TOOLS ON ADAPTATION OF ASIA-PACIFIC FORESTS TO CLIMATE CHANGE

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Acknowledgment

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Acronyms and abbreviations

APFNet Asia-Pacific Network for Sustainable Forest Management and Rehabilitation

BC British Columbia

UBC University of British Columbia

CNM Climate niche model

ClimateAP A model that can be used to downscale historical and future climate data for Asia-Pacific

FORECAST Forestry and Environmental Change Assessment

IPCC Intergovernmental Panel on Climate Change

Executive Summary

The ecosystems of the Asia-Pacific region are particularly vulnerable to climate change as temperatures and aridity are expected to increase more rapidly in a large part of this region than the global average. Climate change is considered to be the most important threat to the capacity of forest landscapes to provide ecological, economic and social services, and mitigating and adapting to climate change are therefore pressing challenges for the scientific community, stakeholders and policy makers in this region. The potential for forests to mitigate climate change through carbon sequestration represents a major opportunity for forestry.

Since 2011, APFNet has funded 2 phases of projects on Adaptation of Asia-Pacific Forests to Climate Change. There are totally 7 economies and regions targeted, including China, Chinese Taipei, Australia, Canada, Malaysia, Laos, Myanmar, and 18 tree species and ecosystems examined and predicted under the impacts of climate change, with 8-year endeavor, the projects phase I (2011-2014) and phase II (2015-2018) have supported the development of several important tools that will aid forest managers to develop effective strategies to address the challenges presented by climate change, which include Climate AP, climate niche models and Forecast models.

APFNet is pleased to share this compilation of modeling tools for forestry under a changing climate, and hope that would be helpful in terms of assisting with efforts to improve the situation in their respective economies.

Introduction

According to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC), temperatures are predicted to rise an average up to 4.8°C globally by the end of the century. This magnitude of temperature rise and its associated climatic changes could overwhelm the resilience of even the most adaptable forest ecosystems and threaten their components, including plants and animals. Bioclimatic envelopes (suitable climate niches) for the current forest ecosystems and their components, particularly forest trees, are predicted to shift much more rapidly than the forest trees can migrate naturally. As a result, some local forest tree species currently occurring in these ecosystems will not be able to adapt to their local environments in the future. This will compromise the productivity and resilience of these ecosystems, and may change the forest landscapes from carbon sinks to carbon sources.

The appropriate management of existing forests and the planning of the new plantations are critical to the adaptation of forest ecosystems to climate change, and to enhance the role of forests in mitigation of climate change. However, there is remarkably little evidence of sufficient quality to be incorporated into science-based decision-making, and as a result, there is considerable uncertainty over the most appropriate policies to enable forests and forest-dependent communities to adapt to climate change. There is a critical need to acquire relevant scientific knowledge and to develop fully functioning networks of scientists, stakeholders and policy makers. To address this gap, the APFNet has funded 2 phases of projects on Adaptation of Asia-Pacific Forests to Climate Change, which developed state of the art tools and models and enhance capacity building and scientific knowledge.

ClimateAP-A high-resolution climate model for Asia Pacific

What is ClimateAP?

Coverage of ClimateAP – a climate model that provides data with:

- High-resolution, high accuracy climate data for AP region
- 208 climate variables for any specific location Historical and future time periods
- A time effective, user-friendly interface

ClimateAP is a cutting edge modeling tool that can generate high quality, high-resolution climate data for the historical (1901-2012) and future (2020's, 2050's, 2080's) time periods. It makes access to climate variables as easy as access to geographic variables, allowing users to generate climate data for any location within the Asia-Pacific.

