the national level. Niche modelling will be extended to include more key forest species and entire ecosystems in selected economies, which will enable us to assess impacts of climate change on all species in these ecosystems. Through the integration of models, development of indicators, and trade-off analyses, adaptive forest ecosystem management strategies will be developed and evaluated in the pilot areas. New features will be added to our high-resolution climate model (ClimateAP) to facilitate modeling of the variability and extremes in climatic conditions, and spatial visualization tools and new datasets will be added to our web-based platform and available for access across economies. Finally, our network and capacity building will be extended through workshops, communications and extension notes into all Southeast Asian countries.

The outputs of this project will build upon phase one to considerably improve the capacity of local and regional forest managers and decision makers to develop robust adaptation strategies to address climate change issues in the Asia-Pacific region. ClimateAP will serve as an essential tool to facilitate and promote research and applications related to climate change. Consensus projections of forest tree species and ecosystems in future climates will provide a solid scientific basis for forest tree species selection to adapt to future climates and for vulnerability assessments of ecosystems and species. Adaptive forest ecosystem management strategies developed for the pilot areas will improve the health and productivity of existing forests and their resilience to a changing climate. Our map-based web platform will make major outputs of the project easily accessible, including spatial visualization and data access. Continued networking and capacity building will ensure effective knowledge transfer and the active participation and involvement of stakeholders and policy makers.

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Abbreviations and acronyms

AP	Asia-Pacific region
BC	British Columbia
ClimateAP	A climate model for Asia-Pacific
CAs	Collaborating Agencies
CO_2	Carbon Dioxide
EA	Executing Agency
FORECAST	Management-oriented, Stand-level Forest-growth and Ecosystem Dynamics Model
GCM	General Circulation Model
IPCC	The Intergovernmental Panel on Climate Change
TACA	Tree and Climate Assessment Model
UBC	University of British Columbia
UPM	Universiti Putra Malaysia

1. Background and Rationale

The impact of climate change on the health and services provided by forest ecosystems is a major concern in the Asia-Pacific region. Shifting climate patterns have led to increased drought-related mortality throughout the region (e.g. Allen et al., 2010; Zhao and Running, 2010) and increasing deviations between past and future climate regimes are placing many species and associated ecosystem types at risk. As climate regimes continue to change, species that have adapted to historic climate patterns will be subject to increasing abiotic (e.g., temperature and moisture) and biotic (pests and diseases) stress. Mismatches between adaptation and future conditions may severely compromise the resilience of forest ecosystems and jeopardize the critical ecosystem services they provide. Southeast Asia is particularly vulnerable to climate change in that the health of human communities and forest ecosystems are often closely linked. Forests in many parts of this region have been degraded due to over-harvesting for fuel wood and timber production and due to declines in soil productivity associated with swidden agricultural practices. Despite these risks, little progress has been made towards developing robust regional forest management strategies to tackle such challenges.

During the initial phase of this project, we refined and tested a suite of scientifically credible modelling tools designed to help regional forest managers develop and evaluate the potential impacts of climate change on forest ecosystems within the Asia-Pacific region. Specifically, a regional climate model called ClimateAP was created to address fundamental data gaps and to facilitate the development and application of detailed climate niche models for five major tree species across large, complex landscapes. ClimateAP, using dynamic local downscaling technology, generates high accuracy, scale-free climate data, explaining over 97% of the total variation in temperature and about 90% in precipitation observed by weather stations over the entire region. This model can be used by anyone interested in climate change or climate-related studies and applications in this region. The climate niche models apply a novel composite modeling approach that integrates multiple Random Forest models to model the climate niche of each species at a high accuracy (error rate < 10%). These models are then used to generate consensus projections of the geographic distribution of the climate niche of each species in multiple future climate scenarios. These projections are sufficiently robust to serve as the scientific basis for policy makers and practitioners developing adaptive strategies for forests and forest-dependent communities. In addition, case studies, including the application of a range of process-based forest management models, have been conducted at three pilot sites. The key results and management recommendations from this work have been summarized and presented in the form of multiple research papers, project reports, management notes and at a regional APFNet workshop held in Kunming in July 2014.

The regional focus of the initial phase of the project was on temperate and subtropical ecosystems. To further advance the capability of forest managers to protect and promote forest resources throughout the Asia-Pacific region, the tools should to be extended (e.g., from individual species to entire ecosystems) and applied to a broader range of ecosystems,

including tropical regions and associated communities. In addition, more work is required to make these tools and their byproducts more widely available and more accessible for use by local practitioners through continued training and technology transfer. Together, these represent the main objectives of the second phase of this project.

With the unrelenting progression of climate change, policy makers, statutory decision makers and forest managers are under increasing pressure to consider new approaches and adaptive strategies to establish and maintain healthy and resilient forest ecosystems. The development of effective adaptation strategies to reduce the negative impacts of climate change on forest resources requires the application of models that include detailed representations of plant-climate relationships. However, the availability of high quality climate data represents a critical barrier that limits the construction and application of such models. The development of ClimateAP during the initial phase of this project provided an essential resource that will serve as a foundation for future research. Building on the advances of other climate models (WorldClim, ANUSPLIN, PRISM, Climate WNA, etc.), ClimateAP, developed at the University of British Columbia (UBC), provides an essential resource for future modelling endeavors. Its defining features include the projection of scale-free (or high-resolution) data, the inclusion of a broad range of useful climate variables and indices derived from thousands of climate stations, the option to select from multiple climate change scenarios developed from world-class GCMs and widely accepted emissions scenarios, and a web-based, user-friendly interface to ensure data accessibility. In the second phase of the project, we propose to improve the usefulness of ClimateAP by making its outputs available at a national scale and adding annual time series projections into the model.

One of the most straightforward and accessible approaches to the development of adaptive management strategies has been the application of climate niche models. This method is based on the idea that climate regimes, defined using complex statistical analyses of regional climate data, represent a fundamental limiting factor to the distribution of tree species and ecosystem types. The approach was pioneered in western North America by Hamann and Wang (2006) and Rehfeldt et al. (2006), but these original studies were limited in the range of future climate projections included in the analyses. Wang et al. (2012) at UBC generated consensus projections for British Columbian ecosystem types and species based on 20 climate-change scenarios. These projections have been used in developing provincial guidelines for tree species selection and seed transfer in forest resources management. In the first phase of the project, we were able to capitalize on the high-resolution climate maps generated by ClimateAP and existing maps of species distributions to construct bioclimatic envelopes (climate niches) for five key tree species in the Asia-Pacific region. Such information allows managers to evaluate the climate conditions for which species have been successful in the past and make predictions about where they will likely be successful in the future under changing climate regimes. In the second phase of the project, we propose to extend the climate niche models to include 10 new key species in these regions. We will also upscale the analysis to cover entire ecosystems in the selected economies to determine

whether existing ecosystem classification schemes will remain robust under changing climate conditions. This is particularly important as it will allow us to associate a large number of individual tree species (not limited to the original 10 species) with the ecosystem classification schemes and to make predictions for all of these species. This will make the method more applicable to subtropical and tropical regions, where a large number of species coexist in the same ecosystem. Furthermore, for the countries without inventory data on individual species, the analysis of existing ecosystem classification schemes can serve as an effective alternative.

