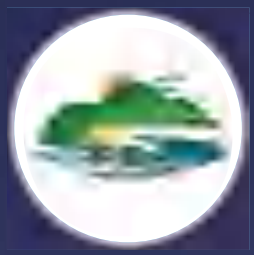

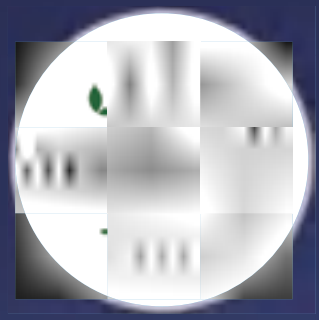

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Asia-Pacific Network for Sustainable Forest Management and Rehabilitation

China Forestry Publishing House

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ABOUT APFNET

The Asia-Pacific Network for Sustainable Forest Management and Rehabilitation (APFNet) is a non-profit international organization dedicated to advancing sustainable forest management and rehabilitation in the Asia-Pacific region.

In spite of an increasing awareness of the importance of managing forests sustainably toward achieving green growth, reducing poverty and responding to climate change, large gaps still exist in knowledge and capacities at global and regional levels. The establishment of the organization was proposed in this context by China and co-sponsored by Australia and the United States at the 15th APEC Economic Leaders' Meeting, in Sydney, Australia, in September 2007. The proposal was adopted by the APEC Leaders and incorporated in the *Sydney Declaration on Climate Change, Energy Security and Clean Development*, in an effort to "enhance capacity building and strengthen information sharing on sustainable forest management in the forestry sector" in the region.

APFNet was officially launched in September 2008, with its arrangement and operations guided by the Operational Framework, evolved from the Framework Document jointly developed by China, Australia and the United States.

AUTHORS

This book was prepared by Mr. Li Zhaochen and Ms. Anna Finke from the Project Management Division of the Asia-Pacific Network for Sustainable Forest Management and Rehabilitation. Design is the work of Ms. Julie Chua.

CONTENTS

EXECUTIVE SUMMARY

The Asia-Pacific Network for Sustainable Forest Management and Rehabilitation (APFNet) aims to promote and facilitate sustainable forest management (SFM), forest restoration and increase livelihoods in the region in an integrated manner. As such, demonstration sites showcasing best practices for a wide range of topics over long periods of time provide APFNet with some of the best tools to effectively enhance progress in its key focus areas, mentioned above. The Pu'er location in Yunnan, China, is perhaps APFNet's most ambitious endeavor, yet. At this site, a wide variety of demonstration projects on SFM, integrated forest ecosystem management, agroforestry, forest fire monitoring, and forestry planning are combined with an integrated training and forest experience base, the *APFNet Pu'er Sustainable Forest Management Demonstration and Training Base*, which provides key facilities for forestry training, capacity building, conferences, forest experience, environmental education, and much more. This unique combination of demonstration sites and training facilities enables APFNet to promote relevant forestry knowledge in an integrated manner that combines theory with practice. This book has been produced to describe in detail all APFNet activities conducted in Pu'er and give the reader a comprehensive understanding of the knowledge that has been gained so far.

In **Chapter 1,** forestry in China at large, China's reforestation efforts to date and relevant forestry plans will be described. Furthermore, the region of Yunnan, where Pu'er is located, its connection to the Greater Mekong Subregion (GMS), APFNet's work in the GMS and the city of Pu'er, as well as Wanzhangshan Forest Farm (WZSFF), the key partner in all APFNet projects there, will be briefly described.

In **Chapter 2,** sustainable forest management and APFNet's related demonstration projects in Pu'er will be described. This includes a look at the short- and long-term forest management plans developed under the project, different silvicultural models and tools recommended in the plans, tree growth models used, and predictions regarding carbon stock growth made. In terms of forest management, as the demonstration project aimed to compare and contrast different forest management models, each of these models will be introduced in detail. This includes intensive management practices of commercial plantations, such as large diameter tree cultivation, management practices for public welfare forests to improve their ecosystem functions, understory planting of epiphytes and different sustainable resin tapping techniques.

In **Chapter 3,** APFNet's work in forest fire monitoring, especially via the installation of a "Forest Fire Monitoring and Early Alarming System" (FFMEAS), which is a camera-based fire detection system aiming to monitor forest fires, detect fires early and prevent them from escalating, will be described.

In **Chapter 4,** the APFNet Pu'er Base, with all of its facilities, will be introduced. Specifically, the overall goals of the base, the different themed buildings, including a description of the economies or cultures they represent, will be outlined, also showcasing its facilities to support regional forestry information sharing and training, environmental education and research.

Finally in the **concluding chapter**, we look forward in terms of the future development of the base and anticipated uses.

We hope this book will not only give you a comprehensive understanding of APFNet's work in Pu'er, but also show how an integrated demonstration site can be designed. We furthermore wish for the knowledge provided in this book to inspire improved forestry practices amongst practitioners and policy makers in the Asia-Pacific region, after all this is what APFNet's work is ultimately about.

CHAPTER 1

INTRODUCTION

1.1 FORESTRY IN CHINA

China is an economy relatively poor in forest resources. These resources are under great pressure due to a large and increasing population, accelerated urbanization, and the booming Chinese economy (Turnbull, 2007). However, during the past several decades China has made tremendous efforts in afforestation and reforestation, taking active steps to increase its forest cover. As such, since the 1980s the Chinese government has followed a national policy of encouraging tree planting. In 1984, the first ever forest law for protecting the forests and improving environmental quality in China was created.

1.1.1 CHINA'S REFORESTATION EFFORTS

In order to increase the forest cover and improve the forest quality, between 1990 and 2020, the National Forest and Grassland Administration (NFGA, Box 1) launched several nationwide programs that aimed both at solving regional environmental problems and improving domestic ecological conditions and rural livelihoods (Wang et al., 2021). These forestry development programs include the Natural Forest Protection Program (NFPP), the Conversion of Cropland to Forests Program (CCFP, also called the Grain for Green Program), the Desertification Combating Program around Beijing and Tianjin (DCBT), the Key Shelterbelt Development Programs in the Three-North Region and in the Middle and Lower Reaches of the Yangtze River (KSDP, also known as the Three-North Shelterbelt Program or the Great Green Wall of China) and the Wildlife Conservation and Nature Reserve Program (WCNR).

As a result of the basic national forestry policy and programs, accompanied with increased investment from the central and provincial government, China has successfully stopped the loss of forests and even managed to reverse the trend. Compared with the forest area reported in its 1st National Forest Inventory (NFI), carried out in the early 70s, the 9th NFI, completed in 2019, shows that China's forest area has expanded from 121.86 million hectares (ha) to 220.47 million ha, and the forest cover has risen from 14 percent (%) to almost 23% (NFGA, 2019; Figure 1). Amongst the 236 economies covered by FAO's Global Forest Resources Assessment (FAO and UNEP, 2020) its reforestation efforts have been the highest both in terms of forest area increase and money invested. China also made a key contribution in achieving the APEC 2020 Forest Cover Goal, where the forest area increased 26.5 million ha during 2007–2020, contributing about 95 percent of the total increase among all 21 members of APEC (APEC, 2021).

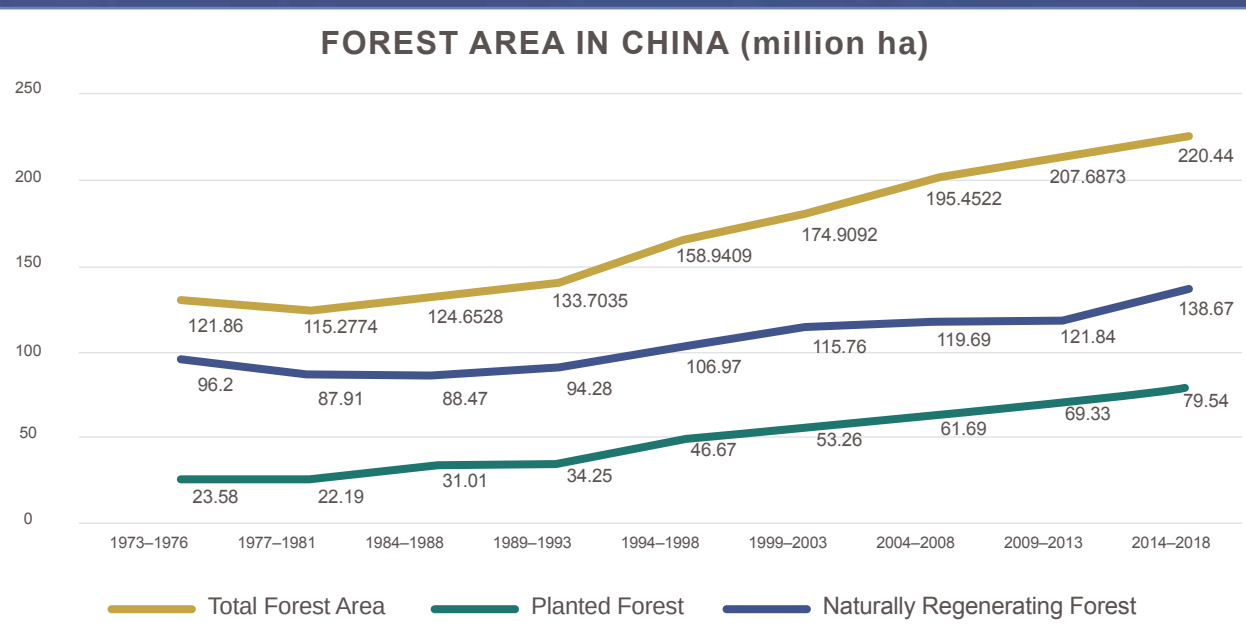


Figure 1: *Forest area change in China (Source: 1st – 9th National Forest Inventory, SFA and NFGA, China)*

BOX 1: The National Forestry and Grassland Administration (NFGA)

The National Forestry and Grassland Administration (NFGA) oversees the conservation and management of China's grasslands, forests, wetlands and wildlife at the national level and is governed by China's Ministry of Natural Resources. The NFGA is the result of a merger of the State Forestry Administration (SFA) and the grassland management section from Ministry of Agriculture in China's institutional reform in 2018 in order to more effectively manage natural resources, which in reality often overlapped. Under the NFGA, the key programs aiming to restore forests are managed. Additionally, the administration is responsible for creating long-term and 5-year strategic forestry plans outlining national priorities. Key forestry laws and regulations regarding the sustainable management of forests are also issued by the administration. While the National Park Administration oversees the national parks system of China, the NFGA oversees China nature reserve system, as well as national forest parks, public forests, natural forests, grasslands, wetlands amongst others. While the NFGA operates on the national level, there are also provincial and city-level departments that work on overseeing more local issues.

1.1.2 FORESTRY GOALS AND STRATEGIC FOREST PLANS

The NFGA primarily guides its work through two different strategic plans, one long-term plan that defines the overall direction of Chinese forestry, and short-term plans, that outline the specific activities in a five-year time frame, each time. The most current plan is the 14th Five-Year Plan. Any subsequent goals and activities on both national and local level are to be aligned with these two plans.

NATIONAL FOREST MANAGEMENT PLAN (2016–2050)

To guide China's forest management for the next 35 years, the National Forest Management Plan of China (2016–2050) was issued by the State Forestry Administration (the predecessor of the NFGA) in 2016. Its aims are to adapt China's forest harvest and utilization to local site conditions, encourage large-diameter timber production, promote the application of multifunctional forest management concepts and technologies, and maintain healthier and more stable forest ecosystems. According to this plan, China aims to increase its forest cover from 21.63% in 2013 to 26%, increase the forest stock volume from 15.14 billion cubic meters (m^3) to 23 billion m^3, and increase the average stock volume to 121 cubic meters per hectare (m^3/ha) compared with 89.79 m^3/ha in 2013. The total carbon stock aims to reach 13 billion tons from a baseline of 8.43 billion tons in 2013.

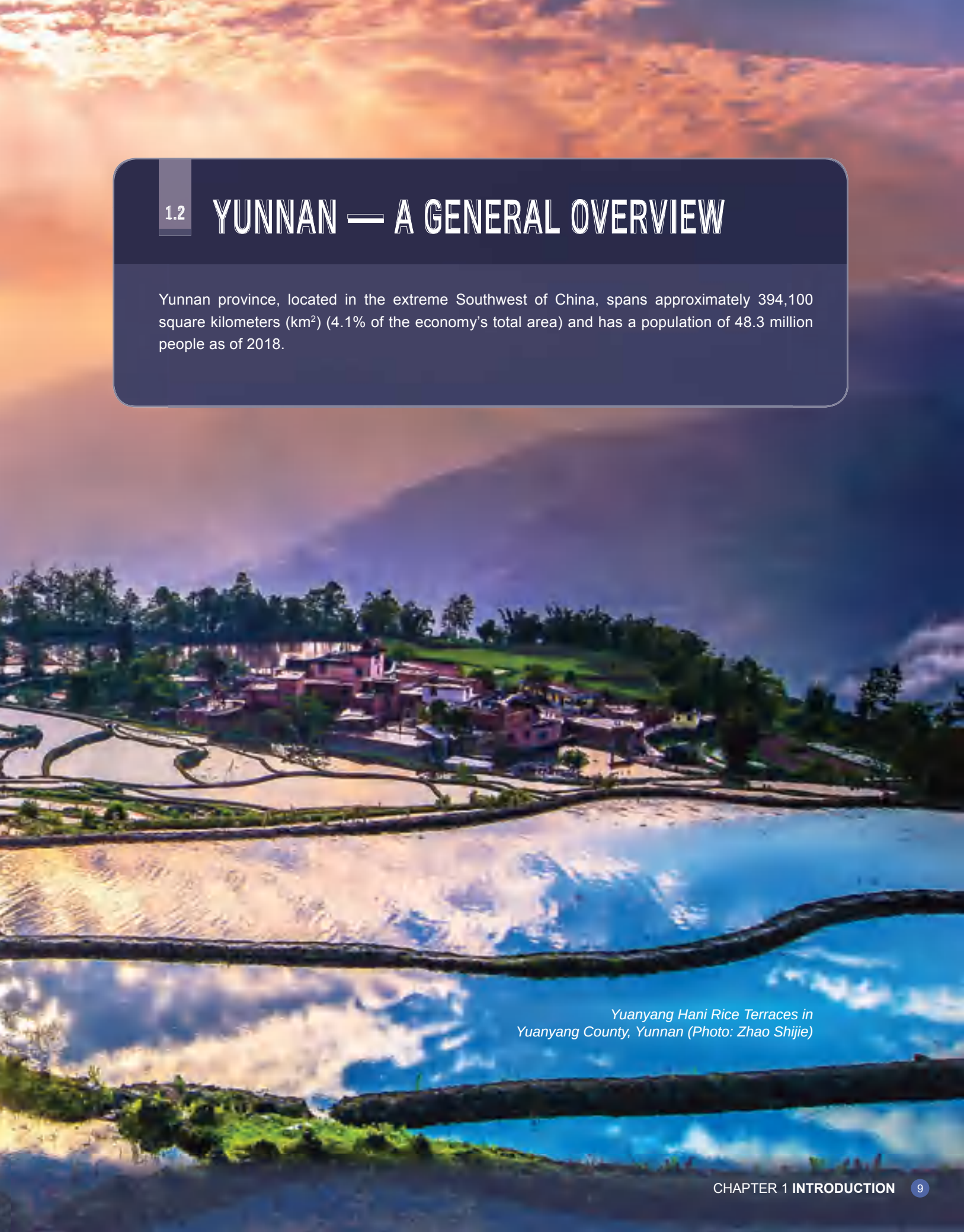
14TH FIVE-YEAR PLAN (2021–2025)

China's 14th Five-Year Plan (2021–2025) introduces an increased focus on the protection and development of forestry. As such, China aims to increase its forest cover from 23.04% in 2020 to 24.1% by 2025. To help achieve its carbon emission reduction goals, China plans to plant 500 million *mu* (about 33.33 million ha) of forests, shrubs and grasslands in the next five years — 100 million *mu* per year, which includes planting 54 million *mu* of trees and 46 million *mu* of grass each year. The economy also aims to raise its forest stock volume to 19 billion m^3 by the end of 2025, an increase of 1.4 billion m^3 from 2020.

Large scale forest restoration program in Chifeng, Inner Mongolia (Photo: China Pictorial)

1.2 YUNNAN — A GENERAL OVERVIEW

Yunnan province, located in the extreme Southwest of China, spans approximately 394,100 square kilometers (km^2) (4.1% of the economy's total area) and has a population of 48.3 million people as of 2018.