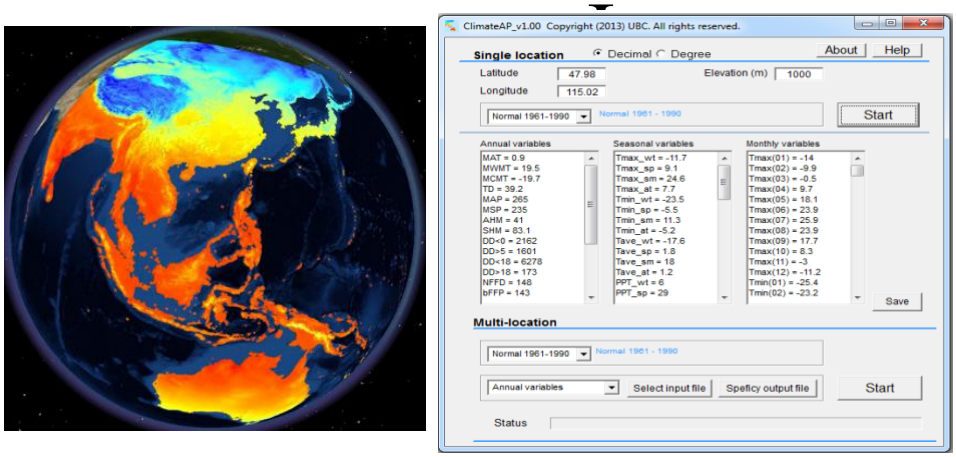


Figure 1 The interface and the coverage of ClimateAP

Historical and future time-series functions in ClimateAP enable users to obtain climate data time-series for multiple locations by a few clicks.

ClimateAP-Web version (http://Climateap.net)

With web-based ClimateAP embedded in Google Maps, users can access climate data and visualize climatic and species distribution maps locally or regionally by zooming in or out. ClimateAP's simple interface (web version) requires no installation or mapping skills.

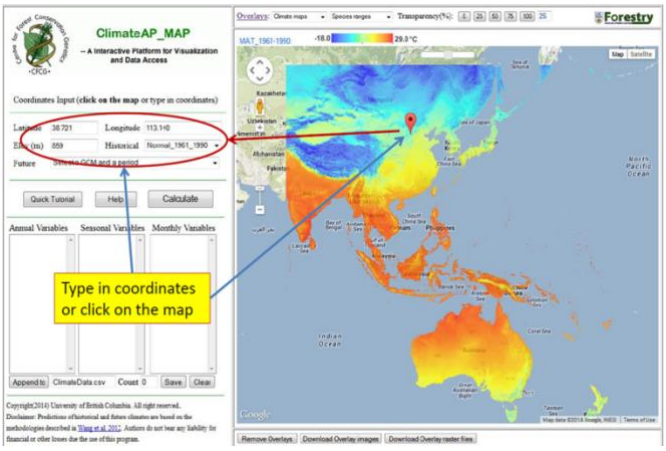


Figure 2 Interface of web-ClimateAP

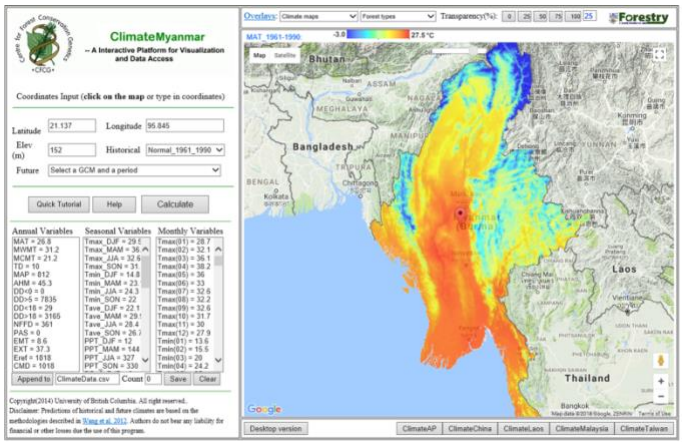


Figure 3 Interface for Climate Myanmar

Why is ClimateAP important?

ClimateAP is an invaluable tool for climate change research and decision-making. The availability of a high quality, easy to use modeling tool such as this will substantially increase and improve climate change related research in the Asia-Pacific. The high-resolution climate data generated by ClimateAP can be matched with locally specific vegetation data, allowing it to be used for:

- Modeling climate niche of ecosystems and species
- Determining population responses to climate change
- Generating accurate predictions of species and ecosystem distribution

By predicting the impacts of climate change on ecosystems, species and populations, ClimateAP can help forest managers and policy makers to formulate and implement targeted and effective adaptation strategies to address climate change effect.

How is ClimateAP being used?

ClimateAP has been used extensively by researchers at UBC and local partners to develop ecological models and provide forest management recommendations to address effect of climate change in AP region.