In parallel with climate niche models, process-based models also play an important role in evaluating the impacts of climate change on forest productivity, water balance, and carbon storage. FORECAST Climate (Seely et al. 2014), an extension of the hybrid forest growth model FORECAST (Kimmins et al. 1999), was created in phase one of the project through the dynamic linkage of FORECAST with the stand-level hydrology model ForWaDy (Seely et al. 1997). This linked model is capable of demonstrating the impacts of climate change on forest growth dynamics. TACA is a mechanistic species distribution model (Nitshke and Innes 2008) that facilitates an analysis of the response of trees to climate-driven phenological and biophysical variables. It assesses the probability of a species being able to regenerate, grow and survive under a range of climatic and edaphic conditions. FORECAST Climate and TACA models were employed in pilot sites in temperate and north sub-tropical regions to evaluate the long-term impacts of alternative climate change scenarios on forest growth and development. Results from the models were subsequently utilized in a tradeoff analysis associated with alternative forest management practices. In the second phase of the project, we propose to expand the application of these models to include additional forest types, particularly in tropical ecosystems of Southeast Asia, at a larger scale, and to improve the accessibility of tools, byproducts and results.

Successful management strategies and practices must be robust in the context of changing conditions associated with climate change and effective in terms of protecting key ecosystem services for the region and local communities. Scientifically credible decision-support tools built from climate/ecosystem models will provide an essential resource to help policy makers design policies that will aid local decision makers, and help forest managers understand the potential long-term costs and benefits of management choices on forest health and ecosystem services. The experience gained from working with local partners to calibrate and help facilitate the transfer of technologies has laid an effective foundation for the expanded application of these decision-support tools into tropical regions in Southeast Asia. This phase of the project will expand the application range of the decision-support tools established during the previous phase and will enhance the capacity of local forestry communities to use the tools to help them achieve their resource management objectives.

In contrast to phase one, which focused mainly on temperate regions, phase two will focus on Southeast Asian economies, particularly in sub-tropical and tropical regions. Southeast Asia

has been identified as one of the most vulnerable regions to climate change, where adaptive strategies are urgently needed. Five economies have been selected: Chinese Taipei and Malaysia to represent well-developed economies, and Laos and Myanmar to represent less developed economics of the Asia-Pacific region. China has been a key focus of this project, as afforestation and reforestation are prevalent and offer a good opportunity to implement forest adaptation by selecting suitable tree species. Partners from China, Chinese Taipei, Laos, Myanmar, and Malaysia will be specifically engaged in the application of tools throughout the project.

2. Goals and Objectives

The overall goal of this project is to build upon the successfully completed outputs of phase one and continue to substantially improve the capacity of policy makers and forest managers in selected economies to develop robust adaptation strategies to improve the health and productivity of forest ecosystems and their resilience to climate change.

Specific objectives of the project include:

1) Improve and expand the essential tools developed in the previous phase of the project, including climate, niche and process-based models, to further facilitate and promote related research and applications in more locations throughout the Asia-Pacific;
2) Continue to build a strong scientific basis and provide adaptive management options to enhance the target economies' capacity for decision making regarding adaptation to climate change;
3) Expand the network built in phase one and continue capacity building through workshops, communication and policy notes to further enhance information sharing and technology transfer.

3. Outputs and Strategic Activities

Output 1: ClimateAP with future annual climate projections

ClimateAP can generate high-resolution climate data for historical years (1901-2012) and three future periods (2011-2040, 2041-2070 and 2071-2100). It will serve as an essential tool to facilitate and promote climate change studies in the region. We have used ClimateAP to successfully generate climate data for the use of all models in Phase I. However, the limits imposed by projecting future climates for only three periods have become an issue, as modelers and users expect to project the future on an annual basis to reflect annual fluctuations and extremes. This limitation will be overcome in this phase of the project by adding annual projections into the model. In particular, the expanded version of ClimateAP will allow for annual time series projections to be generated for any location in the region in a single run.

Activity 1.1 Data collection and processing

Monthly future climate projection data for the next 90 years (2011-2100) will be downloaded from the IPCC CMIP5 data access portal for two greenhouse gas emission scenarios (RCP 4.5 and RCP 8.5) and three Global Circulation Models (GCMs). In total, 540 (90 years x 2 scenarios x 3 GCMs) climatic layers will be added into ClimateAP. The dataset will include monthly maximum and minimum temperatures and monthly precipitation. The data will be formatted for the calculation of anomalies.

Activity 1.2 Calculations of anomalies

In order to incorporate future climate data into ClimateAP, the absolute values of the downloaded data need to be converted into anomalies relative to 1961-1990 normals. ClimateAP uses anomaly data to downscale future climate projections through a delta approach. All the climate variables for each month for the 540 climate layers will be converted. The anomaly data will then be downscaled from various spatial resolutions (1 – 3.5°, varying among the GCMs) to 1 x 1° and formatted to meet the requirements of ClimateAP.

Activity 1.3 Programming and debugging

It is typically very time consuming to deal with climate data. It will take a number of days just to download the future annual projections. A time series function will be added to ClimateAP to allow users to generate climate data for multiple years in a single run, which will save a tremendous amount of time. Programing and debugging for this function will be achieved in this part of the activities.

Output 2: Assessments of the impact of climate change on forest ecosystems, key species and vegetation types

Ecological models, including climatic niche models and process-based models, will be extended to include more species and entire ecosystems in more economies. Future projections for ecosystems will be particularly important as they may serve as a reference for all species associated with those ecosystems. Meanwhile, we will take advantage of our modeling expertise to improve the current classifications of the existing ecosystems. These projections will provide assessments of the impact of climate change on forest ecosystems and key species in terms of the shifts in geographic distribution of suitable climate niches, species selection and vulnerability to abiotic and biotic stresses. Species, ecosystems and vegetation types to be projected are as follows:

China: two larch (*Larix gmelinii* and *L. olgensis*) species, Scots pine (*Pinus sylvestris*), Yunnan Pine (*Pinus yunnanensis*), black locust (*Robinia pseudoacacia*), Chinese cork oak (*Quercus variabilis*), aspen (*Populus tremula*), moso bamboo (*Phyllostachys edulis*) and entire ecosystems.