Yuanyang Hani Rice Terraces in Yuanyang County, Yunnan (Photo: Zhao Shijie)

Moutains in Yunnan

1.2.1 CLIMATE

Yunnan is situated in a mountainous area, with high elevation in the Northwest and low elevation in the Southeast, the altitude variance is more than 6,600 meters(m). Yunnan has a generally mild climate with pleasant and fair weather because of the province's location at the south-facing mountain slopes, receiving influences from both the Pacific and Indian oceans. Much of the province lies within the subtropical highland or humid subtropical zone, with mild to warm winters and temperate summers, except in the southernmost part, where the climate is almost tropical to truly tropical and temperatures regularly exceed 30 degrees Celsius (°C) in the warmer half of the year. In general, average temperatures in January range from 8 to 17°C; July averages vary from 21 to 27°C. Average annual rainfall ranges from 600 to 2,300 millimeters (mm), with over half of the rain occurring between June and August due to monsoonal influences. The plateau region has moderate temperatures, while the western canyon region is hot at the valley bottoms, but has freezing winds at the mountain tops. Although the growing period is long, the rugged terrain provides little arable land, which only accounts for 13.7% of the total land of Yunnan. Since much of the arable lands is located in mountainous areas, many Yunnan people use land terracing techniques to grow their agricultural products. The best example of this may be the famous Yuanyang Hani Rice Terraces, which are the first agricultural heritage and the first world heritage site named after an ethnic group.

1.2.2 BIODIVERSITY

The unique geographical situation and diverse climatic conditions of Yunnan result in a rich biodiversity and abundant natural resources. Accounting for only 4.1% of China's total land area, Yunnan is the province with the most abundant biodiversity in the economy. The number of species of each genus here approaches or exceeds half of the national total. With 19,333 species of higher plants and 2,273 species of vertebrates, it harbors 50% of the economy's plant, bird and mammal species. In Yunnan, there are 60 vertebrates under national first-class protection, 182 vertebrates under national second-class protection, 45 wild plants under national first-class protection and 108 wild plants under national second-class protection. In the past three decades, more than three thousand new species have been discovered here, accounting for one-third of the total number of newly discovered species in China. Yunnan is crowned as the "kingdom of animals and plants" and the "gene bank of species". To protect the natural resources and biodiversity, as of 2020 Yunnan already established more than 166 natural reserves, and started establishing national parks since 2006. There are eight national parks already established and another five in the process of getting established as of 2021.

Left: The black snub-nosed monkey, a large black and white primate that lives only in Yunnan, listed as an endangered species by the IUCN Red List (Photo: Li Xiaojian)

Bottom: The black-necked cranes in Shaotong, Yunnan, a near-threatened species as classified by the IUCN Red List (Photo: Xi Zhinong)

1.2.3 FORESTRY

As of 2020, the forest area of Yunnan is around 23.9 million ha with a forest cover of 62.4%, and the forest stocking volume is 2.02 billion m^3, ranking second in China. Although Yunnan has abundant forest resources now, the forest cover was only 22.57% by the end of the 1970s due to over-harvesting during the previous decades, which resulted in the loss of over two-thirds of its original forest cover. The overharvesting at that time has depleted forests and led to serious soil erosion, local impoverishment, flooding and loss of life in the lowlands. Since 1998 the government banned commercial logging in natural forests, allowing only very restricted cutting for domestic use. In the same year, the Natural Forest Protection Program was started in Yunnan, followed by the Conversion of Cropland into Forests Program in 2000, which both played a crucial role in bringing forests back in the province. Since the 1970s the government has progressively returned land use rights to local farmers, enabling them to manage their forests and benefit from them more effectively. This process accelerated after the 2000s with the collective forest tenure reform. More than 8.4 million forest farmers now directly or indirectly benefit from managing their forests.

With diverse climatic conditions, the forest ecosystems in Yunnan can mainly be classified into tropical forests and subtropical forests, with tropical forests including rainforests and seasonal rainforests, and subtropical forests including monsoonal broad-leaved evergreen forests, semi-humid evergreen broad-leaved forests, subtropical coniferous forests and temperate coniferous forests. With the increase of altitude, cool temperate coniferous forests, cold temperate coniferous forests, shrub meadows and alpine mossy vegetation are also occurring(Figure 2).

Tropical rainforests in Yunnan (Photo: Zhao Shijie)

Figure 2: *Forest classification map of Yunnan Province*

Cold temperate coniferous forests in Yunnan (Photo: Li Fang)

CONNECTION TO THE GREATER MEKONG SUBREGION (GMS)

The Lancang-Mekong River, the sixth-longest river in Asia (4,909km), is a transboundary river in East Asia and Southeast Asia. From the Qinghai Tibet Plateau the river runs through China (Qinghai, Tibet and Yunnan), then crosses Myanmar, Lao PDR, Thailand, Cambodia, and flows into the ocean in Viet Nam. The Mekong acts as a major trade route between Western China and Southeast Asia. Yunnan, located on the lower basin of Mekong River and bordering with Viet Nam, Laos and Myanmar, is an important gateway for trade and cooperation between China and the rest of the Greater Mekong Subregion (GMS, Box 2).

BOX 2: The Greater Mekong Subregion

The Mekong River is a transboundary river in East Asia and Southeast Asia. Its estimated length is 4,909 km, and it drains in an area of 795,000 km^2, discharging 475 km^3 of water annually. The Mekong Basin can be divided into two parts: the "Upper Mekong Basin" in Tibet, and the "Lower Mekong Basin" from Yunnan, downstream from China to the South China Sea. The Greater Mekong Subregion stretches over Cambodia, China (specifically Yunnan Province and Guangxi Zhuang Autonomous Region), Lao People's Democratic Republic, Myanmar, Thailand, and Viet Nam.

The GMS is one of the world's most important areas for biodiversity, home to an incredibly wide range of ecosystems. The subregion's valuable natural capital — including extensive water resources and fertile soils — is central to the subregion's economic development. All the GMS economies are increasing their efforts to ensure environmental sustainability and to develop green growth pathways. Approximately 60 million people live in the Lower Mekong Basin, with many relying on forests to sustain their livelihoods. However, the river basin faces significant deforestation and forest degradation threats.

In 1992, with the assistance from the Asian Development Bank (ADB), the aforementioned six GMS economies entered into a program of subregional economic cooperation designed to enhance inter-economy relations. With support from ADB and other donors, the *Greater Mekong Subregion Economic Cooperation Program* enabled the implementation of high-priority subregional projects in agriculture, forestry, energy, environment, health and human resource development, information and communication technology, tourism, transport and trade facilitation, and urban development. In addition, starting from 2013, the Chinese government launched the Belt and Road Initiative (referring to the "Silk Road Economic Belt and 21st Century Maritime Silk Road"), intending to promote economic cooperation among economies along the proposed Belt and Road routes. The GMS area is one of the important subregions for future economic and general cooperation.

The Lancang-Mekong River

1.2.4 APFNET'S WORK IN THE GMS

The GMS is one of APFNet's priority regions for promoting sustainable multifunctional forestry and forest rehabilitation, as well as livelihood improvement. The cooperation with economies in the GMS subregion started as early as 2009, only a year after APFNet was launched in 2008, and many of the activities were done with joint support from the forestry authorities and academia in Yunnan Province. Below is a selection of current initiatives.

APFNET KUNMING TRAINING CENTER (APFNET-KTC)

The APFNet-KTC is a regional forestry institution, which was established in November 2012 in Kunming City, Yunnan, China, by APFNet in cooperation with the Southwest Forestry University (SWFU). It aims to promote capacity building of forestry practitioners and government officials in the Asia-Pacific region in the areas of forest rehabilitation and sustainable forest management through organizing a series of thematic training workshops, cooperative research, experience exchange and information sharing activities.

@WILD

The APFNet Transboundary Wildlife Conservation Initiative (@Wild), established in 2018, is a platform focusing on conservation of wildlife in transboundary areas in the GMS region. @Wild works with relevant departments of wildlife protection in the region to strengthen cross-border cooperation on wildlife protection, provide a platform for exchanging information and hosting policy dialogues, and enhance the level of regional conservation and management.

SINO–ASEAN NETWORK OF FORESTRY RESEARCH INSTITUTES (SANFRI)

In 2018, APFNet proposed to establish the Sino-ASEAN Network of Forestry Research Institutes (SANFRI) to advance forestry research by facilitating collaboration among forestry research institutes and thus contribute to the advancing of sustainable forest management among ASEAN economies and China. The network not only provides a platform where forestry research institutes exchange research trends and findings, but more importantly, is pinpointed by four on-the-ground actions. The four specific actions include the APFNet Conference Attendance Support, the APFNet Research Fellowship, the APFNet Small Research Grant and the Early Career Academics Forum. The target group is scientists working in the forestry field, especially young researchers among member forestry research institutes in ASEAN economies and China.

DEMONSTRATION PROJECTS

APFNet projects aim to demonstrate best practices for sustainable forest management and rehabilitation, amongst other topics. They also help member economies to build their forest management capacities, promote rehabilitation of degraded forests and improve local livelihoods. As of August 2022, APFNet has conducted 56 projects in 23 economies in the Asia-Pacific region and 18 in the GMS region. Specifically in the GMS, demonstration projects cover a large range of topics, such as forest restoration, non-timber forest product (NTFP) planting and agroforestry, forest fire monitoring, urban forestry, transboundary wildlife monitoring, forest carbon accounting, wetland restoration, and much more.

1.3 PU'ER

Pu'er, situated in a small basin among mountains in the southern part of Yunnan, is an important location at China's southwestern border, neighboring Laos, Viet Nam and Myanmar and sharing 486 kilometers(km) of border with these three economies. Pu'er is the main production area of the famous Pu'er tea, which is a kind of dark tea, also known as fermented tea. Pu'er has been the tea distribution and trade center since the Tang Dynasty (618–907 A.D.). The tea was carried to Lhasa, Tibet, by local horse caravans, together with a number of other trade goods, such as fur and local medicinal herbs, which resulted in the *Tea Horse Road*, now a popular tourist attraction. There are many ethnic minorities living in Pu'er, such as the Lahu, Hani, Wa and Yi, which together account more than 60% of the total population of Pu'er. The tea culture, diverse ethnic foods, ceremonies and costumes are strong attraction points for tourists.

Pu'er, as much of southern Yunnan, has a warm humid subtropical climate, with only a muddled distinction between the seasons and daytime temperatures remaining warm year-round. Temperatures peak in April and May before the rainy season and fall to a minimum in December. The warmest and coolest months are June and January, with 22.7 °C and 13.4 °C, respectively, the annual mean temperature is 18.9 °C. June through September accounts for nearly 70% of the annual rainfall of 1,487 mm and during this time, some rainfall occurs on most days, pushing relative humidity above 80% with a marked reduction in sunshine. Benefitting from these good climatic conditions, Pu'er also has high biodiversity and abundant natural resources. There are more than 5,600 higher plant species and 1,496 animals in Pu'er, and the forest cover is as high as 68.7%.

Pu'er prefecture is also a major timber production area. Unfortunately, for decades, conflicts between forest conservation and use have challenged both policymakers and practitioners. The lack of comprehensive long-term forest management plans and technical expertise have further exacerbated the situation, even on the prefecture's largest forest farm — Wanzhangshan Forest Farm.

Figure 3: *Traditional performance of a Yunnan ethnic minority (left) and the Water-sprinkling Festival of the Dai (right) (Photo: Zhao Shijie)*

Figure 4: *From left to right: A tea plantation, tea being dried, traditional Pu'er tea*

Aerial view of Pu'er city

WANZHANGSHAN FOREST FARM (WZSFF)

Wanzhangshan Forest Farm (WZSFF) is a state-owned forest farm (Box 3) that manages its forests as an enterprise since its establishment in 2001. The farm's forest land is still owned by the government, but the forests are cooperatively managed as a local business according to government guidelines. Adhering to the forest management concept of "Strengthen forest cultivation, prioritize the ecological functions of forests, manage and use forests in a sustainable manner", the forest resources continue to grow and the stand quality has significantly improved. The forest lands managed at WZSFF cover an area of 19,120 ha, including public welfare forests (7,986.7 ha), commercial forest (9,413.3 ha), and other forests (1,720 ha). The forest cover is 80.85%, and the total stocking volume is 2.155 million m^3.

Logo of WZSFF

The forest farm is in the transition zone from the North tropical zone to the South subtropical zone. The vegetation types include seasonal tropical rainforest, deciduous seasonal rainforest, monsoonal broad-leaved evergreen forest, deciduous broad-leaved forest, evergreen coniferous forest and secondary shrub forest. Like many other places in Yunnan, WZSFF also has a rich biodiversity and abundant natural resources. There are nearly 2,000 species of wild animals, including more than 10 species of national first-class protected animals, such as gray langurs (*Presbytis phayrei*), glossy ibis (*Plegadis falcinellus*), silver pheasant (*Lophura nycthemera*) and Asian water monitor, and nearly 30 species of national second-class protected animals. More than 2,000 species of higher plants species, including *Rattus jujube* are national first-class protected plants, and 10 more species are national second-class protected plants like golden hairy dog (*Cibotium barometz*), Chinese tree fern (*Aleuritopteris grevilleoides*), and *Magnolia macrophylla*.

BOX 3: State-owned Forest Farm

China's state-owned forest farms were established through government investments shortly after the People's Republic of China was founded in 1949. Forest farms aim to manage and cultivate public forest resources while also protecting and improving the natural environment. State-owned forest farms operate as public institutions in China, and play an important role in China' s forestry system. After more than 50 years of development, a total of 4,855 forest farms are currently managing 56.67 million ha of public forest land, that is more than a quarter of the total forest area in China. There are only a few forest farms operating as enterprises, such as Wangzhangshan Forest Farm, most of the others are run as public institutions.

Headquarters of WZSFF (Photo: Li Xianze/WZSFF)

1.4 APFNET PROJECTS AT WANZHANGSHAN

APFNet started its cooperation with WZSFF in 2016 with launching the demonstration project Integrated forest ecosystem management planning and demonstration project in the Greater Mekong Subregion (Pu'er Project Site) (see Chapter 2). This project is one sub-project among a total of five, which is a series of projects focusing on integrated forest ecosystem management in the GMS region, specifically in Cambodia, China (Pu'er), Lao PDR, Myanmar, and Viet Nam. At Pu'er, science-based forest management plans have been developed, and a network of site-specific demonstration sites have been established to showcase different forest management models for both public welfare forests and commercial forests, trying to meet socioeconomic and ecological goals for different types of forests. Understory planting and resin tapping technologies are also demonstrated for local livelihood improvement consideration.

Since Pu'er is located in the transition zone between tropical and subtropical forests, APFNet finds it is the best place to showcase forest management practices for both zones in the GMS and other tropical subtropical regions. Starting in 2019, APFNet supported the forest farm to establish the APFNet Pu'er Sustainable Forest Management Demonstration and Training Base, which is the second training base of APFNet, this time focusing on SFM and multifunctional forestry in tropical and sub-tropical areas. The other base is the APFNet Multifunctional Forest Management Demonstration and Experience Base in Wangyedian Forest Farm, Inner Mongolia, which showcases practices relevant for temperate and boreal forest management. The Pu'er Base was officially launched and put into operation in July 2021. Pu'er Base offers opportunities to conduct scientific research related to forests and forestry, forestry training, environmental education and a platform for information exchange and policy dialogue to promote sustainable forest management in the GMS and other regions in Asia-Pacific (see Chapter 4).

To protect the forests and reduce forest fire risk in WZSFF, during 2020–2021 APFNet also installed the "Forest Fire Monitoring and Early Alarming System (FFMEA)" through another demonstration project, aiming to monitor forest fires, detect fires early and prevent them from escalating and thus protect the forest resources. Four forest fire monitoring towers and two control centers were built at the forest farm, which allows the monitoring of the whole Pu'er Base and 50%–60% of the total forest area of WZSFF (see Chapter 3).

The demonstration sites of three APFNet projects at Wanzhangshan Forest Farm are presented in Figure 5.