Its precursor the ClimateBC developed for the province of British Columbia (BC), Canada. ClimateBC has been widely used to develop series of ecological models for BC ecosystems and important tree species, which is currently used by the government as a basis for developing climate-based species selection (CBSS) and climate-based seed transfer (CBST) tools. For instance, ClimateBC has been used for predicting potential shift in distribution of Douglas fir, one of the most important timber species in Canada. In response to this finding, the BC government developed a climate-based seed transfer system to mandate plantation of Douglas fir further north in the province to sustain economic growth and production. However, such application and tools have not been developed yet in the Asia Pacific region, with the ClimateAP, and the most important tree species modeled in many economies in Asia-Pacific, such tools and application as in BC can be extended to the region.

Who can use ClimateAP?

ClimateAP can be used by anyone, including researchers, forest managers, and policy makers. It has a straightforward, user-friendly interface, and requires no installation or mapping skills, making it easily accessible to a wide range of stakeholders. With only a few clicks, users can obtain data for multiple locations and multiple years. A free desktop version of ClimateAP is available through subscription.

A Google Maps based web tool has been developed (http://climateap.net) to provide a platform for data access and spatial visualization of model outputs. In order to increase the effectiveness of spatial visualization and data access, economy-specific web platforms have been developed for

each of the five pilot economies. With the new platforms, climate data and forest ecosystem and/or species distributions can be accessed and visualized for individual economy.

Climate niche models-projecting climate niche of species and ecosystem

Climate niche model

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.

Three unique features of climate niche models:

- Accurate climate data: Climate data from ClimateAP represents specific locations instead of grid average;
- State-of-art modeling: Random Forest and multiple forests;
- Consensus projection: projection are based on 15 climate change scenarios.

Climate niche models for species

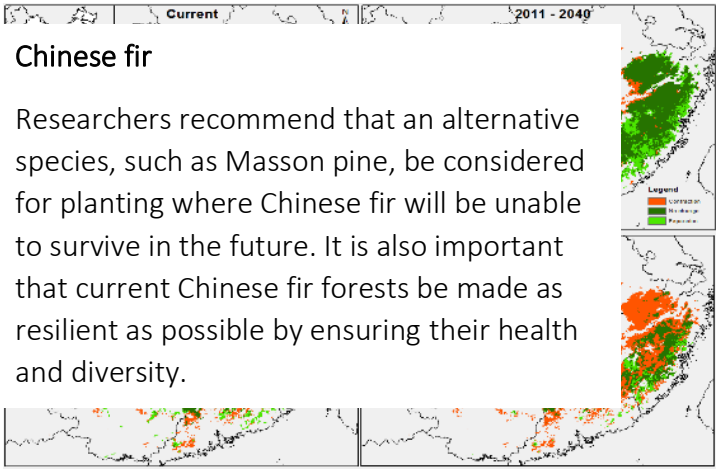


Figure 4 CNM for Chinese fir in China

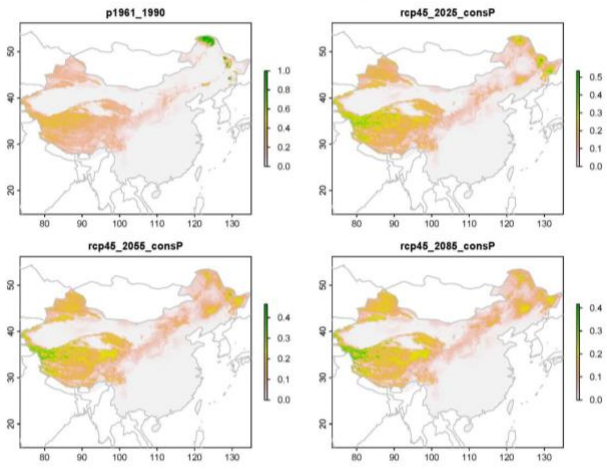
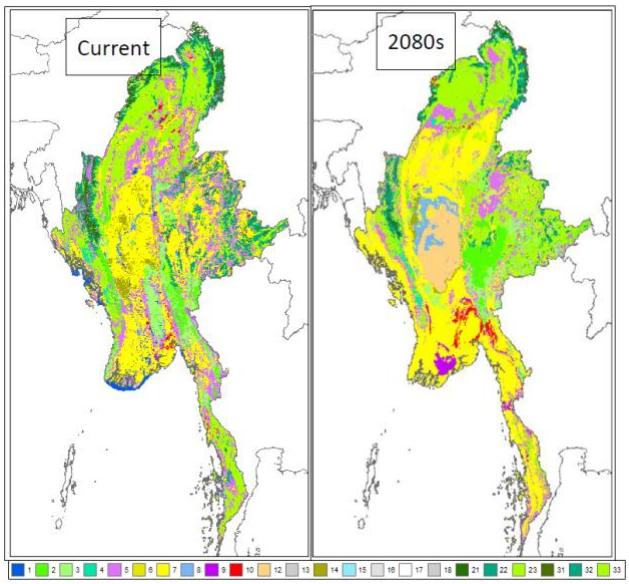