Chinese Taipei: *Cyclobalanopsis longinux* (syn. *Quercus longinux*), *Lithocarpus megalophyllus* and entire ecosystems.

Lao, Malaysia and Myanmar: Vegetation types.

Activity 2.1 Vegetation data collection and climate data generation

Species distribution data will be collected for the ecosystems and each of the 10 species from the Institute of Botany, Chinese Academy of Sciences and Chinese Taipei. Digital information

for vegetation types (at 1x1 km resolution) for the economies in Southeast Asia will be obtained from the NASA database. Additional vegetation data from other sources will be added whenever possible. These datasets will be processed and formatted for modeling. The coordinates of the data points will be used to generate climate variables using ClimateAP for the reference normal period of 1961-1990.

Activity 2.2 Development of climate niche models

Random Forest, the machine-learning modelling approach used in Phase I of the project, will be used to build climate niche models for each of the 10 species, ecosystems and vegetation types. In the modeling process, we will first select the most important climate variables from over 200 climate variables generated by ClimateAP. The models will then be optimized and validated using out-of-bag (independent) samples. Once the models are built, we will use them to generate climate niche spatial distributions for the objectives modeled. To do this, we also need to generate spatial climate data using ClimateAP for the reference period of 1961-1990. Meanwhile, we will improve the current classification of ecosystems in China and Chinese Taipei through the machine-learning modeling process and generate a set of climate-based ecosystem classifications, which will be useful for forestry planning and natural resource management under a changing climate.

Activity 2.3 Consensus projections using multiple climate change scenarios

Predicted distributions of the species, ecosystems and vegetation types will be generated for three future periods: 2020s, 2050s and 2080s. To deal with an uncertain future climate, we will project the future distributions with multiple (=>10) climate change scenarios. A consensus projection will be produced for each period based on multiple projections, so that our projections will be more robust than those using a single or a small number of climate change scenarios. For this purpose, we will need to generate a large volume of spatial climate data for each climate change scenario.

Output 3: Evaluations of adaptive forest ecosystem management strategies through model integration, development of indicators and trade-off analysis

One of the ultimate objectives of this project is to facilitate policy discussions through scientifically credible evaluation of existing data and information. It aims to help policy makers and practitioners understand the complex systems they are dealing with, as well as provide opportunities for addressing policy and data gaps to formulate alternative adaptive forest management strategies. We will achieve this objective by developing indicators from the results of the integration of process-based (i.e., TACA and FORECAST Climate) and niche-based models, as well as input from local partners, to conduct trade-off analyses at representative pilot areas in Southeast Asia.

Activity 3.1 Model calibration and simulations

FORECAST Climate and TACA models will be calibrated for key species and ecosystem types within the pilot project areas. We will apply cutting-edge remote sensing technologies to generate cloud-free high-resolution vegetation cover data at pilot areas to obtain parameters (such as leaf area index) for the models. This will serve as an alternative to observations at pilot areas. Representative forest analysis units will be identified within the pilot regions as the foundation for stand-level modelling. A suite of forest management

practices, including adaptive management options for use in simulations with input from local partners, will also be identified. Stand-level simulations will be conducted with models utilizing climate change data generated from the expanded version of ClimateAP to reflect annual variability and extremes.

Activity 3.2 Model integration and indicator development

A coordinated effort will be enforced during the project implementation to ensure that the models presented above are formulated with a smooth feedback mechanism in which one's output or input is easily prepared for another's input and output. Thus, climate change, data and policy gaps, and ecosystem responses can be clearly captured during model integration. Furthermore, the results will be used to develop localized indicators, including climatic conditions, species range and presence, biomass and timber production, carbon storage, and disturbances. We will also focus on model integration at the local level to empower practitioners addressing their management challenges in practice, and/or enable them to bring the information gaps to higher levels for policy and planning discussions.

Activity 3.3 Trade-off analysis

One of the key components of model integration that helps to ensure practical implementation of results is the overall trade-off analysis. The outputs from one model versus another are more often than not contradictory. Consequently, balancing the values and/or management objectives becomes extremely challenging if demands are coming from two or more positions with equal power, especially when decision-makers do not have adequate quantitative measures. Practitioners must carefully identify information gaps, managers must isolate social, economic, and environmental pressures and stresses, and planners must build the challenges into current management plans as known issues, modify the plans to accommodate them, bring them into the next phase of planning, and/or seek policy support. This adaptive management method will greatly enhance science and technology transfers in practice. In addition, understanding the trade-offs and/or synergies between ecosystem services and society will be critical in fostering policy discussions, which will in turn further improve adaptive management practices. As a result, the trade-off analyses not only address information gaps, social pressures, and environmental stressors, but also offer quantitative measures for each decision in the pilot areas.

Output 4: A web platform for data access and visualization for specific economies

A Google Maps based web tool has been developed (climateap.net) to provide a platform for data access and spatial visualization of model outputs. It facilitates and promotes the outreach of project outcomes to users. Due to the large area and the large number of economies in the region, it will be very difficult to interpret these maps if all outputs of the project are piled up on the same map. It is also difficult to visualize local variations on a large map due to limits in color spreads. Economy-specific maps using the same platform will be developed in this project to make the spatial visualization and data access more effective.

Activity 4.1 Generation of maps

Projection maps will be individually generated in ArcGIS and processed to meet the requirements for overlaying on Google Maps. Color regimes will need to be configured to

optimize the effects of spatial visualization. Map legends will need to be separately processed so that their sizes are not affected by zooming.

Activity 4.2 Development of economy-specific web platforms

As the web-based platform is an integration of spatial visualization and ClimateAP, the economy-specific web platform will have the same functions, but it will zoom in on the specific area for each economy, without overlays for other economies.

Activity 4.3 Map uploading and web maintenance

All the economy-specific web platforms will be hosted by the same domain, climateap.net, while each economy-specific web platform will be located at a sub-domain. A mirror site will be hosted at the APFNet website at the completion of the project. The website will be maintained on a regular basis.

Output 5: Networking and capacity building

A comprehensive network, involving scientists, policymakers, decision-makers, practitioners and other stakeholders, will be extended and the capacity of stakeholders will be enhanced through a suite of approaches designed to address the needs of different types of stakeholders. In particular, the capacity of government officials and local forest managers will be enhanced in the area of policy making and policy implementation related to forestry adaption to climate change using the methods described below.