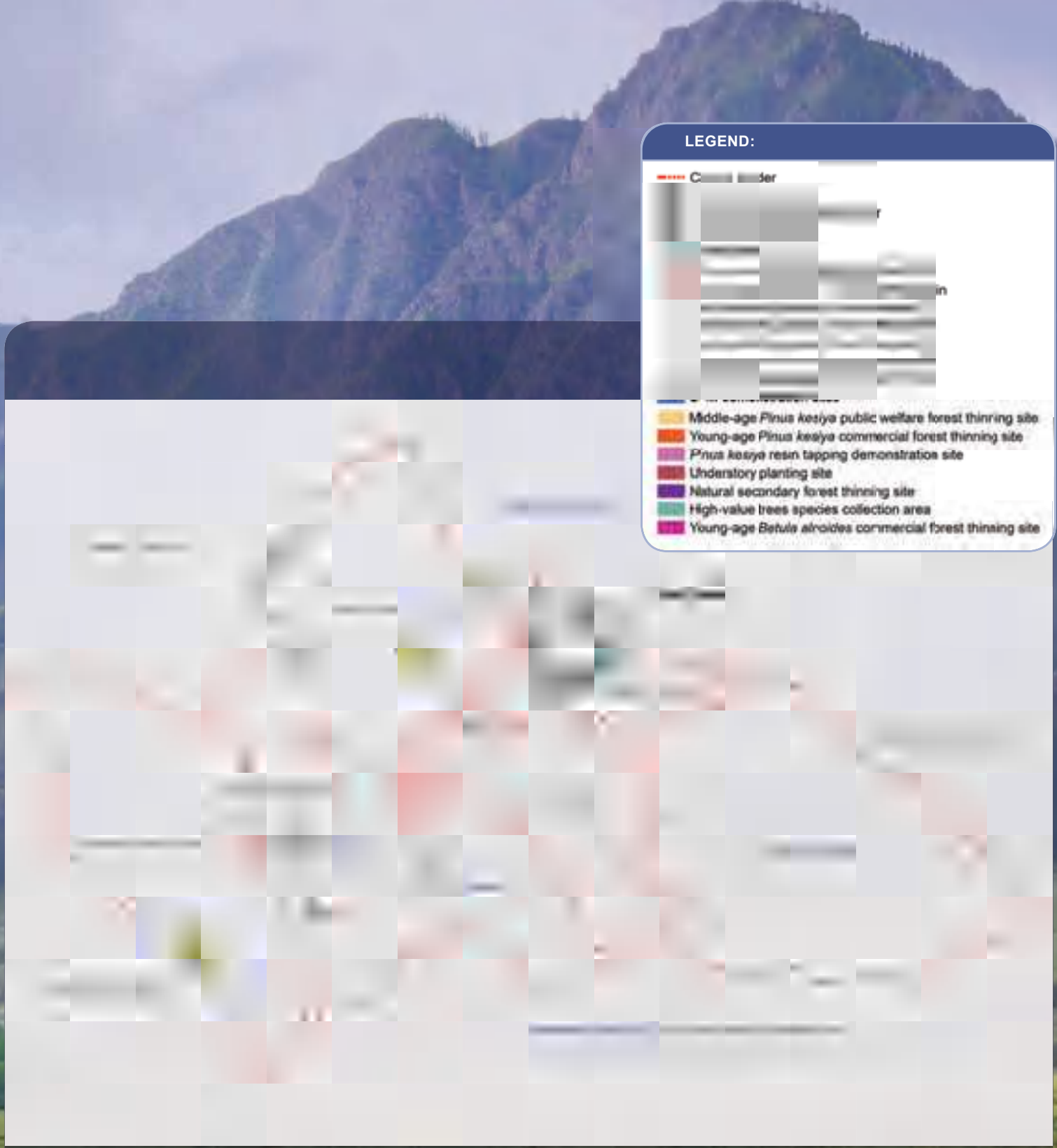


Figure 5: *Demonstration sites of APFNet projects at Wanzhangshan Forest Farm (WZSFF)*

CHAPTER 2

SFM IN WANZHANGSHAN

2.1 FORESTRY PLANNING

Science-based forestry planning is an important part of modern forestry, and it is also the first step to realize sustainable forest management. With a long-term vision and appropriate interventions, it guides forest managers to improve the quality of forests and establish a stable forest ecosystem to meet with the various needs of socio-economic development. In 2015, the Chinese government rolled out national reforms targeting all state-owned forest farms in response to the lack of long-term plans, inflexible operational mechanisms, and low resilience of forest farms. The major objectives of these reforms were to change the primary goal of forest farms from timber production to forest conservation and integrated ecological restoration, and improve the governance structure to form streamlined and efficient forest resource management agencies. The reforms required all forest farms to develop science-based forest management plans in order to cultivate and preserve national forest resources in the long term.

In response, through the Integrated Forest Ecosystem Management Planning and Demonstration Project in the Greater Mekong Subregion (Pu'er Project Site, P. R. China) [2016P1-GMS-PE], APFNet helped WZSFF develop a *20-year Master Plan of Integrated Forest Ecosystem Management (2017–2036)* to provide long-term integrated planning for forest ecology and forest health, forestry industry, institutional matters and training of personnel. In addition, a more detailed *10-year Multifunctional Forest Management Plan (2020–2029)* was prepared to meet the objectives set in the master plan. These plans will serve as frameworks to inform policymakers and guide practitioners, and increase the ecological, social and economic benefits of the forest farm in the long term, while also serving as a model for partner economies in the GMS region.

INTEGRATED FOREST ECOSYSTEM MANAGEMENT PLANNING AND DEMONSTRATION PROJECT IN THE GREATER MEKONG SUBREGION (PU'ER PROJECT SITE, P.R.CHINA) [2016P1-GMS-PE]

Supervisory agency: Forestry and Grassland Bureau, Pu'er Prefecture
Executing agency: Wanzhangshan Forest Farm, Simao District, Pu'er Prefecture
Total budget: USD 1,210.085.40
APFNet grant: USD 829,858.24
Start date and duration: January 2017 to December 2021, 60 months, extended to April 2022
Site location: Wanzhangshan Forest Farm, Simao District, Pu'er Prefecture

OBJECTIVES:

- Develop the *Master Plan of Integrated Forest Ecosystem Management (2017–2036)* and the *Multifunctional Forest Management Plan (2020–2029)* for WZSFF;
- Establish integrated forest ecosystem management demonstration plots, and select the optimal forest management models to showcase the best practices on managing both commercial forests and public welfare forests;
- Establish the project sites as best practices on integrated forest ecosystem management in the GMS through project dissemination and capacity building.

BOX 4: Forest Classification in China

The *China Forest Law* of 1998 (also the latest amendment of the *Forest Law* in 2019) divides forests into two categories — ***public welfare forests*** (also called ecological forests) and ***commercial forests*** — according to use purpose. Based on the *China Forest Law*, the forest lands and the forests with an important ecological location or in ecologically fragile conditions, for the main purpose of ecological benefits, are classified as public welfare forests. Forest lands and the forests not so designated are commercial forests.

In 2016, the National Forestry and Grassland Administration (NFGA) published the *National Forest Management Plan (2016–2050)*, which further sub-divides forests into three categories: (a) ***strictly protected public welfare forests***, those located in ecologically important and fragile areas needing total protection; (b) ***multifunctional forests***, those are forests with the potential to play an important role in ecological protection, carbon trading, and the production of non-timber forest products and services; and (c) ***intensively managed commercial forests*** for industrial uses and timber production. The plan also clarified the meaning of multifunctional forest management.

It should be noted that while the formal mention of multifunctional forests in the strategic plan is an important step, because the *China Forest Law* only classifies forests into two categories, forests are now effectively only managed as public welfare forests and commercial forests. There are no systematic policy or regulations on the management of multifunctional forests in China as of yet.

2.1.1 MASTER PLAN OF INTEGRATED FOREST ECOSYSTEM MANAGEMENT (2017–2036)

Given the fact that Pu'er City wants to follow a clean development pathway, it needs to balance social, economic and environmental needs. WZSFF, known as one of the largest forest management units in Pu'er, shoulders the responsibility of protecting the forest resources and managing them properly. Through a comprehensive analysis of the status of the forests of the farm through forest baseline data obtained between 2012 and 2016, while also taking into consideration the long-term sustainable development of the farm, APFNet, together with the Yunnan Forestry and Grassland Academy (YFGA), helped the farm develop a *20-year Master Plan of Integrated Forest Ecosystem Management (2017–2036)*. The plan provides scientific guidance for WZSFF to carry out the key tasks of forest management activities for both commercial forests and public welfare forests (Box 4), from afforestation, tending, and thinning to harvesting; as well as some other aspects like forest protection and conservation, multiple use of forest resources, infrastructure construction, or development of eco-tourism.

The investigation results of 2016 show that, although the forest cover is high (80.7%), the quality of the forests still hasn't reached its full potential. For example, stocking volume is 139.7m^3/ha which is relatively low compared with similar areas with intensive forest management [e.g. planted forests in Peru are at an average of 319.4 m^3/ha, and for Brazil it is 272.33 m^3/ha (FRA, 2020)]. The age structure of the forests is also unbalanced, with young and middle-aged forests accounting for more than half of the total forest area. The Master Plan aims to significantly improve the forest quality of the farm within the next 20 years. It is estimated the forest cover rate will only increase by 1%, from 80.7% to 81.7% with 170 ha of land reforested, but the total stocking volume is projected to reach 4.74 million m^3 from 2.155 million m^3 in 2016, so that the unit stocking volume could increase from 139.7 to 303.85 m^3/ha by 2036.

Master Plan Key Data and Objectives

Forest area: 15,430–15,600ha
Forest cover: 80.7%–81.7%
Stocking volume: 2.155–4.74m^3

Other main objectives of the master plan include:

- Develop a short-term 10-year multifunctional forest management plan for the farm;
- Practice science-based forest management ranging from afforestation to tending, thinning and harvesting;
- Promote the productivity of commercial forests through intensive management and conserve natural resources and protect biodiversity, especially in public welfare forests, through integrated forest ecosystem management;
- Promote the development of understory planting of NTFPs and other alternative uses of forest resources to improve people's livelihoods;
- Promote modern forestry development, including installing a forest fire monitoring system and constructing other relevant infrastructure;
- Build an international forestry cooperation platform and the Sustainable Forest Management Demonstration and Training Base through APFNet;
- Capacity building.

2.1.2 MULTIFUNCTIONAL FOREST MANAGEMENT PLAN (2020–2029)

Multifunctional Forest Management (MFM) is guided by the principles of sustainable forest management. The concept of MFM was developed more than 60 years ago in the US with the *Multiple Use-Sustained-Yield Act* passed in 1960. MFM is a forest management concept that combines two or more objectives at the same time, such as production of wood or wood-derivative products, wildlife protection, protection against floods and erosion, recreation, or protection of water supplies.

Arguments regarding the suitability of MFM for China have been going on for a long time. The core contradiction originates from the forest classification and management system in China. Forests are formally classified into commercial forests and public welfare forests through the *1998 Forest Law* in China (Box 4). Furthermore, China operates through a forest-classification-based management strategy, which means the forest management policies and regulations strongly depend on the classification types, especially regarding commercial forests and public welfare forests. And while multifunctional forests are classified as one forest category in the *National Forest Management Plan (2016–2050)* by the NFGA in 2016, there are still no systematic regulations on the management of multifunctional forests in China, resulting in practitioners still effectively treating multifunctional forests as either commercial or public welfare forests.

Figure 6: *Cover page of the Multifunctional Forest Management Plan (2020–2029)*

APFNet holds the idea that multifunctionality is deeply embedded in the nature of forests, and forests can and should be managed with multiple purposes as objectives in mind. Starting from 2011, APFNet has been demonstrating multifunctional forestry in different places, such as the "Construction of Multifunctional Forest Management Demonstration Project" in Wangyedian, Inner Mongolia, China, and the "Multifunctional Forest Restoration and Management of Degraded Forest Areas" project in Cambodia. However, these projects only show demonstration site-specific MFM practices without developing an overarching multifunctional forest management plan. Thus, to showcase MFM at the forest management unit, as well as to serve as an indispensable addition for the 20-year Master Plan, APFNet developed a *10-year Multifunctional Forest Management Plan (2020–2029)* (MFMP) for WZSFF (Figure 6).

The 10-year plan has the following key components.

FOREST MANAGEMENT ZONES

Based on the current forest condition, combined with the forest management objectives, policies and regulations, the forest area of WZSFF is sub-divided into six zones: 1) a Timber Production Zone; 2) an Ecological Use Zone; 3) a Nature Reserve Zone; 4) an Arboretum Zone; 5) a Recreation and Urban Forestry Zone; and 6) a Research and Demonstration Zone (Table 1, Figure 7).

TABLE 1: Forest management zones with dominant functions

Management Zone	Management Objective	Area (ha)
Timber Production Zone	Intensive management to maximize timber production	9,558.98
Ecological Use Zone	Integrated management focusing on improving the ecological functions/services of the forest. Non-timber forest products can be cultivated and harvested	3,641.21
Nature Reserve Zone	Located mainly in watersheds, logging ban, management of forests with the primary goal to protect water quality and soil. Biodiversity protection is also one focus in this zone	3,319.45
Arboretum Zone	Establishing an arboretum for tropical and subtropical areas	2,181.08
Recreation and Urban Forestry Zone	Improve the aesthetic value of forests, promote forest recreation and ecotourism	447.73
Research and Demonstration Zone	Scientific research and best practice demonstration	171.12

Note: The total area of the 5 forest management zones is 19,320 ha which is the size of all land managed by WZSFF, not the current forest area.

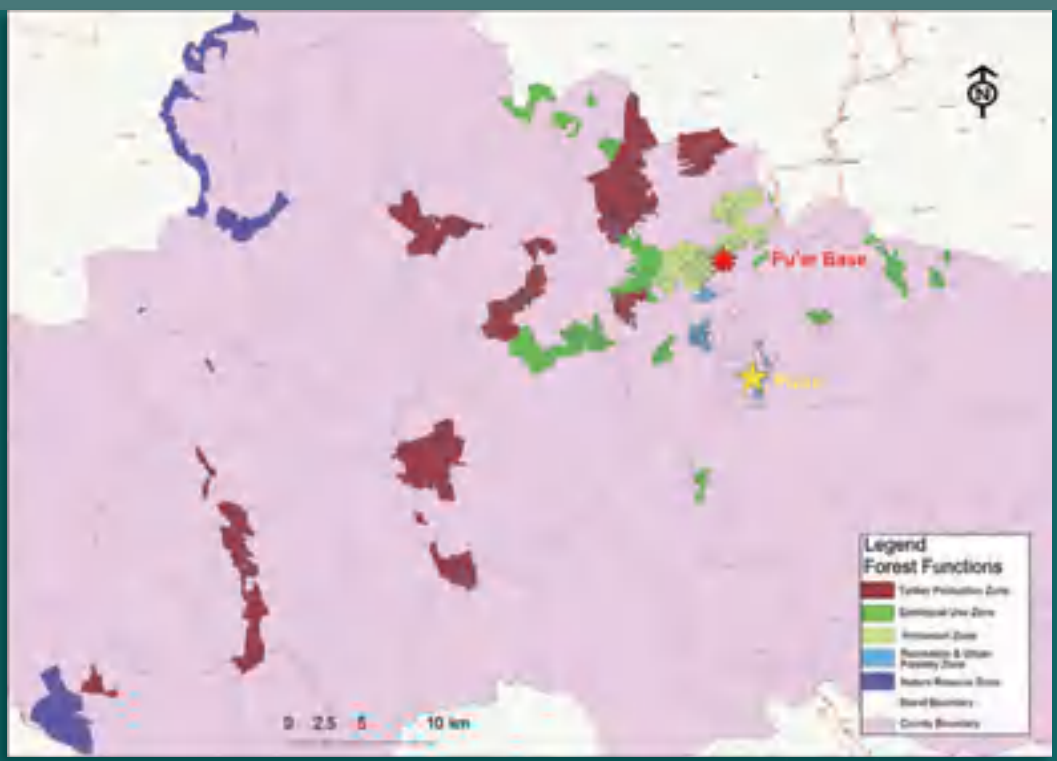


Figure 7: *Wanzhangshan Forest Farm Forest Function Map*

FOREST MANAGEMENT PRACTICES

The forest management practices are selected based on the management objective (which is based on the forest management zone), the forest type (based on key species), and which age group the stand belongs to. For example, a young Simao pine (*Pinus kesiya*) plantation in the timber production zone will be managed intensively to increase the growth of each individual tree; at least 2 thinnings with an intensity of 20%–40% (depending on the current density of the plantation) will be conducted during the following 10 years to improve forest productivity. In contrast, if a Simao pine plantation with similar age and density is located in the Ecological Use Zone, the management will focus on improving the ecological function of such a plantation, meaning relatively low intensity group-thinning to open forest gaps is preferred, and enrichment planting of broad-leaved species in the resulting gaps will also be conducted to transform the monoculture into a more natural mixed-species forest.