Figure 6 CNM for Scots pine

Scots pine *(Pinus sylvestris Var.mongolica)*

Forest managers should be cautious while they are identifying suitable growing areas for this species in future looking at drastic range contraction in future. Recent observation of sharp increase (since 2016) in number of dead trees of this species may be as a result of this. Therefore, it is recommended to consider alternative tree species plantation in those unsuitable area whereas assisted migration may be considered in the future suitable area in Southwest Tibet (Tibet and Qinghai) for checking their potential in future. Being one of the most important afforestation tree species, it is also important that current pine species be made as resilient as possible by ensuring their health and diversity.

Climate niche models for ecosystems



Spatial distributions of forest ecotypes in Myanmar under the current and a future

Policy implication

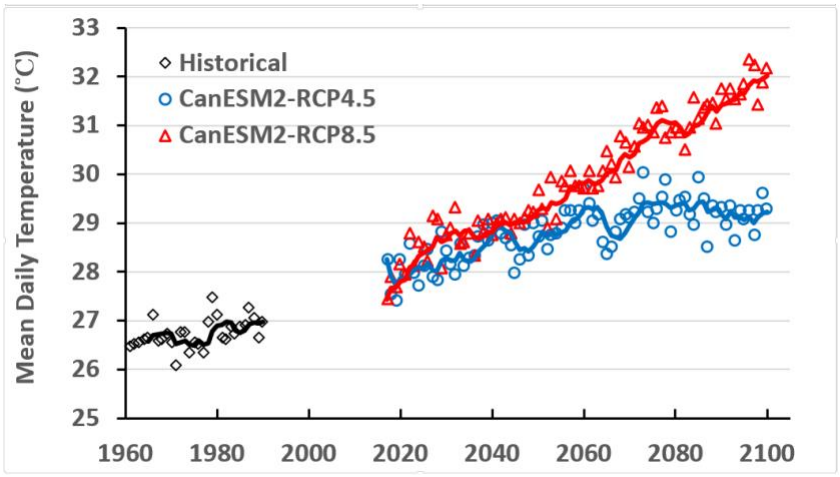
Forest managers should monitor forest health in broadleaf and needle-leaf ecotypes. Species and provenance trials may be helpful to identify climate resilient species towards targeted regeneration.

FORECAST/FORECAST Climate model-evaluating climate impacts on species

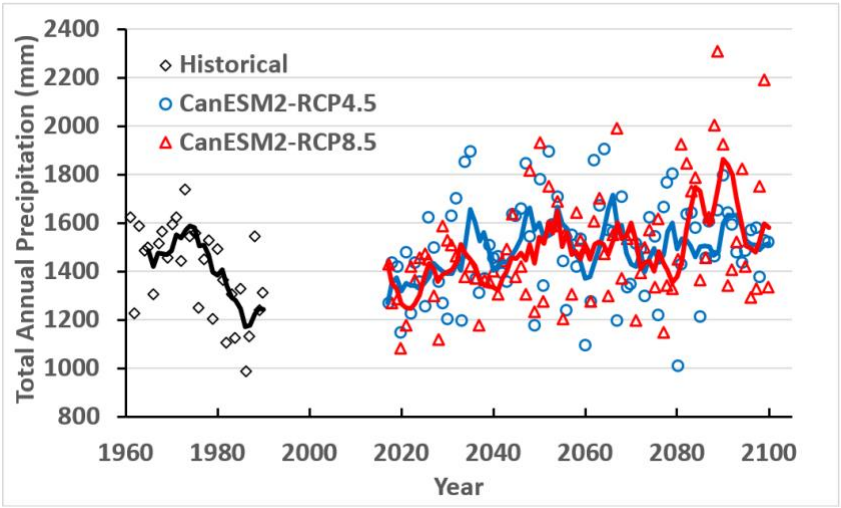
FORECAST/FORECAST Climate model can be used for trade-off analysis to evaluate the impacts of various alternative managements and climate change scenarios on species/forest productivity, water balance, nutrient cycling and carbon storage.