Activity 5.1 Workshops

Two training workshops will be held with the assistance and support of APFNet for the economies in Southeast Asia on application of the tools and models developed by the project. The first one will be held on September 8-10, 2015, in South Africa, as one of the sessions of the World Forestry Congress. This session is intended to share the project and outcomes with the international community at the World Forestry Congress, to promote ways to integrate scientific tools with forest management, and to develop better decision-making strategies at both the management and policy level.

Several of our research team members and renowned researchers around the world will outline their work and explain their area of expertise. The topics to be covered include:

1. Policies for sustainable forest management under climate change.
2. Applications of high-resolution climate models for improved forest management.
3. Techniques for conducting tradeoff analysis of management strategies.
4. Tools to manage carbon storage under climate change.
5. Improving watershed and landscape level forest management under climate change.

This event is consistent with the objectives of the World Forestry Congress in that it will provide technical and scientific tools to promote sustainable forest management, and improve policy and decision-making in the face of climate change. The research and tools to be presented represent cutting-edge developments and innovations in the field of forest management and adaptation to climate change. We hope to share these advances with the broader scientific and political communities, so that the best possible policies and

management strategies can be developed to ensure the continued productivity and vitality of the world's forests.

The second workshop will likely be held in Taipei to demonstrate research extensions on climate adaptation. The workshop will invite government officials, local foresters, and community managers from the AP region to participate. The objective of the workshop is to showcase the extensive scientific knowledge on tree species, ecosystems, and current and future climate impacts in the AP region. In addition, it will demonstrate increased scientific capacity associated with the project through its cutting-edge models and tools for local predicted climate change scenarios, forest adaptation strategies, and ecosystem dynamics. This workshop will further facilitate and promote real action on climate change in the region, allowing the identified gaps in science, technology, and policy regarding adaptation of forests to climate change to continue to be addressed.

Activity 5.2 Network extension and policy notes

Throughout the second phase of the project, the network of scientists, policymakers, decision-makers, practitioners and other stakeholders will be further expanded, with a focus on local foresters and young practitioners.

A second research questionnaire (an extension of the questionnaire used the first phase) regarding gaps in climate policy, technology, actions (both regional and international) and community engagement will be conducted to further investigate the need for climate adaptation.

Regional sustainable forest management policy notes will be delivered based on the outcomes of the training workshop and network development. Several types of notes will be produced, aimed individually at policy makers, statutory decision makers and practitioners.

Activity 5.3 Conferences and publications

Other than the two abovementioned workshops, the project achievements will be presented at regional and international conferences. We also expect to produce about ten scientific papers and the technical reports/guidelines to be published in peer-reviewed journals.

4. Risks and assumptions

In general, this project is low risk. This is because the major tools and technologies have been developed in the previous project, and the main objective of this project is to extend these tools and technologies to a broader region. However, due to limited availability of inventory data in the Southeast Asia areas, the applications of tools and models may encounter some challenges, especially the process-based models. To address this concern, we will apply state-of-the-art remote sensing technologies to generate high-resolution and cloud-free vegetation data to obtain parameters required by the models as an alternative to forest inventory data. We have communicated with our partners and they have agreed to provide relevant inventory data.

5. Human Resources and capacity assessment

Human resources:

Professor John Innes is Dean of the Faculty of Forestry at UBC and, as such, is responsible for an annual budget of approximately $22 million (ca. RMB 150 million). This involves the management of approximately 150 full-time staff and 1200 students, as well as two research forests. He has been responsible for the management and completion of more than 30 research projects, funded by a range of international funding sources. He has previously worked on four projects based in China, including a project looking at the sustainability of the Min River Basin, a project looking at the introduction of certification and its association with forest tenure reform, and a project looking at the impacts of climate change on forests in Jiangxi Province. The proposed project lies well within the financial range of projects that Professor Innes has successfully managed in the past, and he has previous experience of work in China. Professor Innes has close links with forestry schools throughout the region, and will involve these in the extension of the results to a broader area within the region.

Dr. Guangyu Wang is Assistant Dean in the Faculty of Forestry at UBC. Dr. Wang has extensive experience in managing collaborative projects, particularly with partners in China. He has worked with Dr. Innes as a research associate on research projects in China for more than seven years. His research has been recognized by the international community. Dr. Wang will be responsible for project management including coordination of team members, progress monitoring and budget management. He is also responsible for impact assessment, best management practice and forest related policy development, as well as the integration of sustainable forest management under a changing climate. His efficient coordination skills will ensure a smooth implementation of the project plan in a timely manner.

Dr. Tongli Wang is an expert in climate and ecosystem modeling. He is the designer and developer for the widely used climate models ClimateBC and ClimateWNA. His work on modeling forest ecosystems and forest tree species distributions for climate change has been well known and influential in BC and in North America. Dr. Wang has developed the climate model "ClimateAP" for the APFNet project and will add new features to it. He will also be responsible for the development of climate niche models for forest ecosystems and species ranges and consensus projections for the future periods. Dr. Wang will also be responsible for developing the economy-specific Google Maps based platform for data access and spatial visualization of the results generated from this project.

Dr. Brad Seely is a research associate in the Department of Forest Resources Management at UBC. He has 20 years experience in the development and application of forest ecosystem management models and is one the developers of the FORECAST Climate model. Dr. Seely has been involved in several international projects examining the potential impacts of climate change on forest growth and development and has participated in several training workshops for the application of decision-support tools. He will oversee application of the process-based

models within the pilot demonstration areas and will help conduct the training workshops.

Dr. Qinglin Li is an expert in carbon modelling and forest inventory analysis with the government of British Columbia. He is one of the government carbon experts in forest carbon science, climate change research, and modelling. He is also interested in forest management and related policy, ecosystem science and landscape ecology. His expertise in carbon modelling, climate change adaptation and management practice at landscape and regional levels will greatly enhance the project outcomes.

Dr. Nicholas Coops holds a Tier 1 Canada Research Chair in Remote Sensing at the UBC. He has published over 280 total refereed peer-reviewed journal publications over the past 5 years. He was awarded a Killam research scholarship in 2012 and a medal by the Canadian Remote Sensing Society in 2014, the top award for a mid-career scholar in Canadian remote sensing. Dr. Coops will be responsible for applying cutting-edge remote sensing technologies in this project to generate high-resolution vegetation data.

Organizations:

University of British Columbia: As one of the world's leading publicly-funded universities, UBC's location in Vancouver, Canada's gateway to Asia, together with the large population of people of Chinese origin in Vancouver, makes Vancouver a strong location for collaborative ventures with China. UBC has developed long-term relationships with China's government, academic and business sectors. Several faculties, particularly the Faculty of Forestry, have strong links to China and have conducted many research projects including climate change, environmental protection, rural development and sustainable agricultural management. The results of these research projects will be of great help to this project.