The MFMP gives guidance for all types of forests at WZSFF based on management objectives for the entire forest life cycle. Eight main forest types are identified, namely, birch (*Betula alnoides* and *Betula chinensis*) plantations, oak (*Quercus variabilis* and *Quercus acutissima*) natural secondary forests, other broad-leaved plantations, other broad-leaved natural secondary forests, Chinese fir (*Cunninghamia lanceolata*) plantations, Simao pine (*P. kesiya*) plantations, Simao pine (*P. kesiya*) natural secondary forests, and Timor white gum (*Eucalyptus urophylla*) plantations (Figure 8). Forest management and silvicultural practices like reforestation, thinning, enrichment planting and harvesting are selected for each forest stand.

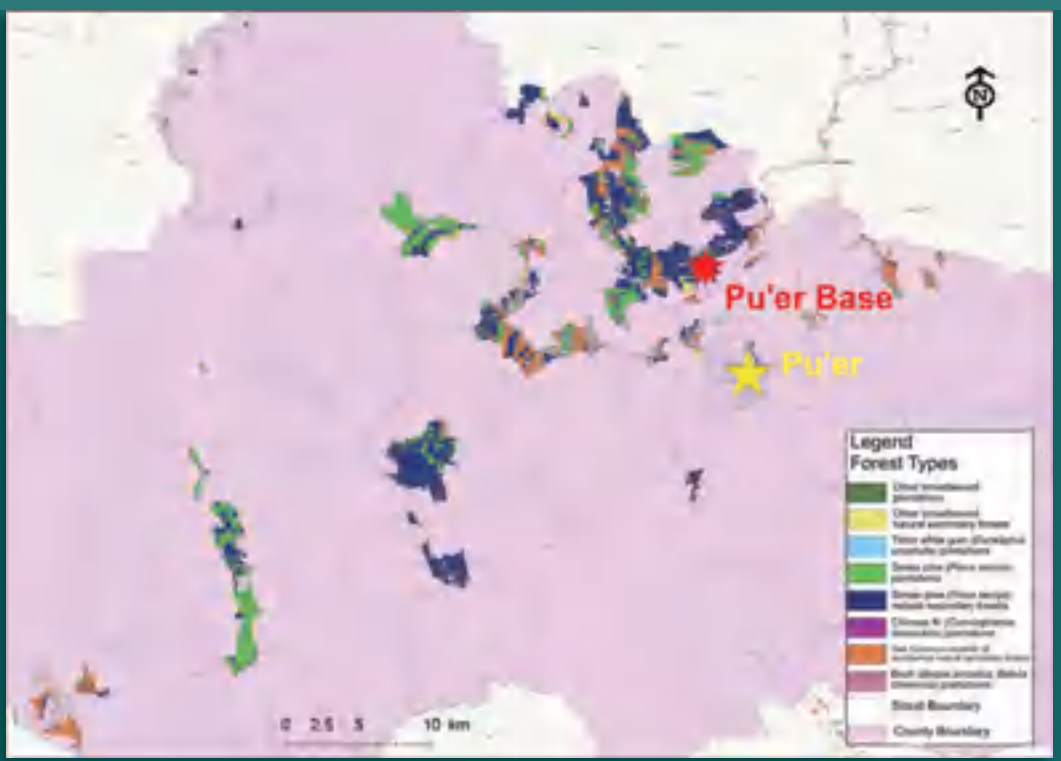


Figure 8: *Wanzhangshan Forest Farm Forest Type Map*

Different thinning methods are selected for different purposes (Figure 9), namely:

1) **Light/release thinning** is carried out when the trees of the target species are suppressed by dominant trees or non-target trees above, and their removal enables the height growth of young trees;

2) **Row/group thinning** is usually carried out in intensively management young and middle-aged forests with high density to release more space for target trees (when light thinning would not release enough space);

3) **Target tree thinning** is carried out in middle-aged to mature forests when target trees are negatively affected by surrounding non-target trees the non-target tree might be removed;

4) **Sanitation cutting** is carried out to remove the dead or unhealthy trees.

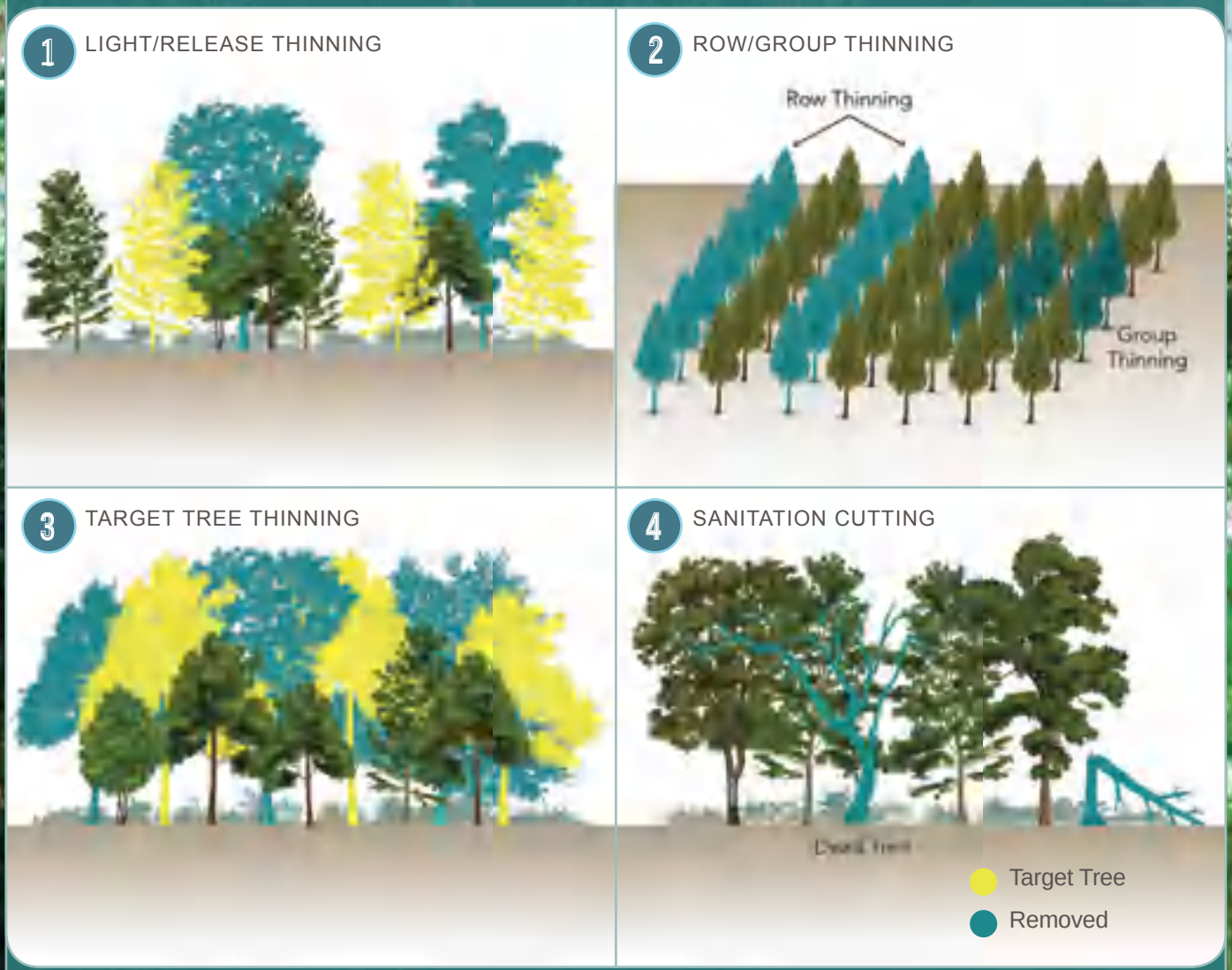


Figure 9: *Different thinning methods*

Note that the thinning intensities should be selected differently based on the current density of the forest and thinning objectives. Different silvicultural methods (clearcut, selection harvests, shelterwood harvests, etc.) will also be conducted according to the management objectives and forest condition. Natural regeneration, assisted natural regeneration and enrichment planting will also be applied in WZSFF.

IDENTIFY TREE GROWTH MODELS

Four common theoretical growth models, based on Richard (Richards, 1959), Gompertz (Gompertz, 1825), Logistic (Verhulst PF, 1827), and Weibull (Bailey and Dell, 1973) are used to simulate the diameters and height growth of each of the aforementioned forest types using the inventory dataset with a nonlinear curve fit (Table 2). Amongst these the growth models, the best fit is selected. Since the majority of the trees at WZSFF are young or middle-aged, the growth curves simulated based on the current inventory cannot reflect the growth trend accurately for mature or overly mature forests. To improve the accuracy, the curves of unit stocking volume are simulated based on the Flexible Yield Model for Regional Timber Forecasting (Murray and von Gadow, 1993), a method to develop volume functions, which uses the mean annual increment (MAI), the maximum Mean Annual Increment (MAImax) and the age a tree reaches MAImax (Tmax), and correlates it to the tree age to generate stand volume curves for each forest type (Figure 10).

TABLE 2: Mathematical expressions of the four selected growth models

Equation	Expression formula
Richards	$y_t = a \times (1 - e^{-c \times t})^b$
Gompertz	$y_t = a \times e^{-e-c \times (t-b)}$
Logistic	$y_t = \frac{a}{1 + b \times e^{-c \times t}}$
Weibull	$y_t = a(1 - e^{-bt^c})$

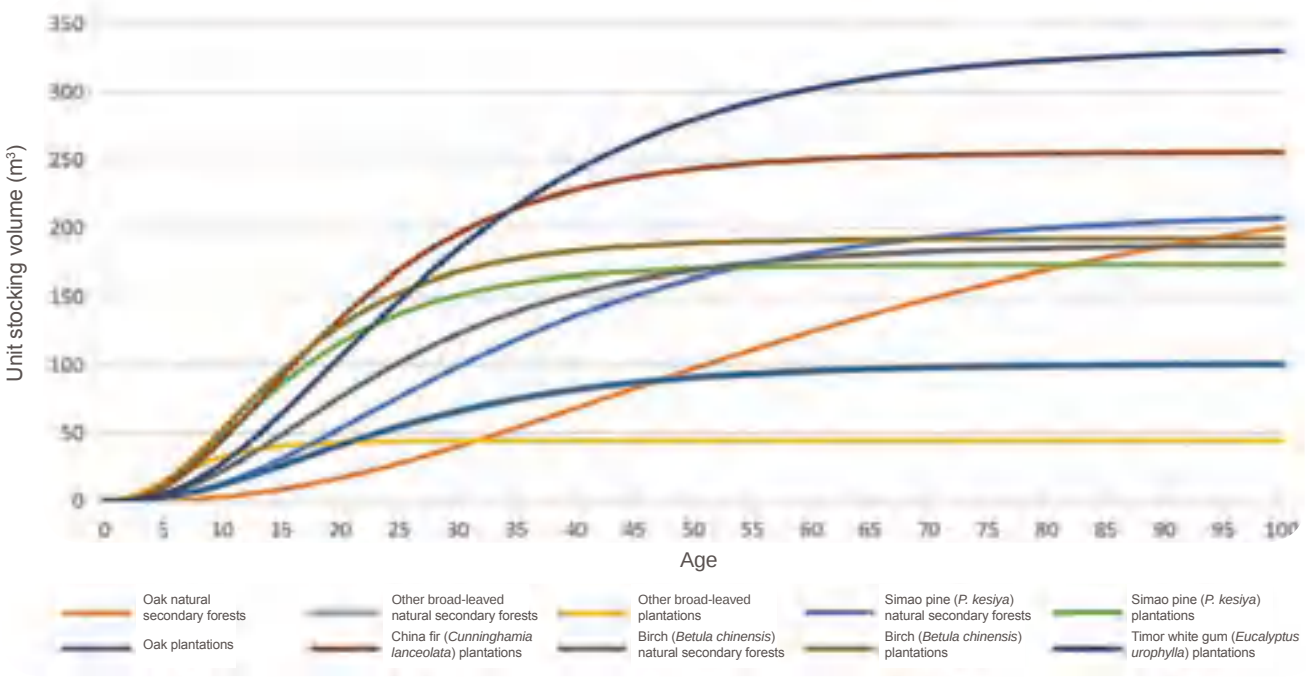


Figure 10: *Stocking Volume Curves of Each Forest Type at Wanzhangshan Forest Farm*

THE FOREST SIMULATION OPTIMIZATION SYSTEM (FSOS)

The Forest Simulation Optimization System (FSOS) was used to develop management scenarios for the *Multifunctional Forest Management Plan* (MFMP) for WZSFF. FSOS is developed for multiple-objective forest analysis and planning, it integrates long-term strategic planning and short-term operational planning into one model. It is a great tool for forest management simulations, animations and optimizations. Users can compare management scenarios and see future forests under these scenarios. Take forest carbon stock as an example, the following are four management scenarios simulated for WZSFF for the next 100 years (Figure 11 and Figure 12).

- **Scenario 1**: Let forests grow naturally, no management, not considering any natural succession.
- **Scenario 2**: Manage the commercial forest area only.
- **Scenario 3**: Let forests grow naturally, no management, considering natural succession.
- **Scenario 4**: Manage the commercial forest area only, but no harvest allowed in the first 20 years.

According to the simulation of FSOS, by 2060 the total carbon storage of WZSFF will increase to 4.03 million tons(t) (Scenario 1), 4.15 million t (Scenario 2), 3.59 million t (Scenario 3), or 4.09 (Scenario 4) from the current 2.59 million t. The average annual carbon sequestration of the farm is estimated to be 36,000 t (Scenario 1), 39,000 t (Scenario 2), and 25,000 t (Scenario 3). By the year 2121, the carbon storage of the farm is predicted to reach 4.44 million, 5.19 million, 3.69 million and 4.97 million t for Scenario 1–4, respectively. The average annual carbon sink of Scenario 2 (26,200 t) is 2.5 times as much as that of Scenario 3 (11,000 t). The average annual timber amount harvested in Scenario 2 can reach as much as 24,000 m^3 in 2121, and the average annual revenue is estimated to reach CNY 28 million [around USD 4.4 million, not adjusted for Net Present Value (NPV)] with an average annual profit of CNY 22 million (ca. USD 3.5 million). The social and economic contributions to the local communities of Scenario 2 is much more than Scenario 1 and Scenario 3 because of the timber production.