Output from tools such as this will allow forest managers, resource planners, and policy developers to generate targeted and adaptive management strategies, and successful long-term forestry policy while facilitate and improve the accuracy of future climate research in the region.

Case study: Climate Change Scenarios



A result of FORECAST Climate model for Chinese fir plantations in Fujian province predict modest increases in productivity (6.1 to 12.1%) over the next 30 to 60 years (2013-2110) due to a lengthening of the growing season.



A result of FORECAST Climate model for Teak plantations in Myanmar predict modest increases in productivity due to a lengthening of the growing season.

Management Scenario

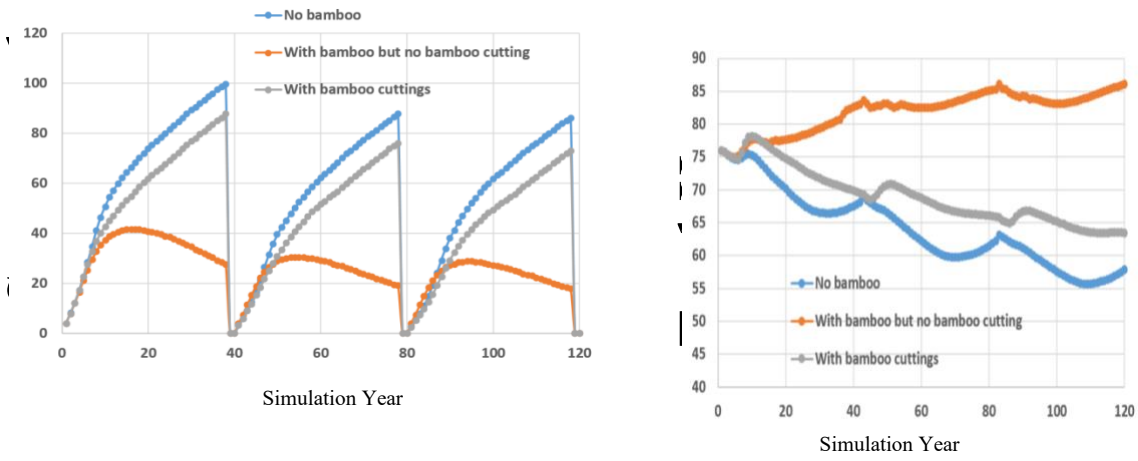


Figure 5 A result of FORECAST model for teak plantation productivity in Myanmar with and without Bamboo competition.

Bamboo is commonly associated with teak in the study area, and it is seen as an indicator of deep, rich, well-drained soils on which teak also develops well. Many studies indicates that retaining or intercropping bamboo in teak plantations may help in improving soil fertility thus making the plantation more productive.

Model results (Fig.8) suggest that bamboo competition will result in reduction of teak productions. Without regular bamboo cutting, bamboo would out-compete teak. Compared to pure teak plantation, the survival rate of teak was higher in the plantation with bamboo regenerated+ cutting across three rotations. Although Bamboos could lead to reduction in teak productivity, they can increase the soil organic matters (SOM) thus improve soil fertility. Appropriate control of the compatibility and interspecific competition between bamboos and tree species should be done for full use of the available resources.

Back and forward

Forests play an indispensable role in mitigating and adapting climate change. In 2017, the establishment of APFNet was included it in the Sydney Declaration on Climate Change, Energy Security and Clean Development to promote and improve sustainable forest management and rehabilitation in the region. As one of it's priority, APFNet has been mitigating climate change

through forest rehabilitation and sustainable forest management, as well as climate change focused project here we talk about. As the international community has recently embarked on a new era of sustainable development through Agenda 2030 and the Paris Agreement on climate change,in the future, APFNet will continue to work with regional governments and international organizations to migrating global challenge, and acting as a strong link between the global policy agenda and economy-level policy development and actions.