UBC Faculty of Forestry is one of the most prestigious faculties of forestry in the world, and a key player in climate change research and related studies. The Faculty is a leading player in the development of high-resolution climate models, modeling and predicting potential impacts of climate change on forest ecosystems and species ranges and developing adaptation strategies for forests. It has a framework that supports a broad range of climate change related studies in western North America. There is a demand to expand this framework to the rest of North America and beyond. Through this project, a similar framework will be built up for the Asia-Pacific region.

Ministry of Forests, Lands and Natural Resource Operations of British Columbia is the government agency to manage forests, lands and all natural resources in the province. Forestry plays an important role in this province and this ministry is well known for the high standard of forest resources management, particularly in the areas of conservation of forest genetic diversity and forest adaptation to climate change.

School of Agriculture and Forestry, National Ilan University, is one of the oldest institutions of higher education in Chinese Taipei. It is a five-year school providing two areas of study: agronomy and forestry. Areas of interest in research and education include

sustainable forest management, natural forest protection and conservation. Climate change and adaptation have been a growing interest in this school.

Department of Forestry, Ministry of Agriculture and Forestry, Laos is responsible for national forestry inventory, planning, monitoring, evaluation and development. It also manages production forests and wood businesses, supervises provincial forestry offices, and manages production forest areas and timber harvesting. Within DOF, there is a REDD+ Office, which was set up in 2012 to support the REDD+ Task Force and to establish a number of technical working groups for REDD+, including those related to the development of reference levels and the MRV system, stakeholder participation and consultation, land-use and benefit sharing.

Federal Forestry Department Peninsular Malaysia (FFDRM) is responsible for the management, planning, protection and development of the Permanent Reserved Forests (PRF) in accordance with the National Forestry Policy (NFP) 1992 and the National Forestry Act (NFA) 1984. At its central office (headquarters), FFDRM is responsible for the formulation of forestry policies, providing technical advice and assistance to the State Forestry Departments with regard to forest planning, management and development, forest harvesting and wood-based industries, forest operational studies, as well as training and human resource development.

Ministry of Environmental Conservation and Forestry, Myanmar (MECF) is a ministry in the Burmese government responsible for the country's forestry and logging sectors. MECF is responsible for evaluating and monitoring the implementation of forest policies, production and work targets, short and long-term planning and the project achievements of the Ministry of Environmental Conservation and Forestry. It includes the following departments: 1) Planning and Statistics Department; 2) Forest Department; 3) Dry zone Greening Department, 4) Environmental Conservation Department, 5) Survey Department, and 6) Myanmar Timber Enterprise.

Faculty of Forestry, UPM, Malaysia is one of the most established tropical forestry education and research institutions in this region, and the most complete forestry school in the country. It includes a Bachelor Science in Forestry, Bachelor of Wood Science and Technology, Bachelor of Parks and Recreation Science, and a number of Masters and Doctor of Philosophy (PhD) programs. The Faculty of Forestry has an extensive network with many universities and agencies abroad and locally, built upon mutually beneficial collaborations, that allow easy mobility of students and faculty to carry out joint-research, practical training and attachments. The faculty has grown to become the leading forestry education center in the country, with a wide array of expertise and support facilities such as the Sultan Idris Shah Forestry Education Centre (SISFEC).

Faculty of Forestry, National University of Laos is the foremost location for higher education in forestry in Laos. The faculty, which developed from a forestry training center to the Vientiane Forestry College and was then upgraded to the current faculty of forestry, consists of the Department of Watershed Management and Land Use Planning, the Department of Sustainable Forest Management, the Department of Wood Industry and Wood

Technology, and the Department of Eco-tourism. In parallel with teaching, the faculty conducts scientific research on forestry, sustainable natural resource management, environment, socio-economic development, etc. The faculty has established a Research Center on Natural Resource Management and Climate Change (NRMCC). This center is currently providing both research/technical services and capacity building.

Forest Research Institute of Myanmar was established in 1856 with expertise in all forestry fields, especially natural forest management and plantation establishment. The Institute has facilities for carrying out the work related to laboratories, experimental facilities, training facilities, etc. It has access to large amounts of data, and is the foremost forestry research institution in Myanmar.

Chinese Academy of Forestry is directly under the State Forestry Administration and is a comprehensive, multidisciplinary, national research institution. The main focuses are forestry applications of basic scientific research, strategic high-tech research, major social welfare research, soft science research, and technology development with emphasis on China's forestry development and ecological construction. The academy now has 4,476 staff workers, including 55 researchers, 230 associate researchers, 90 senior engineers, 654 research assistants and engineers, 730 primary technicians and 600 lab technicians. It has more than 150 disciplines, including 12 disciplines authorized to grant master's degrees and 3 to grant doctorate degrees. The academy is active in academic exchanges and has established cooperative relationships with more than 20 national and international organizations. Since its establishment, the academy has accomplished 715 research achievements and won 245 various prizes, many of them relating to climate change.

Fujian Agricultural and Forestry University is a key university in its province, with focus on production forestry. The university consists of 18 colleges with 63 specialties. Currently, there are 20,802 undergraduate and 2,267 graduate students studying for master’s and doctorate degrees. Employing more than 1000 professors and 2000 supporting staff, the university has become one of most productive universities, with 100 national or provincial technological innovation platforms and research centers. It has a long history working on climate change and its impact on Chinese fir and Masson pine productivities and subtropical ecosystem stability.

Nanjing Forestry University is located in the east of Nanjing City and is a comprehensive university administered directly by Jiangsu Province. There are more than 60 departments in 20 colleges in the university, with a total of 26,000 students, 500 professors and 600 supporting staff. There are 35 R&D research centers, national key open labs, engineering centers, institutes, and divisions approved by the State Forestry Administration and the provincial government. NFU pays particular attention to climate change research programs and has attained great achievements in this area.

Capacity:

The strategic focus of the primary organization (University of British Columbia) is teaching, research and outreach. As one of Canada’s foremost universities, it has a strong record of

research and partnership. The project is consistent with UBC's vision 'to promote the values of civil and sustainable society and to conduct outstanding research to serve the people of British Columbia, Canada and the world'. More specifically, the UBC strategic plan identifies the need to "collaborate with local, national and international communities and problems of global interest in such areas as sustainability… and social and economic development". UBC's location in Vancouver, Canada's gateway to Asia, together with the large population of people of Asian origin in Vancouver, makes Vancouver a strong location for collaborative ventures with the Asia-Pacific region.