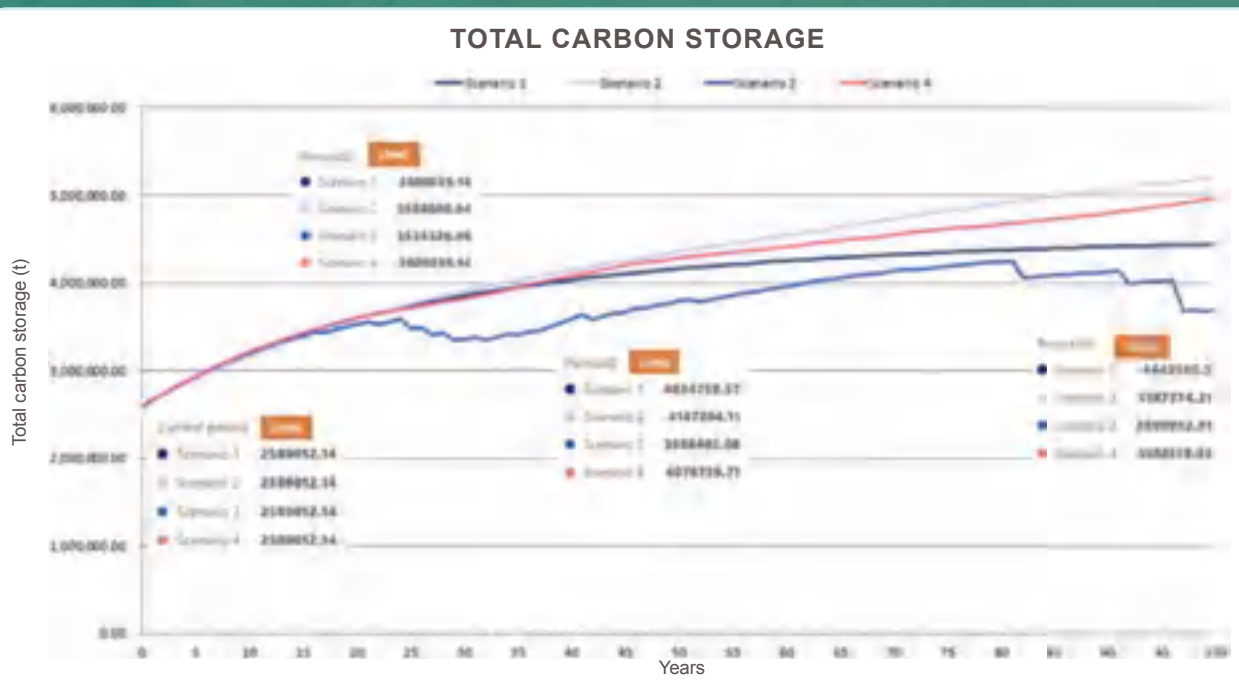


Figure 11: *Comparison of carbon storage in four different scenarios (Photo: WZSFF)*

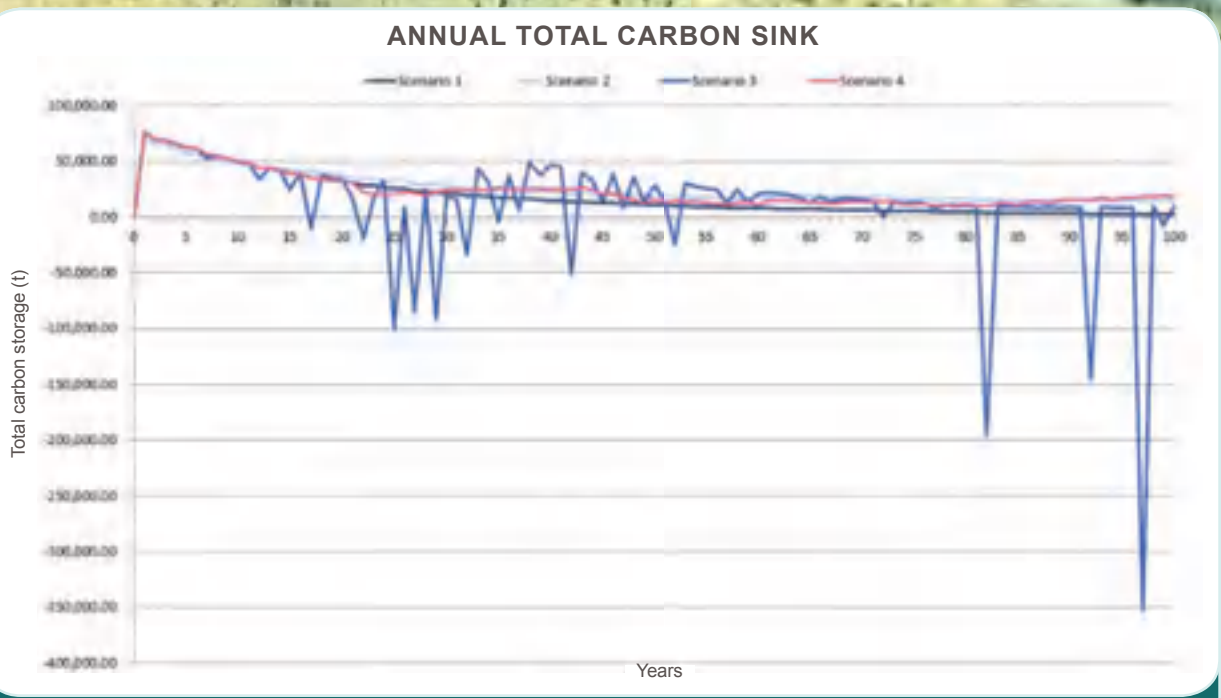


Figure 12: *Comparison of carbon storage in four different scenarios (Photo: WZSFF)*

2.2 FOREST MANAGEMENT

As mentioned earlier Simao pine (*P. kesiya*) and Western birch (*B. alnoides*) are two common local species in Yunnan, and thus also at WZSFF. However, the stocking volume and timber productivity of both species are far from satisfying. This is primarily due to the combination of single-species, high-density plantation establishment adopted in previous decades. Nevertheless even the natural secondary forests of these two species display these issues as they have not been treated with effective silvicultural practices. These plantations and natural secondary forests are thus recognized as having a simple structure, poor stability, and low biodiversity, which has greatly lowered their productivity and ability to provide ecosystem services. The current average stocking volume for *P. kesiya* and *B. alnoides* at WZSFF is 138 and 122 m^3/ha. According to the forest management and thinning regulations of Yunnan, the thinning intensity (removal of stems) is limited to a maximum of 30% per thinning with the pre-condition that the removal of total stocking volume should be kept within 20%. The regulation is applied to both commercial and public welfare forests in Yunnan, which is obviously not suitable for the already overly dense young and middle-aged plantations at WZSFF, especially since it is difficult to apply multiple thinnings within the same decade considering the sheer work load. Therefore, it is essential to find an optimal thinning technique and thinning intensity through comparing the tree growth performance after different thinning intensities. This can be best showcased through demonstration projects, such as the APFNet project, which set out to answer this question for these two key species in ecological and commercial forests.


APFNet
亚太森林恢复与可持续管理组织
Asia-Pacific Network for Sustainable Forest Management and Rehabilitation

2.2.1 INTENSIVE MANAGEMENT OF COMMERCIAL PLANTATIONS

Plantation forests can play an important role in producing timber and providing other ecosystem services. While the total area of planted forests in the world — 278 million ha — amounts to only 7% (FAO, 2015), in 2012 over 46% of global industrial roundwood came from plantation forests (Payn et al., 2015). Buongiorno and Zhu (2014) further estimated that plantation forests reduce pressure on natural forests by decreasing timber harvesting from natural forests by 26% globally. China has the largest area of plantation forests in the world (Chen et al., 2020; Lei et al., 2007) with a size of 79.5 million ha accounting for 36.5% of China's total forest area (NFGA, 2019). Despite China's massive expansion of plantation forests, their quality and growth rate remains very low, because of a lack of appropriate and adequate management (Hou et al., 2019; Ke et al., 2020). Many plantations are signified by poor stand structure, resulting in low growth, yield, and productivity (Bull and Nillsson, 2004; Liu et al., 2018; Peng et al., 2018). The average stocking volume is 59.3 m^3/ha, and the mean annual increment is only 4.23 m^3/ha (NFGA, 2019). These figures are less than a half of the world average under similar growth conditions (Ke et al., 2020).

THINNING FOR BETTER GROWTH

Experimental and simulation-based studies have demonstrated that various thinning measures to remove small or defective trees are commonly used silvicultural practices in managing plantation forests throughout the world to increase the growth rate and productivity of the retained trees (Nakvasina et al., 2019). Consequently, the profitability of plantations can also be improved, especially when applied early on in the life cycle. The management of a plantation forest is optimized by finding a desirable combination of initial planting density, thinning methods and times, and rotation length (Bettinger et al., 2017; Halbritter and Deegen, 2015; Peng et al., 2018). Thus, at WZSFF, APFNet set up demonstration plots of different thinning intensities to test and identify the best intensity suitable for young plantation forests in the area.

COMMERCIAL PLANTATIONS

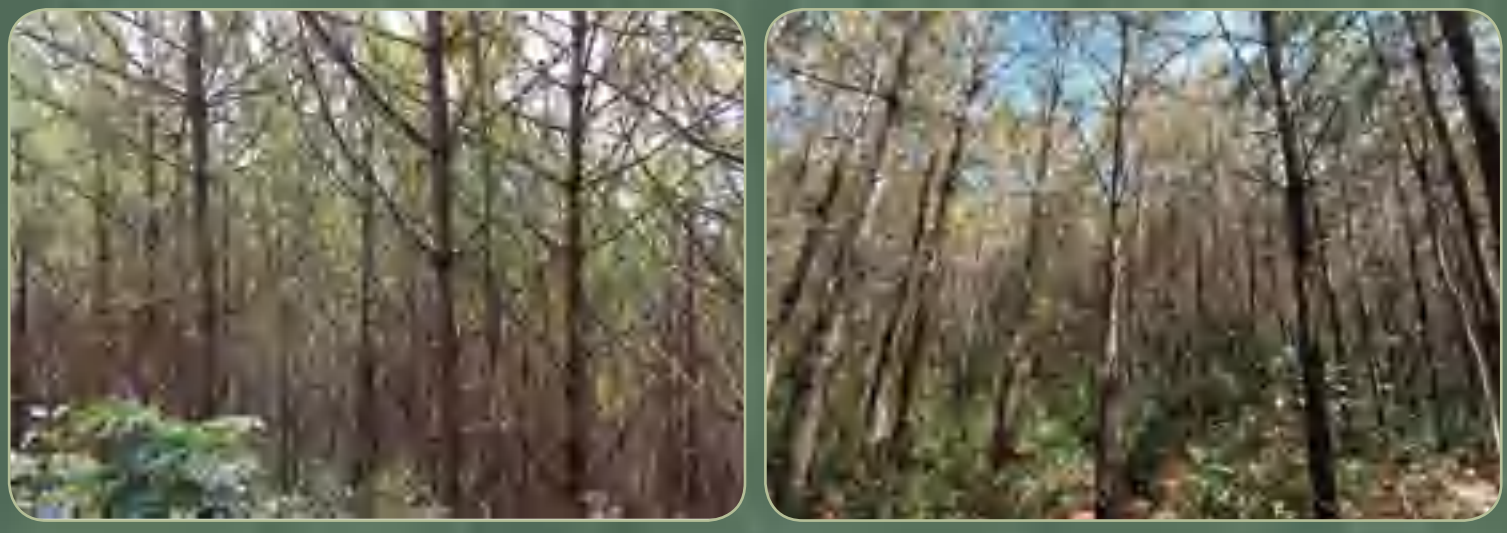
Demonstration Site	7-year-old *P. kesiya* commercial plantation (40 ha)	6-years-old *B. alnoides* commercial plantation (30 ha)
Site conditions	Dominated by planted *P. kesiya*, with some naturally regenerated hardwood broadleaved species and oak. The canopy density ranges from 75% to 90%, the average DBH and tree height are 5.5 cm and 8 m, respectively. The average density of *P. kesiya* was 2,253 trees/ ha.	Dominated by planted *B. alnoides*, with some naturally regenerated hardwood broadleaved species and oak. The canopy density ranges from 70% to 85%, the average DBH and tree height are 8 cm and 7.5 m, respectively. The average density of *B. alnoides* was 2,308 trees/ ha.
Management goal	Maximize forest productivity and profitability through intensive management of the plantations. A series of intermediate thinning and pruning measures were applied to determine which approach improves stand quality and increases tree growth the most.	
Treatments	A one time thinning with different intensities (20%, 30%, 40%, 50% and a control group) was applied to *P. kesiya*, for each intensity the demonstration area is 8 ha. Pruning was conducted every spring and winter, with removal of branches lower than 1/3 of the tree height.	A one time thinning with different intensities (removal of trees, specifically, 25%, 30%, 35%, 40% and a control group) was applied to *B. alnoides*; for each intensity the demonstration area is 6 ha. Shrubs and lianas with negative impact on the growth of *B. alnoides* were also removed.
Monitoring	Sample plots for monitoring were identified through random selection. The sampling ratio for growth increment monitoring is not lower than 1.5% of the treatment area. Within each thinning treatment, three permanent ecological monitoring plots (20 m×20 m) were set up. The sample plots were monitored at the end of each year to measure tree growth (height and DBH) and stocking volume. Main physical and chemical properties of the soil were tested at the beginning and end of the project.	

This 7-year-old *P. kesiya* plantation and 6-year-old *B. alnoides* plantation are categorized as **commercial forests**, therefore, the management goal is to improve land productivity (tree growth), so that higher-quality timber can be produced, and profitability increased. Due to the high initial planting density, these two plantations still had a very high tree density (2,253 trees/ha and 2,308 trees/ha, respectively) at the beginning of the project, which significantly decreased tree growth rate. As already mentioned, thinning is an effective approach to accelerate tree growth, but which thinning intensity is more suitable at this young age group is not clear. Thus, the APFNet project tested different thinning intensities between 20% and 50% during one treatment to identify which one is most suitable for young *P. kesiya* and *B. alnoides* plantations.

COMMERCIAL PLANTATIONS

A young high-density P. kesiya commercial plantation (Photo: WZSFF)

The tree growth performance and volume increment for the 7-year-old *P. kesiya* plantation and the 6-year-old *B. alnoides* plantation are shown in Table 3 and Table 4. While only four years have passed since the treatment, it can already be ascertained that the thinning had a significantly positive impact on individual tree growth, specifically, **higher thinning intensities resulted in greater DBH and height growth**, thus, accelerating more on individual volume increment.



Before (left) and after (right) the thinning treatment in the P. Kesiya commercial plantation (Photo: WZSFF)

TABLE 3: Tree growth performance of the 7-year-old *P. kesiya* commercial forest with different thinning intensities after 4 years

Thinning Intensity (%)	Year [a]	Individual Tree				Stand	
		Height (m)	DBH (cm)	Individual Tree Volume (m^3/tree)	Individual Tree Volume Increment (m^3/tree)	Stocking Volume (m^3/ha)[a]	Annual Stocking Volume Increment [m^3/(ha·year)]
0	2017	7.87	7.87	0.0227		51.12	
	2021	9.76	9.76	0.0411	0.0185	92.69	10.39
20	2017	7.4	8.77	0.0266		47.81	
	2021	9.91	10.96	0.0522	0.0256	93.76	11.49
30	2017	7.03	8.53	0.0242		38.12	
	2021	9.55	11.22	0.0530	0.0288	83.54	11.35
40	2017	8.07	9.67	0.0345		46.70	
	2021	10.73	12.26	0.0693	0.0347	93.62	11.73
50	2017	7.17	8.77	0.0259		29.21	
	2021	9.16	11.36	0.0524	0.0265	59.06	7.46

Note: a. 2017 set the baseline for comparison, the stand stocking volume for 2017 is after thinning practice.

For the *P. kesiya* plantation, compared with the control group, the relative individual volume growth amount to 0.0185 m^3 (100%), 0.0256 m^3 (138.56%), 0.0288 m^3 (156.06%), 0.0347 m^3 (188.08%), 0.0265 m^3 (143.61%), respectively, at control group and intensities of 20%, 30%, 40% and 50% after 4 years thinning treatment. From the preliminary data, **40% thinning intensity resulted in best individual tree growth performance**, however meaningful conclusions can only be drawn after monitoring growth for a longer time period. Stand productivity can be reflected through the annual increment of the stocking volume, as such 40% thinning intensity also resulted in the highest increment. However, high thinning intensities do not always result in increasing stocking volume increment. For instance, the 50% thinning resulted in the lowest annual increment of stocking volume, likely because too many of the trees were removed, outpacing the increased individual tree growth. That being said, that does not necessarily mean that such high thinning intensities will negatively affect forest productivity over longer periods of time, as the increased individual tree growth of the remaining trees may eventually outpace the loss of the growth increment by the additional trees removed.

TABLE 4: Tree growth performance of the 6-year-old *B. alnoides* commercial forest with different thinning intensities after 4 years

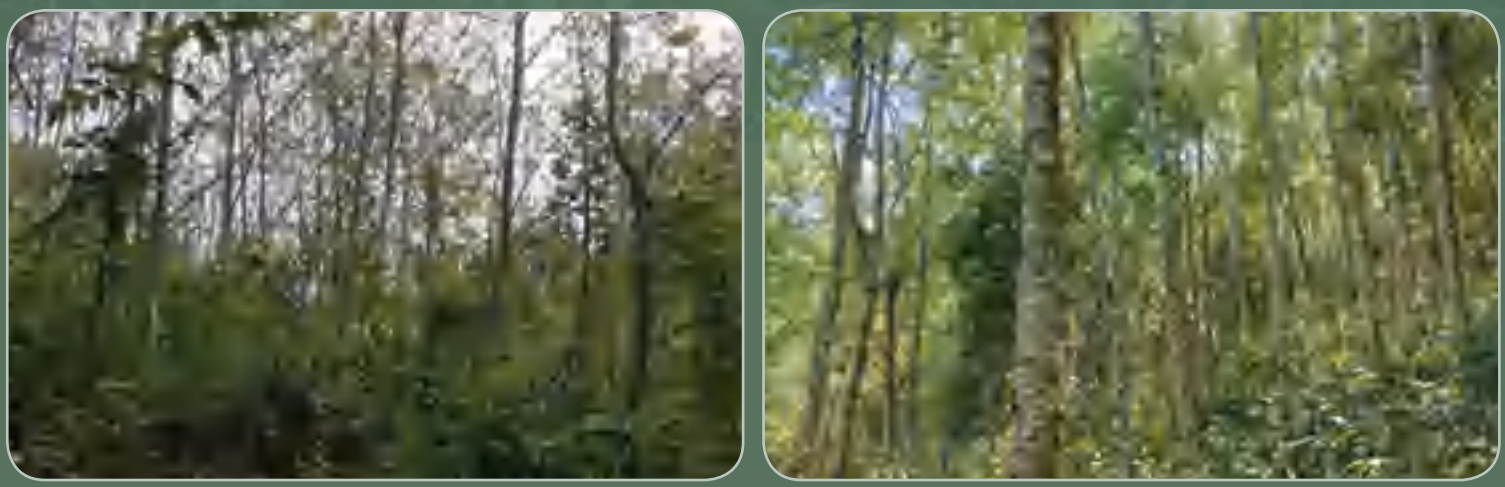
				Individual Tree		Stand	
Thinning Intensity (%)	**Year [a]**	**Height (m)**	**DBH (cm)**	**Individual Tree Volume (m^3/tree)**	**Individual Tree Volume Increment (m^3/tree)**	**Stocking Volume (m^3/ha)[a]**	**Annual Stocking Volume Increment [m^3/(ha·year)]**
0	2017	8.04	7.02	0.0158		36.46	
	2021	10.27	9.13	0.0333	0.0175	76.96	10.12
25	2017	7.21	6.37	0.0118		19.86	
	2021	10.49	9.19	0.0344	0.0226	58.00	9.53
30	2017	8.04	7.00	0.0157		25.38	
	2021	11.01	9.44	0.0379	0.0222	61.29	8.98
35	2017	7.69	6.63	0.0135		20.30	
	2021	10.87	8.84	0.0329	0.0193	49.29	7.25
40	2017	7.85	7.31	0.0168		23.24	
	2021	10.72	9.79	0.0399	0.0231	55.22	7.99

Note: a. 2017 set the baseline for comparison, the stand stocking volume for 2017 is after thinning practice.

Workers conducting thinning a B. alnoides plantation (Photo: WZSFF)

In the *B. alnoides* plantation, the thinning also accelerated the individual tree growth, the thinned groups having higher individual tree volume increment, **with the 40% thinning group also reaching the highest increments**. However, on the stand level the thinning intensities of 25%, 30%, 35%, 40% resulted in an annual stocking volume increment of 9.53 m^3/ha, 8.98 m^3/ha, 7.25 m^3/ha and 7.99 m^3/ha, respectively, which were all lower than the control of 10.12 m^3/ha. In this case, the added individual tree volume increment could, at least in the short term, not make up for the removed trees. This is in line with previous studies, which have shown that greater initial planting density or retained tree density increase the total wood volume per ha but have smaller mean diameters and volume per tree (Acuna et al., 2017). Accordingly, high stocking densities are favored for pulpwood plantations where maximum fiber yield is the main management objective, while low initial planting densities or retained tree density are favored for sawtimber plantations where the production of large-diameter trees is sought (Poynton, 1981). As it is traditionally harder to produce high-quality timber from birch than from pine, it may be that the reduced stand increment is not worth the additional thinning, albeit the data obtained is not enough to conduct a real cost-benefit analysis for the longer term (or the whole forest management rotation cycle).

As it is at this stage impossible to simulate tree growth models for each thinning intensity, the project cannot prove which thinning intensity is the optimal one, yet. However, it can already be predicted that the current local forest management regulations (thinning intensity limited to 30% at maximum with pre-condition that the removal of stocking volume cannot exceed 20%) cannot effectively guide the development of individual tree high quality timber development at WZSFF. In order to support this prediction, APFNet and WZSFF will continue to collect data post-project and publish results as they become available.



Before (left) and after (right) the thinning treatment in the B. alnoides commercial plantation (Photo: WZSFF)

LARGE DIAMETER TREE CULTIVATION

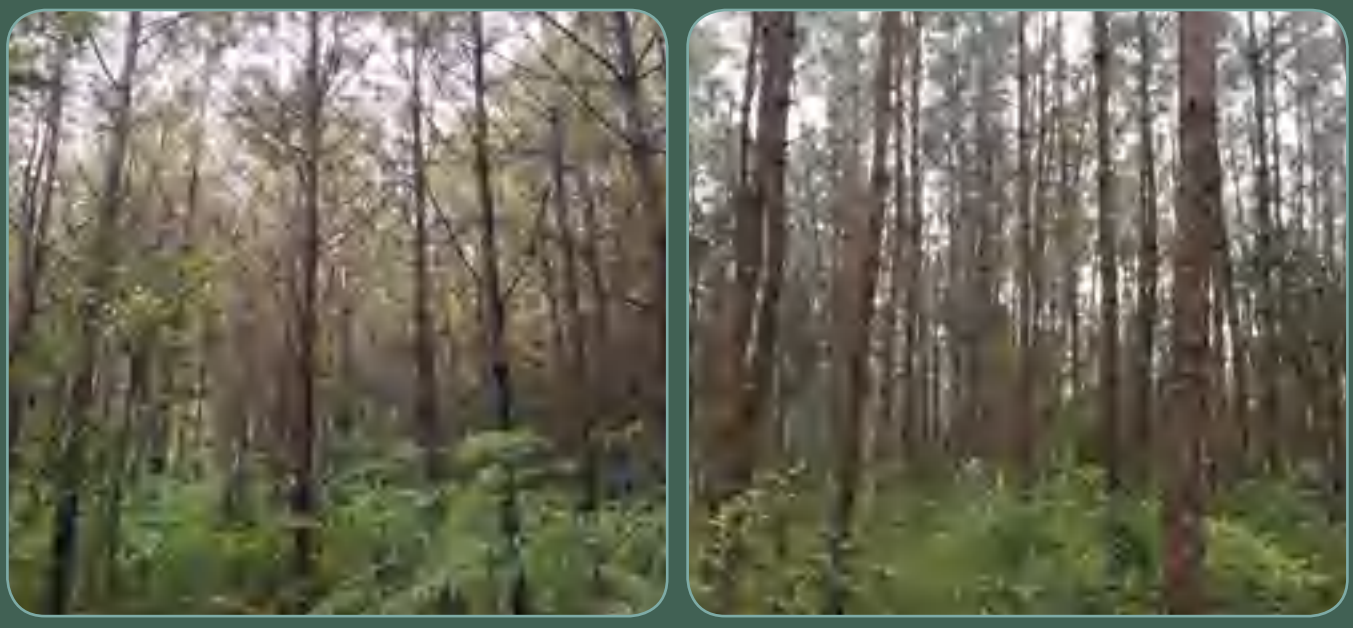
As mentioned, economically speaking the percentage of good quality, large-diameter trees in a stand largely defines the profitability of the land. Opposed to traditional thinning, which removes primarily small or low-quality trees, and also unlike mechanical thinning, which systematically thins out trees in rows, there is one management system with an aim to cultivate high-quality, large-diameter trees while minimizing the disturbance of the forest. This idea is derived from Close-to-Nature Forest Management (CNFM), which originated in Germany. CNFM is based on the idea of managing a forest by working with nature instead of against it. It respects the natural constraints of the forest and manages it in accordance with its ecology to achieve high-quality forest stands and cultivates a few larger trees that then can be sold at higher prices. There are different CNFM silvicultural techniques, such as target tree selection, cutting of competitor trees, assisted natural regeneration or enrichment planting with local species, selection harvest and others. By applying these techniques, the forest can be slowly converted into a multi-aged, diverse forest with a structural composition and species mix mimicking that of a natural forest in later successional stages.

Forester conducting a field investigation and selecting target trees (Photo: WZSFF)

Large diameter tree cultivation works based on the same principles as target tree selection of CNFM, where well-growing, good quality or high-value trees are defined as target trees to ultimately become large-diameter trees in commercial plantations, and competing trees that crowd nearby target trees are removed to give them more growing space. It is important to note that compared with traditional thinning, even if a tree is of lower quality or dying, if it does not directly compete with a target tree, it will generally not be removed. The earlier target trees are defined, the higher the quality of the wood is likely to be at the end of the growing cycle. As the technique was only introduced a few years ago, there are some plantations where the overall quality of the target trees is sub-optimal due to late selection.

Demonstration Site	8-year-old *P. kesiya* plantation (5 ha)	14-year-old *P. kesiya* plantation (5 ha)	6-year-old *B. alnoides* plantation (7 ha)
Site conditions	Dominated by planted *P. kesiya*. There are no nationally protected plant species. Canopy density ranges from 75% to 85%, the average DBH and the average tree height are 5.5 cm and 8 m, respectively. The average density of *P. kesiya* was 2,253 trees/ha.	Dominated by planted *P. kesiya*. The canopy density ranges from 65% to 85%, the average DBH and tree height are 14 cm and 12 m, respectively. The average density of *P. kesiya* is 2,240 trees/ ha.	Dominated by *B. alnoides*. The canopy density ranges from 70% to 85%, the average DBH and tree height are 8 cm and 7.5 m, respectively. The average density of *B. alnoides* was 2,308 trees/ ha.
Management goal	Test the growth performance of *P. kesiya* and *B. alnoides* plantations after different thinning interventions, specifically, target tree management, comparing it with traditional thinning, mechanical thinning and no treatment.		
Comparison Trials	1) **Target tree management:** Target trees will be selected first considering growth performance and trunk shape for long-term management, competing trees will be thinned out; 2) **Traditional thinning:** Remove small, unhealthy and dead trees in the plantation, especially the trees in the lower layer of the canopy. The removal rate is 20% in terms of stems thinned out; 3) **Mechanical thinning:** One out of four trees (25%) will be cut mechanically in the whole stand; 4) **Control:** No treatment (thinning) applied. The size of demonstration sites is the same among the 4 treatments. Weeding and compound fertilizer be applied to all treatments.		
Monitoring	Sample plots for monitoring were identified through random selection. Within each thinning treatment, three permanent ecological monitoring plots (20 m×20 m) were set up. The sample plots were monitored at the end of each year to measure tree growth (height and DBH) and stocking volume. Main physical and chemical properties of the soil were tested at the beginning and end of the project.		

COMMERCIAL PLANTATIONS



Before (left) and after (right) the target tree thinning management of young P. kesiya plantation

To introduce the concept of CNFM and large-diameter tree cultivation to WZSFF and demonstrate its advantages to traditional management, the project selected two commercial *P. kesiya* plantations (8 years and 14 years old) and one *B. alnoides* plantation (6 years old) to demonstrate target tree management. For comparison, three different treatments were set up as well, which are traditional thinning, mechanical thinning and a control (no treatment).

The preliminary results of the tree growth performances after 2 years are shown in Table 5. The results show that **target tree management performed best both in terms of DBH increment and individual tree volume increment for all demonstration sites**. For the 14-year-old *P. kesiya* plantation, after 2 years the DBH increments for target trees is 2.97 cm compared with 2.52 cm for normal trees in the target tree management group and 2.24 cm and 2.64 cm for traditional thinning and mechanical thinning, respectively, all of them showing higher individual tree growth than the control group (1.56 cm). The DBH increment performance of the 8-year-old *P. kesiya* plantation and the 6-year-old *B. alnoides* plantation is similar to the 14-year-old *P. kesiya* plantation, where the target trees performed best, and the control groups always have the lowest DBH increment. In terms of individual tree volume growth, as target tree cultivation mainly promotes the growth of target trees, the increment of individual tree volume of target trees in the 6-year-old *B. alnoides* plantation is also the largest with 0.0575 m^3/ha, which is significantly higher than the normal trees (0.0262 m^3/ha) in target tree management group and also higher than traditional thinning (0.0278 m^3/ha), mechanical thinning (0.0259 m^3/ha) and the control (0.0168 m^3/ha). The 8-year and 14-year-old *P. kesiya* demonstration sites thus have similar results.

As only two years have passed since the treatment, the project still needs to continue the monitoring of the demonstration sites (and possibly apply another treatment) to generate more concrete outcomes. Additionally, it's important to note that since the target tree management only focuses on the selected trees for large-diameter tree cultivation, the disturbance of the forest is usually lower than with other thinning types.

TABLE 5: Comparison of growth performance for *P. kesiya* and *B. alnoides* plantations under different thinning measures

Year	Thinning Measure		14-year-old *P. kesiya* Plantation					8-year-old *P. kesiya* plantation					6-year-old *B. alnoides* plantation				
			Height (m)	DBH (cm)	DBH Increment (cm)	Individual Tree Volume (m^3/tree)	Individual Tree Volume Increment (m^3/tree)	Height (m)	DBH (cm)	DBH Increment (cm)	Individual Tree Volume (m^3/tree)	Individual Tree Volume Increment (m^3/tree)	Height (m)	DBH (cm)	DBH Increment (cm)	Individual Tree Volume (m^3/tree)	Individual Tree Volume Increment (m^3/tree)
2019	Target tree management	Target Tree	14.33	18.10	2.97	0.1873	0.0927	10.10	14.10	3.47	0.0864	0.0728	10.07	11.70	2.48	0.0540	0.0575
2021		Target Tree	16.33	21.07		0.2800		12.63	17.57		0.1593		14.74	14.18		0.1116	
2019		Normal Tree	13.88	16.18	2.52	0.1466	0.0664	9.68	11.95	2.72	0.0605	0.0464	8.76	9.32	1.94	0.0302	0.0262
2021		Normal Tree	15.53	18.69		0.2130		11.91	14.67		0.1069		11.53	11.26		0.0564	
2019	Traditional thinning		12.82	15.27	2.24	0.1228	0.0652	9.62	12.05	2.50	0.0612	0.0411	9.72	9.52	1.28	0.0346	0.0278
2021			15.57	17.51		0.1880		11.51	14.55		0.1023		14.19	10.8		0.0623	
2019	Mechanical thinning		11.9	15.35	2.64	0.1167	0.0815	8.21	11.19	1.86	0.0465	0.0411	9.74	9.65	1.28	0.0356	0.0259
2021			15.57	17.99		0.1981		12.32	13.05		0.0876		13.6	10.93		0.0615	
2019	Control		12.32	14.93	1.56	0.1138	0.0382	8.42	11.38	1.87	0.0491	0.0296	9.12	8.9	1.06	0.0285	0.0168
2021			13.85	16.49		0.1519		10.43	13.25		0.0787		11.9	9.96		0.0453	

2.2.2 OPTIMAL MANAGEMENT OF PUBLIC WELFARE FORESTS

Unlike in commercial forests, where the main goal is to maximize forest productivity (individual tree growth), public welfare forests should be managed to maintain and improve ecological functions, protect biodiversity, provide forest ecosystem services for public welfare and meet the needs for the sustainable development of human society. Except for forests located in extremely important and fragile natural protected areas public welfare forests should still be properly managed so that their ecological functions can be improved. This applies especially to monoculture plantations that, due to historical reasons, were classified as public welfare forests. These forests have a high initial planting density that cannot make use of natural processes that multi-species, multi-aged true natural forests are guided by, thus without artificial treatments those plantations are or will be highly degraded with low productivity and low ecological value. Such is the case at WZSFF, where a large amount of *P. kesiya* plantations are classified as public welfare forests.

PUBLIC WELFARE FORESTS

Demonstration Site	13-year-old *P. kesiya* plantation (40 ha)
Site conditions	Dominated by planted *P. kesiya*, with some naturally regenerated hardwood broadleaved species and oak. The canopy density ranges from 65%-85%, the average DBH and tree height are 14 cm and 12 m, respectively. The average density of *P. kesiya* was 2,240 trees/ ha.
Management goal	Improve the ecological functions of the selected *P. kesiya* plantations and slowly transform the monoculture into a multi-strata conifer-broadleaved mixed forest with a healthy forest structure.
Treatments	Keep naturally regenerated native broadleaved species (i.e., Lauraceae, Fagaceae, Magnoliaceae, Theaceae) with good growth conditions as reserve trees, so that forest structure and biodiversity can slowly be improved. Traditional thinning with removal of small, unhealthy and dead trees was applied. Different thinning intensities (15%, 20%, 25%, 30% and 45% removal of trees) using a traditional thinning approach were applied to *P. kesiya*, for each intensity the demonstration area is 8 ha. The control group without any thinning was set up next to the demonstration area.
Monitoring	Sample plots for monitoring were identified through random selection. The sampling ratio is no less than 1.5% of the treatment area. Within each thinning treatment, three permanent ecological monitoring plots (20 m×20 m) were set up. The sample plots were monitored at the end of each year to measure tree growth (height and DBH), stocking volume and biodiversity.