UBC has developed long-term relationships with the Asian government, academic and business sectors. Several faculties at UBC, such as Asian Studies, Law School, the Sauder School of Business, the School of Community and Regional Planning, the Asian Research Center, and the Faculty of Forestry, have strong links to Asian countries and have conducted many research projects ranging from Asian social, political, legal and economic systems reform to climate change, environmental protection, rural development and sustainable agricultural management. The results of this research are very helpful for the extension to this project.

Through our research in Phase I, we have developed a strong, scientifically based research team and gained local pilot research experience. The partnering universities and organizations chosen for Phase II are all well known for forest and climate change research in the region. Particularly, they have accumulated long-term historical data, both in climate change and forest management, which will allow our research team to conduct research more effectively and efficiently in this phase of the project.

6. Stakeholders analysis

The countries included in this project are particularly vulnerable to climate change in that the health of human communities and forest ecosystems are often closely linked. Many of the region's forests have been degraded due to over-harvesting and poor management. Lack of scientific evidence and science-based decision-making processes have limited the ability of countries to develop adaptive forest management strategies. Developing sustainable forest management strategies will benefit local communities through the provision of employment opportunities and will safeguard the environment through the inclusion of appropriate criteria and indicators.

- China: Most afforestation worldwide in recent years has occurred in China. Large-scale (>20 million ha) afforestation has been planned for the next 15 years, providing a good opportunity to select forest species suitable for future climates. The output of this project will be able to provide a scientific basis for the selection of suitable species adaptable to future climate changes.
- Taipei: Sustainable forest management, natural forest protection, and conservation are the key mandates for this region. Climate change and adaptation have been taken into account in national strategic development. Application of niche modeling will enable the assessment of vulnerability of existing ecosystems and forests. This information will help this region to set priorities for conservation and adaptation to climate change.
- Laos: Laos is particularly rich in commercially valuable and ecologically unique forests. Due to extensive degradation of forestland, forest restoration has been identified as a future priority. Modeling climate niches of existing ecosystems and assessing the impact of climate change on the ecosystems through this project will directly improve the success of forest ecosystem restoration in this region.
- Myanmar: Forests play a vital role in stabilizing environmentally critical areas such as coastal areas, dry zones, and hilly regions by providing protection against natural disasters. The extremely high floral and faunal diversity in forests of this region require an ecosystem-based adaptive forest management approach to adapt to climate change.
- Malaysia: More than 75% of forestland in Malaysia has been designated as permanent forest reserve and is managed for conservation, timber production, and protection of ecosystem services. Assessing the vulnerability of forest ecosystems and balancing protection and production in a changing climate through this project are therefore crucial.

Table 1: Stakeholders analysis

Stakeholder group	Characteristics	Problems, needs and interests	Involvement in project	Potential benefits
Policy and decision makers	Directly involved with planning, implementing, and managing forests	Uncertainty of forest dynamics under a changing climate, failure of forest management, including regeneration and rehabilitation; interest	Users of the results; Stakeholders are directly involved with the research, such as forest services, ministries of forestry, and forest managers	Improved management capability, adaptability to climate change

		in recommendations on mitigation and adaptation	from the pilot areas	
Forest managers, timberland inventors and owners	Directly benefit from forest management and wood products	Issues of maintaining land productivity and revenue from wood products; need for guidelines on species selection, harvest rotation and management	Users of the results; Stakeholders will be involved in the extension program of the projects and the project outcomes will be disseminated to a large range of stakeholders in the region	Ability to make better investment decisions; increased revenues from forestlands
Forest dependent communities	Rely on the revenue generated from wood products and ecosystem services	The quality of life has been lowered due to the closure of wood mills, ecosystem degradation and deforestation; interests in scientific outcomes and recommendations on mitigation and adaptation	Users of the results; Stakeholders will be involved in the extension program of the projects and the outcome will be disseminated to a large range of stakeholders in the region	Use the outcome of the research to educate locals and support mitigation efforts
Academic and research organizations	Indirect and direct benefits from the research	Lack of scientific data on climate change at a fine scale has limited further research on forest adaption and mitigation; interest in better climate models	Researches will have access to the results, enabling follow-up and complementary research projects	Improved modeling of changes, impacts and adaptation strategies

7. Budget, funding resources and financial management

For a detailed budget, please refer to Annexes D and E. UBC and the Faculty of Forestry would like to contribute $400,000 in kind to the research. Being very important to our Asian outreach and extension, UBC fully supports APFNet and its vision of sustainable forest management in the AP region. UBC has a rigorous financial management system controlled centrally by professional accountancy staff, and an effective financial and research management control framework for the monitoring of the use of funding. Funding will be managed by the UBC Central Office and reimbursements will occur through the department's financial reporting systems. The project will follow systematic approaches to project management, including reporting, review, monitoring, and evaluation, and these will be adopted by the collaborating agencies to ensure successful implementation of the project. The project team will follow the established procedures of annual plans, bi-annual progress reports, quarterly review, and monthly project meetings and video conferencing to identify any gaps between the actual and planned situations. Timely corrective actions will follow to

ensure the efficiency and effectiveness of project implementation and to achieve the ultimate objectives of the project.

Throughout the project implementation, annual work plans will be developed to provide detailed information about project planning and other issues. Biannual and annual progress reports will be prepared covering the expenditures, progress, and achieved outputs according to the annual plan in the middle and at the end of each project year. A financial audit report will be submitted by the Executing Agency (EA) to APFNet to indicate the opening balance, expenditure incurred to date, and the closing balance for the project account. Upon completion of the project, EA will produce a completion report to summarize the activities, inputs, expenditures, achieved outputs and objectives during the entire implementation phase and will identify any major differences between planned and realized budgets.

8. Monitoring and evaluation

A systematic and comprehensive approach, including reporting, review, monitoring, and evaluation, has been developed and adopted by the EA in the previous project. The second phase of the project will follow the management approaches that were developed and used in the first phase. These approaches will also be applied to new Collaborating Agencies (CAs) to ensure the successful implementation of the project when it is initiated.

A monitoring system will be adopted to identify any gaps between the actual situation and the planned situation once the second phase is initiated, depending on the indicators related to each activity listed in the logical framework matrix (Annex A). Afterwards, corrective actions may be necessary to ensure the efficiency and effectiveness of project implementation, to achieve the ultimate objectives of the project, to avoid encountering unexpected delays in such areas as output delivery, and to ensure the timing and actual availability of planned input items (e.g., personnel, equipment, funds).

A periodic progress review (after the completion of each output) will be conducted by the EA to guarantee that the project implementation is on track to achieve the anticipated objectives. This will be done using the associated logical framework matrix and work plan (Annex D) in the project documents as a reference. By actively interacting with project staff involved in the project implementation, and by assessing the progress of the project according to the annual plan, recommendations and changes in actions will be suggested in order to better support the success of the project.