P. kesiya plantation classified as public welfare forests at Wanzhangshan (Photo: WZSFF)

THINNING OF A P. KESIYA PLANTATION IN A PUBLIC WELFARE FOREST

This 13-year-old *P. kesiya* plantation is categorized as a public welfare forest, thus, as previously mentioned, to improve its ecological functions the monoculture will be slowly transformed into a multi-layer conifer-broadleaved mixed forest with a healthy forest structure. The overly dense forests not only affect the tree growth of dominant species, *P. kesiya* in this case, but also negatively impact the rest of the forests, especially shading out small broadleaved trees or reducing regeneration. However, tree growth, as an indicator for vitality, is still an important indicator to test the most suitable thinning intensity even though productivity is not the main purpose. Biodiversity of trees, shrubs and herbs was also monitored.

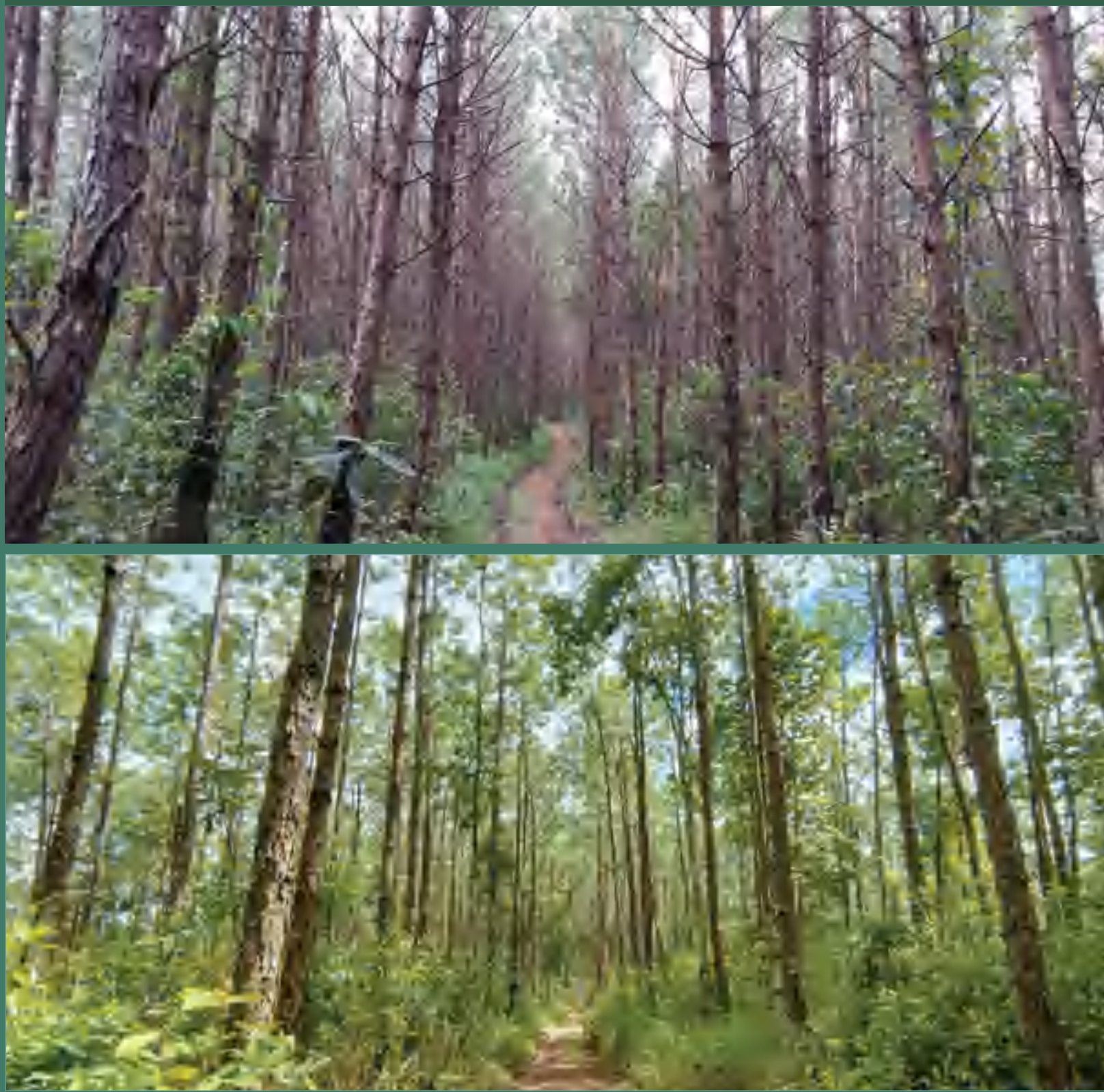
The tree growth performance and stocking volume increment is presented in Table 6. Generally, higher thinning intensities result in a higher increment of individual tree volume (Z. Li et al., 2020). Compared with the control (0.0292 m^3), the relative individual tree volume increments were, 0.0391 m^3 (133.9%), 0.0398 m^3 (136.3%), 0.0404 m^3 (138.35%), 0.0350 m^3 (119.86%), 0.0516 m^3 (176.71%), respectively, at intensities of 15%, 20%, 25%, 30%, and 45%, 4 years after the thinning treatment. However, at the stand level, high thinning intensities generally did not immediately result in higher stocking volume increment, it may in fact have affected it negatively in the short-term, which is caused by the removal of a higher percentage of trees. On the other hand, higher intensity thinning results in a lower crown density and thus increases light penetrating to the understory, which is good for increasing biodiversity and encouraging natural regeneration. As already mentioned, the sample plots will be continued monitored post-project to see the long-term influence of different thinning intensities.

TABLE 6: Tree growth performance of the 13-year-old *P. kesiya* public welfare forest with different thinning intensities after 4 years

Thinning Intensity (%)	Year [a]	Individual Tree				Stand	
		Height (m)	DBH (cm)	Individual Tree Volume (m^3/tree)	Individual Tree Volume Increment (m^3/tree)	Stocking Volume (m^3/ha)[a]	Annual Stocking Volume Increment [m^3/(ha·year)]
0	2017	13.80	12.97	0.0950		211.01	
	2021	15.11	14.33	0.1243	0.0292	275.94	16.23
15	2017	12.90	12.83	0.0880		166.39	
	2021	14.98	14.55	0.1271	0.0391	240.26	18.47
20	2017	13.27	13.60	0.1009		178.60	
	2021	15.17	15.25	0.1407	0.0398	249.07	17.62
25	2017	12.87	13.13	0.0919		153.01	
	2021	15.13	14.79	0.1323	0.0404	220.29	16.82
30	2017	12.10	12.70	0.0819		127.73	
	2021	14.44	14.15	0.1168	0.0350	182.26	13.63
45	2017	12.90	13.57	0.0982		125.16	
	2021	15.07	15.79	0.1497	0.0516	190.91	16.44

Note: a. 2017 set the baseline for comparison, the stand stocking volume for 2017 is after thinning practice.

PUBLIC WELFARE FORESTS



Before (top) and after (bottom) the thinning treatment of the P. kesiya public welfare forest (Photo: WZSFF)

PUBLIC WELFARE FORESTS

Species diversity can reflect the structural improvement of a forest. Table 7 presents the species diversity for the shrub layer of the *P. kesiya* public welfare forest in 2021, 4 years after thinning with different intensities. However, since the monitoring period is not long enough, the current result shows that there is no significant difference for all indexes of species number, individual plant number, and shrub coverage between different thinning intensities. But it is commonly accepted that with thinning opening up the canopy, natural regeneration will be accelerated, and the increased light availability provides opportunity for new species to establish themselves. Thus, in the long-term species diversity is expected to increase. Development of a new forest community and species succession is a long process, understanding this aspect the project will continue monitoring the species diversity of the demonstration site.

The natural secondary forest at WZSFF (Photo: WZSFF)

TABLE 7: The species diversity of the 13-year-old *P. kesiya* public welfare forest in 2021 with different thinning intensities

Thinning Intensity (%)	Shrub Layer			
	Species	Plant No.	Height (m)	Cover (%)
15	23	74	1.80	5.68
20	18	71	0.93	6.20
25	24	87	1.12	5.65
30	20	79	1.07	6.17
45	21	76	1.55	8.28
0	26	65	1.14	5.95

Note: The species and plant numbers represent the species except Pinus kesiya in 2 m × 2 m plots.

IMPROVING THE ECOLOGICAL FUNCTIONS OF A NATURAL SECONDARY FOREST

As of 2018, China's natural forest area is 138.68 million ha accounting for 64% of the total forest area in China. The average stocking volume for natural forests is 111.36 m^3/ha, higher than that of plantations, which is 59.3 m^3/ha. Among natural forests, natural secondary forests make up 71.86% of the total area (as well as 46% of the total forest area in China). Responding to concerns over illegal logging or high-intensity logging for profit, in order to protect natural forests, in 2016 China adopted strict protection measures, which include closing off mountains to allow for natural regeneration, and *completely* stopping commercial logging in natural forests. According to Article 32 of the *China Forest Law*, "The state shall implement a comprehensive protection system for natural forests, strictly limit the felling of natural forests, protect and restore natural forest resources, gradually improve the ecological functions of natural forests and strengthen the capacity building regarding the management and protection of natural forests". However, this focus on the protection and conservation of natural forests does not necessarily mean that they do not need to be managed at all. Stocking volume in some stands has the potential to become very high, but without appropriate management these forests could develop into low quality, overly dense forests with low productivity. What needs to be clarified is how natural forests, especially natural secondary forests, are to be managed in order to improve ecosystem service functions and increase forest productivity and forest health. In practice, some provincial or local forestry authorities' understanding of the policy "stopping commercial logging from natural forests" is too narrow, which resulted in strictly prohibiting all forms of forest management activities in all natural forests. In addition, natural secondary forest management can use understory and NTFP planting in general to increase income generation from those forests without negatively affecting the stability of the forest ecosystem or its service functions.

The APFNet project selected a low-quality, overly dense, natural secondary forest of *P. kesiya* to demonstrate how to manage and improve its productivity and ecological functions. The original vegetation (of the type monsoon evergreen broadleaved seasonal rainforest) of the demonstration site was logged over, afterwards *P. kesiya*, as a pioneer species, quickly established itself, growing fast and finally dominating the canopy. Subsequently, due to abundant seed sources in this area, this secondary forest became a mixed forest of both coniferous and broadleaved species. While this by itself was a very positive development, the ratio of conifer to broadleaved tree species was still sub-optimal at around 7:3 before the treatment. Additionally, since there was no effective management, both economic and ecological benefits of the secondary forest were not high, and the forests were vulnerable to pests. Through understory planting, thinning and tending measures, the project adjusted the ratio of conifer to broadleaved tree species to 2:8, 3:8, and 4:6, to transform this low efficiency secondary forest into a healthier forest with a multi-story canopy, and a species mix more closely resembling the natural forest composition in the area (Table 8).

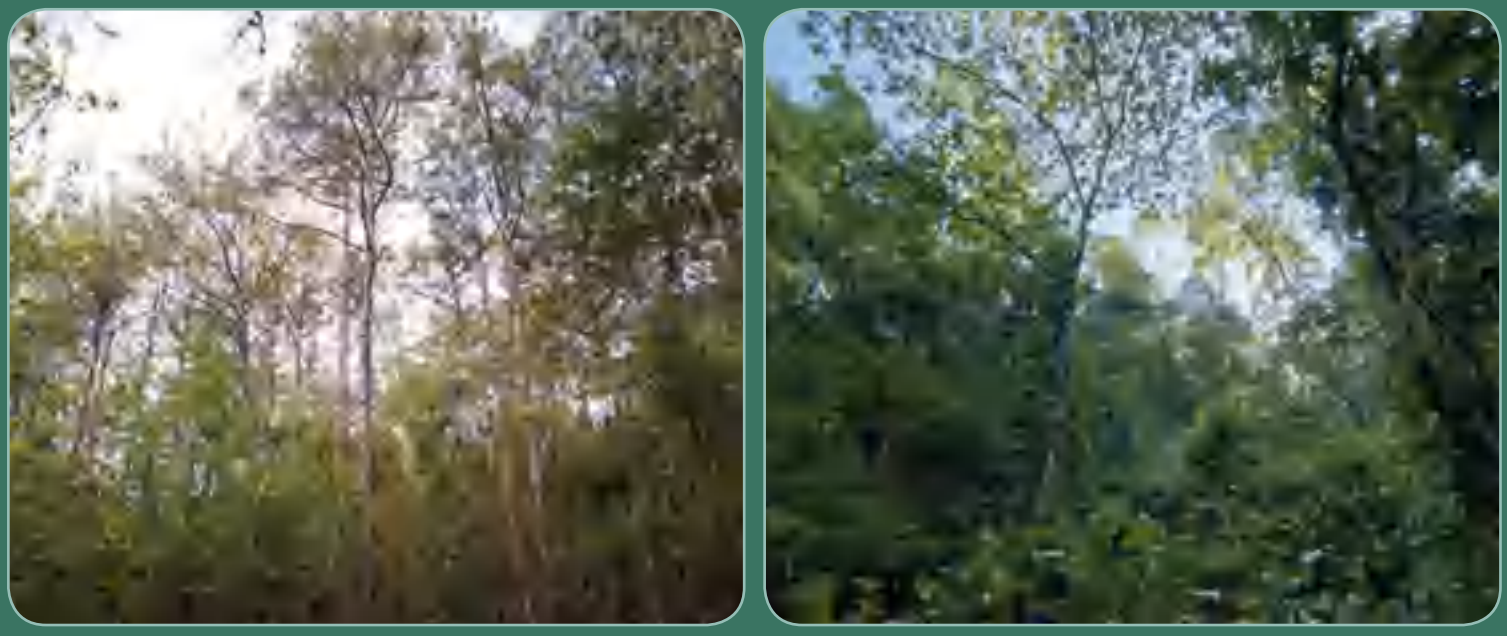
TABLE 8: The species diversity of the *P. kesiya* natural secondary forest with different treatments after 3 years

Treatment (conifer/ broadleaf ratio)	Tree layer (20m×20m)							
	No. of species		No. of individuals		Height tree layer (m)		DBH (cm) increment	
	2018	2021	2018	2021	2018	2021	2018	2021
2:8	22	24	85	71	11.30	11.70	9.73	11.53
3:7	14	17	85	75	9.30	10.19	8.57	9.49
4:6	18	17	42	47	11.89	10.85	13.88	12.85
Control	22	21	53	61	12.47	11.95	11.64	11.74
Treatment	**Shrub layer (2m×2m)**							
	No. of species		No. of individuals		Height Shrub layer (m)		Shrub cover (%)	
	2018	2021	2018	2021	2018	2021	2018	2021
2:8	30	33	90	118	0.95	1.13	6.05	4.42
3:7	27	34	105	114	0.79	1.17	6.16	6.02
4:6	25	29	95	100	1.04	1.01	7.14	3.93
Control	32	32	101	99	1.11	1.01	8.05	4.21
Treatment	**Grass layer (1m×1m)**							
	No. of species		No. of individuals		Height Grass layer (m)		Grass cover (%)	
	2018	2021	2018	2021	2018	2021	2018	2021
2:8	17	20	49	69	0.95	0.48	5.46	5.38
3:7	22	17	81	133	0.62	0.43	5.37	6.26
4:6	24	20	101	125	0.59	0.52	5.20	5.27
Control	15	13	42	45	0.82	0.47	7.37	4.06

Generally, the number of individual trees and the average height in the 3 treatments decreased by a certain amount, which was caused by the cutting of the dominant pine trees. The average DBH of the trees in the upper layer increased by a significant degree in the different treatments, especially in plots with a conifer-broadleaf ratio of 2:8, because with more of the dominant pines cut more growing opportunities were provided to the trees in the layer below. After 4 years the number of tree species in the three treatments increased slightly, while it slightly decreased the control plot (likely due to increased shading). This indicates that the thinning of pine trees in the dominant crown layer promotes the growth of broad-leaved trees, as more light reaches the understory.