A midterm review and a final evaluation will be conducted in the middle of the project implementation and after the completion of the project, respectively. APFNet will be directly involved in these activities. For the midterm review, experts in the same field will be invited to review the project documents (including proposal, annual plans, and process reports), listen to presentations, interview project team members, and provide evaluations on the project progress status and recommendations for improvements. For the final evaluation, the focus will be on the project final output, the completion report and the technical report. It will also evaluate the potentials of the project output for applications and future development.

9. Dissemination and sustainability

The key to the second phase of this project is to disseminate the major outcomes achieved during the first phase to the AP region through wider demonstration, modeling integration and application. Various workshops, conferences, inclusion in teaching materials, newspaper and journal articles, guided visits of sample sites, and online tools will be used to disseminate the project results.

- ClimateAP can generate scale-free climate data for over 100 climate variables at high accuracy for any locations in the Asia-Pacific. The model has a user-friendly interface and can be used by anyone (i.e., it does not require any specific knowledge). It is so far the best climate model available for the region. It has the potential to be used in any climate change or climate related studies and applications. Potential users are not only limited to foresters and policy makers, but also include hydrologists, climatologist, agriculturists, city planners and builders, as has been the case for ClimateWNA in North America. It will serve as an essential tool and will considerably improve climate change related studies in the region. The remaining issue is to make users aware of the availability of this tool. This issue will be addressed below.
- The climate niche models and their future projections previously generated and to be generated in this project have applied state-of-the-art modeling technologies and considered uncertainties in the future climate. The use of these models will boost the progress of this research area in the AP from lagging-behind to the forefront. Together with outputs from the process-based models, these projections will provide a solid scientific basis for scientists, policy makers and local practitioners in the target economies to formulate forest adaptive strategies.
- The key at this stage is to communicate with a broader range of stakeholders through application, demonstration, capacity building and also community engagement in the five partnering economies: China, Chinese Taipei, Malaysia, Myanmar, and Laos. The scientific and application results should be widely disseminated to all stakeholders, especially to strategic and decision-making bodies in the region.
- Since we gained the capacity to generate long-term climate data and to build ecological niche models for most of the AP region in the first phase, an efficient approach to improve the status of forestry adaptation to climate change is for our scientific team to work closely with APFNet leadership and the project division to provide scientific support to other APFNet demonstration projects in the region. We should also take advantage of APFNet activities such as workshops, conferences, seminars, webinars and training to promote the application of project outcomes.
- The third means is to communicate with and receive feedback from relevant stakeholders to enrich the current project website. The web tool we have developed and improved during this project has facilitated interactive access to historical and future climate data and spatial visualization of the project outputs. The web tool will be helpful to various audiences, including forest managers, scientists, and policy makers directly involved in the project, and those indirectly involved or unable to directly participate in the project.
- In terms of the advancement of relevant knowledge systems, the project outcomes will be compiled into a series of scientific manuscripts for publication in peer-reviewed,

open access journals and books. This is an important part of the project, as publication in peer-reviewed literature will demonstrate the scientific credibility of the results. It will also enable incorporation of the results into future IPCC reports. In addition to scientific publications, various reports will be prepared and submitted to APFNet so that network participants can gain better insight into important outcomes and deliverables from the project.

- A major promotion of the project will be associated with an organized event at the 2015 World Forestry Congress in South Africa, aimed at forest policy makers globally. Based on the IUFRO Conference in 2014 in Salt Lake City, USA, we will also integrate our colleagues around the globe from different climate research fields together to further promote the project. A showcase will also be organized in Taipei, Chinese Taipei to further communicate the scientific tools and models with foresters and local decision makers.
- Several workshops will be held. Forest professionals attending the workshops will be expected to increase their knowledge regarding climate change and related issues. Potential recommendations and solutions will be discussed amongst various focus groups during these training programs.
- In order to engage a wider range of audiences, workshops will be held to inform participants of the latest results and publications. This provides an opportunity to further communicate project outputs, far beyond the original scope. Exchange programs will be available for Chinese forest professionals to the collaborating agencies, allowing them to advance their knowledge and expertise in western countries.

The interaction between academia and government departments through this demonstration and application of climate adaptation will increase understanding and will lead to better formulation of scientific outcomes in policy making, which is often inadequate. This, in turn, may result in changes to policy and legislation, may enhance the adoption of better practices, and may foster better forest law enforcement and governance. The results of this project could be extended to all economies in the Asia-Pacific region to help adapt their forests to climate change.

Sustainability is a significant feature of this project. A large number of peer-reviewed journal publications, technical reports and educational materials have been produced in Phase I of the project and more will be produced in the current phase. These publications have enriched the knowledge base on forestry adaptation to climate change for this region. The tools developed are accessible online. ClimateAP is available for download as a desktop version and is also accessible online as a Google Maps based version. Projections for species ranges in current and future climates are also available for spatial visualization and download. Projections of ecosystems and their associated forest tree species, to be generated in this phase of the project, will also be uploaded onto these web-based tools. Even after the project is completed, these tools and outputs will still be available to users, including policy makers and practitioners.

Annex A: Project sites map and relevant information

The areas involved in this project include the following economies:

China: China is a large (>9.7 million km^2) and diverse country with a wide range of forest resources ranging from boreal mixed woods in the northeast to temperate coniferous forests in the east and on the Tibetan plateau to subtropical mixed and tropical forests in the south. As of the 2009 national forest inventory, about 195 million ha were identified as forested. Plantation forests represent a large percentage of the total forest area and reforestation has been a priority in recent years. Forest degradation represents a problem in many parts of China, largely due to over harvesting of fuel wood and conversion to agriculture. Large-scale afforestation is a significant feature, which offers an opportunity to select forest species for future climates.

Chinese Taipei: Located off the southeast coast of mainland China, Chinese Taipei has a large forest area relative to its size (~36,000 km^2). It contains more than 2 million ha of forestland including several forest types, ranging from tropical hardwoods in the lowland areas to cold temperate conifer forests along a gradient of increasing elevation. Chinese Taipei has a well-developed industrial economy and an established plantation forestland base designed to support a variety of ecosystem services including wood production, carbon storage, watersheds, and conservation of biodiversity.

Laos: Laos, a country with a total land area of 236,800 km^2, is particularly rich in commercially valuable and ecologically unique forests. In 2002, the total forest area was estimated at 41.5% or about 9.8 million ha. By law, these forests are classified into five categories: (i) Production Forest, (ii) Conservation Forest, (iii) Protection Forest, (iv) Regeneration Forest, and (v) Degraded Forest. Production forest covers 33% (3.2 mill. ha) of the forest area, while protection forest and conservation forest covers 10% (1.03 mill. ha), and 49% (4.8 mill. ha), respectively. Regenerated and degraded forests cover the remaining areas. Like many places in Southeast Asia, forest resources and associated ecosystem services in Laos are closely linked to local communities. There has been extensive degradation of forestland due to a

long history of swidden agriculture practices, but forest restoration has been identified as a future priority. The tropical hardwood forest types in Laos are representative of those in other countries in the Southeast Asia region.

Myanmar: The Republic of the Union of Myanmar (Myanmar) is situated at the western end of Southeast Asia. Myanmar is the largest country in Southeast Asia, covering approximately 676,578 km^2 and extending 800 km east to west and 1,300 km north to south. Forests in Myanmar play a vital role in stabilizing environmentally critical areas such as coastal areas, dry zones, and hilly regions by providing protection against natural disasters. Myanmar forests have extremely high floral and faunal diversity. They harbour about 7,000 species of vascular plants including 1,696 species of climbers, 65 species of rattans, and 841 species of orchids. 85 species of trees have been identified as being premium sources of timber.

Malaysia: With more than 18 million ha of its total land area (32.6 million ha) covered with natural forest, Malaysia enjoys one of the highest percentages of forested land among tropical countries. Consequently, the timber and timber products industry are very important and play a significant role in Malaysia's economy. At the same time, there is increasing recognition of the protective roles that forests play, such as the conservation of biodiversity, protection of soil and water resources and stabilization of the climate. Forestlands in Malaysia are dominated by dry inland Dipterocarp forests but also include mangroves and peat swamp areas. More than 75% of forestland in Malaysia has been designated as permanent forest reserve and is managed for conservation, timber production, and protection of ecosystem services. However, deforestation and degradation remain a problem for forest managers.

Annex B: Project logical framework

Items	Intervention logic	Objectively verifiable indicators of achievement	Sources of information and means of verification	Assumptions
Goal	To considerably improve the capacity of forest managers and policy makers to develop robust adaptation strategies to improve the health and productivity of forest ecosystems and their resilience to a changing climate, thereby helping forest ecosystems mitigate and adapt to climate change in the Asia Pacific region.	1. Essential tools to conduct studies and applications for forestry adaptation to climate change; 2. Scientific basis to assess the impacts of climate change and to choose adaptive management options; 3. Personnel with enhanced capacity for adaptive decision-making.	1. Tools will be delivered to APFNet at the end of the project; 2. Scientific basis and adaptive management options will be documented; 3. Reports, extension notes and publications will be submitted to APFNet	The project is based on experiences obtained from the previous project. No factors are beyond our control so far.
Objectives	1. Improving the essential tools developed in phase I of the project to further facilitate and promote related research and applications; 2. Building and extending a scientific basis and adaptive management options to enhance the target economies' capacity in decision making for adaptation to climate change;	1. ClimateAP to generate annual climate projections for the future; 2. Consensus projections of climate niches for ecosystems, key species and vegetation types for the future; 3. Adaptive forest ecosystem management strategies developed through model integration,	1. ClimateAP will be delivered to APFNet at the end of the project; 2. The web platforms will be uploaded and accessible at climateap.net 3. The Consensus projections will be uploaded on the web platform; 4. Adaptive forest ecosystem management strategies will be reported and demonstrated at a	The same as above.

	3. Expanding network and capacity building through workshops, communications and policy notes to further enhance information sharing and technology transfer.	development of indicators and trade-off analysis; 4. An accessible web platform for data access and spatial visualization; and 5. An extended network and enhanced capacity for adaptation of forestry to climate change.	local workshop; 5. Reports, extension notes and publications will be submitted to APFNet	
Output 1	ClimateAP with future annual climate projections	ClimateAP to generate annual climate projections for the future.	The ClimateAP package to be delivered.	N/A
Activity 1.1 Activity 1.2 Activity 1.3	• Data collection and formatting • Calculations of anomalies • Programming and debugging	• Future monthly climate data to be collected and formatted 90 years x 2 scenarios x 3 GCMs • Anomalies to be calculated for all climate layers • Time series function implemented and tested	• Semi-annual and annual reports • Semi-annual and annual reports • ClimateAP software package	N/A
Output 2	Assessments of the impacts of climate change on forest ecosystems, key species and vegetation types	Consensus projections of climate niches for ecosystems, key species and vegetation types for future climates	The Consensus projections will be uploaded on the web platform, which will be accessible with a browser.	N/A
Activity 2.1 Activity 2.2 Activity 2.3	• Vegetation data collection and climate data generation • Development of climate niche models	• Present-absent species data, spatial ecosystem data and vegetation types collected, and climate data	• Semi-annual and annual reports • Modeled spatial distributions of species, ecosystems and	The accuracy of the vegetation data may not be desirable, but it will be the best available.

	• Consensus projections using multiple climate change scenarios	generated • Climate niche models for 10 species, ecosystems in two economies and vegetation types for five economies in Southeast Asia • Huge volume of climate data will be generated using ClimateAP for 10 climate change scenarios, consensus projections for species, ecosystems and vegetation types generated	vegetation types to be presented • Consensus projections to be visible on the web-based platform	
Output 3	Adaptive forest ecosystem management strategies through model integration, development of indicators and trade-off analysis	Model integration of process-based and niche-based models, indicators developed from the model integration and trade-off analysis for alternative management strategies	Implementation at pilot sites	Inventory data will be available. Otherwise, high-resolution remote sensing data will be used.
Activity 3.1 Activity 3.2 Activity 3.3	• Model calibration and simulations • Model integration and indicator development • Trade-off analysis to provide qualitative measures for each management decision	• FORECAST Climate and TACA models will be calibrated for key species and ecosystem types. Stand-level simulations will be conducted • Localized indictors of forest resource values • Qualitative evaluation of	• Output of model simulations and high-resolution cloud-free vegetation dataset • Localized indictors and results of trade-off analysis to be reported • Recommendations for adaptive management decisions	The same as above

		adaptive management decisions		
Output 4	Economy-specific web platform for data access and visualization	A functional web platform	Verifiable through a browser	Google Maps is working or an alternative map application with similar API becomes available.
Activity 4.1 Activity 4.2 Activity 4.3	• Generation of maps • Development of economy-specific web platforms • Map uploading and web maintenance	• Maps and legends with specific color regimes for overlaying • Web platforms ready to host climate data and projections • All the economy-specific web platforms deployed and mirror sites at APFNet being setup	• Reports and demonstrations	N/A
Output 5	Network and capacity building	• A network involving scientists, policymakers and stakeholders; • Workshops, extension notes, conferences and publications	Reports and workshops	N/A

Annex C: Project organization chart