Both the number of shrub species and the amount of individual shrubs in the three treatments increased to a certain degree after cutting some of the pines. Shrub height also increased slightly in all treatments. Regarding the grass layer, the number of grass species decreased in 2 treatments (Treatment 2 and 3) and the control, and only increased slightly in Treatment 1. However, the number of individual plants in each of the three treatments increased significantly. The control, in comparison, only shows a slight increase, almost unchanged.

Demonstration Site	***P. kesiya* natural secondary forest (45 ha)**
Site conditions	Native vegetation largely absent. The pioneer tree species *P. kesiya* established dominance, mixed with local broadleaved species (ratio between conifer and broadleaved species is around 7 : 3). The forest canopy rate is 65%–85%, mean DBH is 16–20 cm, mean height is 12.4–16.2 m, and the forest density is 658–1,005 trees /ha.
Management goal	Adjust the conifer to broadleaved species ratio, and transform this conifer dominant forest into a multi-storied, mixed species forest and accelerate forest succession towards the native climax community — the monsoon evergreen broad leaved forest.
Treatments	**Step one:** Selective thinning of P. kesiya, especially of trees that received excessive resin tapping or defective trees. Conifer/broadleaved ratio adjusted to 2 : 8, 3 : 7, 4 : 6, respectively, and control group without any interventions was also set up. (11.25 ha for each conifer/broadleaved ratio). **Step two:** Enrichment planting of native broadleaved species (i.e. Castanopsis hystrix, Schima wallichii, Machilus rufipe, Millettia leptobotrya, Lithocarpus truncates, *etc*.) or high value tree species (i.e. Erythrophleum fordii, Swietenia mahagoni, *etc*.) in forest gaps with an area larger than 15 m^2 to create an uneven-aged, multi-story, mixed forest. **Step three:** Conserve the understory shrubs and herbaceous plants, eventually a tree-shrub-grass, mixed, uneven-aged forest structure will be formed with better soil conditions and water conservation ability.
Monitoring	Three monitoring plots set up for each treatment (conifer/broadleaved ratio 2 : 8, 3 : 7, 4 : 6 are the three treatments, each treatment in the demonstration area is 15 ha). The control group without any interventions was set up beside the demonstration site. Within each monitoring plot, the sample size is 20m×20m for the tree layer, 2m×2m for the shrub layer, and 1m×1m for the grass layer. The sample plots were monitored at the end of each year to measure tree growth (height and DBH), stocking volume and biodiversity.



Before (left) and after (right) thinning and enrichment planting in the natural secondary forest

Enrichment planting of broadleaved species in the natural secondary forest

2.2.3

UNDERSTORY PLANTING OF EPIPHYTES FOR ECOLOGICAL AND ECONOMIC ENHANCEMENT

Besides timber and other wood products, a healthy forest can be maintained while providing a wide range of food, medicinal, and other non-timber forest products (NTFPs). Understory planting is the intentional cultivation of edible, medicinal or decorative specialty crops or plants beneath native or planted woodlands that are managed to provide additional forest products. It can present profitable opportunities for local communities to improve livelihoods without negatively impacting the stability of the forest and its ecosystem services.

Understory planting of Dendrobium (an epiphyte species) on the tree trunk in a secondary forest of Wanzhangshan (Photo: WZSFF)

With the goal to improve the livelihoods of the local community, while taking full advantage of the forests, APFNet selected 5 ha of natural secondary forests with good site conditions and convenient access to demonstrate understory planting. Medicinal plants belonging to *Dendrobium*, *Anoectochilus formosanus*, *Rhizoma bletillae* and other Orchidaceae were selected to plant in the demonstration site. Amongst these species, *Dendrobium*, which is an epiphyte species (Box 5), fetches an excellent price. *Dendrobium* has been used as a medicinal herb in traditional Chinese Medicine (TCM), for example to nourish the stomach and enhance the production of body fluids. Chinese people consider *Dendrobium* one of the fifty fundamental herbs used to treat all kinds of ailments and use a *Dendrobium*-based tonic for longevity. Thus, at the end of 2017, *Dendrobium chrysotoxum*, *Dendrobium aurantiacum*, *Dendrobium nobile*, *Dendrobium crepidatum*, *Dendrobium pendulum*, *Dendrobium thyrsiflorum*, and *Dendrobium primulinum* were planted on trunks (on a height suitable for planting and harvesting) with a density of 2–4 clusters per tree (3–5 plants per cluster). Around 4,200 clusters were planted within 1 ha. *Dendrobium* can also be raised in a nursery on seedling beds, provided a forest canopy shades it, but the price of the flowers and plants sold from the nursery is less than of the ones planted in the forest on tree trunks.

BOX 5: Epiphytes

Epiphytes — non-parasitic plants living on top of other plants, such as trees — use water vapour in the air and humus accumulated on trees to grow. They are quite sensitive and need good hydrothermal conditions for growth; in this context they serve as natural indicators of environmental changes. Epiphytes are of great significance for sustaining forest ecosystem functions, including maintaining nutrient and water circulation within the forest and increasing biodiversity.

1. Dendrobium chrysotoxum; 2. D. nobile; 3. D. aurantiacum; 4. D. pendulum; 5. D. thyrsiflorum; 6. D. crepidatum; 7. D. primulinum

PUBLIC WELFARE FORESTS

Understory planting with epiphytes (Photo: WZSFF)

Since 2017, the highest net weight of fresh stems was found in *D. chrysotoxum* (3,777 g/cluster), followed by *D. nobile* (719 g/cluster) and *D. aurantiacum* (622 g/cluster). *D. pendulum*, *D. thyrsiflorum*, *D. primulinum* and *D. crepidatum* had a lower production with net weights of 523 g/cluster, 430 g/cluster, 397 g/cluster and 314 g/cluster, respectively. Please note that not all *Dendrobium* plants will be harvested, 3–5 newly regenerated plants will be left in each cluster for the next generation. The current market price for fresh stems of dendrobe is USD 1.6 per kg for *D. chrysotoxum* and USD 2.4 per kg for other dendrobes. Thus the highest income comes from *D. chrysotoxum* at USD 25,586 per ha, followed by *D. nobile* USD 7,307 per ha, *D. aurantiacum* USD 6,316 per ha and *D. crepidatum* USD 3,186 per ha (Table 9).

Understory planting with epiphytes, such as dendrobes, provides profitable NTFPs, improves ecosystem services and benefits forest ecosystems. It also enables forest farmers to obtain real benefits and improve their livelihoods. In the long term, understory planting will prove highly significant in improving forest ecosystem quality in this region and enhancing overall ecological, economic and social conditions.

TABLE 9: Production and economic value of planted understory dendrobe species

Species	Shrub Layer		Price (USD/kg)	Output value	
	plants/ clump	grams/ clump		USD/ clump	USD/ha
D. chrysotoxum	55	3,777	1.6	6.09	25,586
D. aurantiacum	7	622	2.4	1.50	6,316
D. nobile	26	719	2.4	1.74	7,307
D. crepidatum	26	314	2.4	0.76	3,186
D. pendulum	18	523	2.4	1.27	5,318
D. thyrsiflorum	14	430	2.4	1.04	4,368
D. primulinum	28	397	2.4	0.96	4,038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高效思茅松采脂示范林简介

2.2.4 RESIN TAPPING TO INCREASE THE PROFITABILITY OF PINE FORESTS

Resin circulates through coniferous trees and serves to seal damaged areas of the tree. Human use of plant resins has a very long history already documented in ancient Greece, Rome, Egypt and China. Nowadays, resins are valued for the production of varnishes, adhesives, and food glazing agents. They are also prized as raw materials for the synthesis of other organic compounds and provide incredients for incense and perfume. Thus, resin tapping can be a great opportunity to increase the profitability of pine forests. It contributes to job creation in rural areas and thus additional management of pine forests to increase resin productivity can be beneficial.

Due to the large amount of resin naturally produced in *P. kesiya*, these trees are often commercially tapped for resin prior to the harvest of the tree for timber. In Pu'er, *P. kesiya* trees older than 20 years yield an average of 1,800–2,450 g of resin per tree per year. Resin is usually collected by causing minor damage to the tree by scraping deep enough into the trunk to puncture the vacuoles, then letting the sap slowly exit the tree (often into a bucket, placed below), after which the tree repairs its damage by filling the wound with resin. This usually takes a few days. Finally, the excess resin is collected. This process can be done sustainably for years, if tapped correctly. Unfortunately in practice, due to a lack of knowledge of proper techniques, as well as in pursuit of short-term benefits, resin tapping is done excessively in some resin production areas of Pu'er. For example, in some areas resin production starts tapping from young trees less than 10 years old, which strongly affects tree growth and may cause the premature death of trees. In other cases excessive resin tapping with a high cutting-face load rate (above 40%, the width of the cut surface exceeds 40% of the circumference of the trunk), depth of the cutting (closer than 1 cm to the xylem of the tree), and a too high frequency of resin tapping, can cause severe damage of the tapped trees and the forest ecosystem at large.

Therefore, the APFNet project established a 30 ha sustainable resin production demonstration site in a *P. kesiya* plantation, not only to demonstrate the silvicultural techniques for managing resin production plantations but also to showcase effective resin tapping techniques in terms of collection method, collection volume, and collection intensity.

PUBLIC WELFARE FORESTS

Resin tapping in a P. kesiya plantation (Photo: WZSFF)

Demonstration Site	Efficient *Pinus kesiya* resin production demonstration plot (30 ha)
Site conditions	A 19-year-old middle-aged *P. kesiya* plantation with an average DBH of more than 18 cm (mainly ranging from 18 to 20 cm). The main species is *P. kesiya*, accompanied by naturally regenerated *Schima*, *Alnus*, and *Quercus* species. Canopy density of the stand ranges from 0.6 to 0.7, the average DBH, tree height and average tree density were 16 cm, 14.5 m and 1,050 trees/ ha, respectively.
Management goal	Demonstrate silvicultural techniques (thinning intensities and fertilization application) for managing resin production plantations and effective resin tapping techniques in terms of collection method, collection volume, and collection intensity.
Treatments	1) **Comparison of thinning intensities:** Three thinning intensities of 15%, 30% and 45%, as well as a control group without thinning, were set up. Resin tapping was carried out using the descending tapping method with a cutting-face load rate (the width of the cut surface in relation to the total circumference of the trunk) of 40%, at a frequency of once every three days during May to October. In each treatment, 20 trees with a DBH between 18 and 20 cm were tagged and regularly observed. There were 3 replications for each treatment, each sample plot is 30 m × 40 m. Totally 12 plots were set up for monitoring. 2) **Comparison of fertilizer application:** Compound fertilizer with a ratio of N : P : K=15 : 15 : 15 was used in the fertilization experiment and demonstration. A fertilization gradient of 500 g, 1,000 g, 1,500 g per tree and the control were applied as treatments in each 30 m × 40 m permanent plot, with three duplicates (totally 12 sample plots). Resin tapping was carried out using the descending tapping method with a face load rate of 40%, at a frequency of once every three days. In each treatment, 20 trees with a DBH from 18 to 20 cm were tagged and regularly observed. 3) **Comparison of resin tapping methods and tapping intensities:** Two methods for resin collection, i.e., the Descending Resin Tapping (DRT) method and the Ascending Shallow Drilling Resin Tapping (ASDRT), were tested and demonstrated. The DRT method is used to compare the effects of cutting-face load rate and collection intensity on resin yield. The ASDRT method is used to test and demonstrate effects of the number of holes in the tree on resin yield (Box 6). a. In the DRT method, first, four tapping intensities, that is cutting-face load rates of 30%, 40%, 50%, and 60% were applied with a tapping frequency of once every three days; second, they mainly varied the tapping frequency, setting to once every 2, 3, or 4 days with a constant face load rate 40%. (18 sample plots in total, for cutting-face load rate at 30%, 50% and 60%, 3 sample plots for each intensity; with a cutting-face load rate at 40%, 9 plots in total, 3 plots with tapping frequency of every 2, 3, and 4 days each) b. In the ASDRT method, the collection intensity is set with 2, 3, and 4 holes each time, and collection was once every five days (9 sample plots in total). In each treatment, 20 trees with a DBH ranging from 18 to 20 cm were selected, tagged, and regularly observed.
Monitoring	A total of 51 fixed demonstration sample plots with an area of 30 m x 40 m were set up. Growth indices of tree height and DBH, as well as resin production after the treatments were investigated in the sample plots. According to the requirements of the experimental plan, target trees for resin tapping tests were selected and marked in each test plot.

BOX 6: Resin tapping methods

Descending Resin Tapping (DRT)

The cutting surface of resin tapping starts from a height of about 2 m in the trunk and extends downward year by year. The first pair of side grooves are arranged at the top of the cut surface, the second pair of side grooves are below the first pair of side grooves. The new cut surface in each resin harvesting season is located just below the old cut surface until you reach the base of the trunk. Advantages: 1) suitable for medium and long-term resin harvesting over 5 ha; 2) resin flows down rapidly along the middle ditch without going through previous side grooves, so the collected resin is cleaner with good quality; and 3) it's more efficient for the resin collector to collect resin (Figure 13).

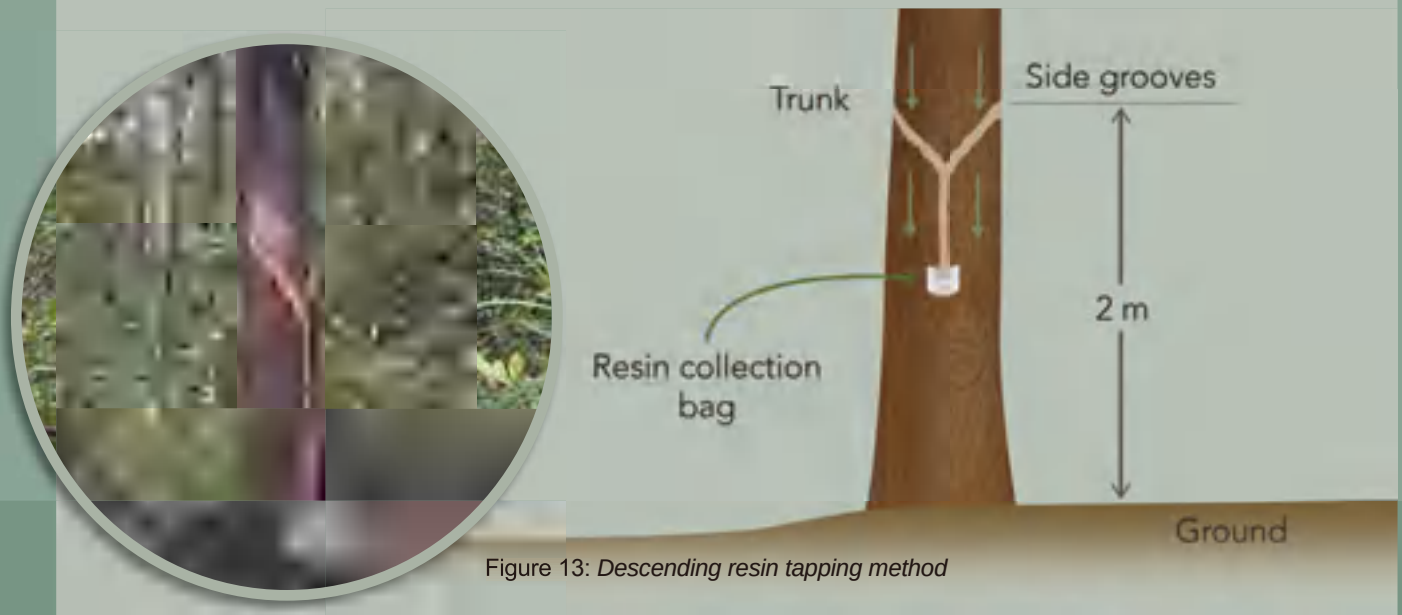


Figure 13: *Descending resin tapping method*

Ascending Shallow Drilling Resin Tapping (ASDRT)

The harvesting sequence of the Ascending Shallow Drilling Resin Tapping (ASDRT) method is exactly opposite to that of the DRT method. The ASDRT method starts from the base of the trunk, the first pair of side grooves is cut 20 cm above the ground, the second pair of side grooves is above the first pair, and so on, extending to the upper part of the trunk year by year. Advantages: each pair of side grooves is close to the shortest distance for nutrient transport, which is conducive to promoting the synthesis of resin, so the yield is 3%–7% higher than that of the DRT method (Figure 14).

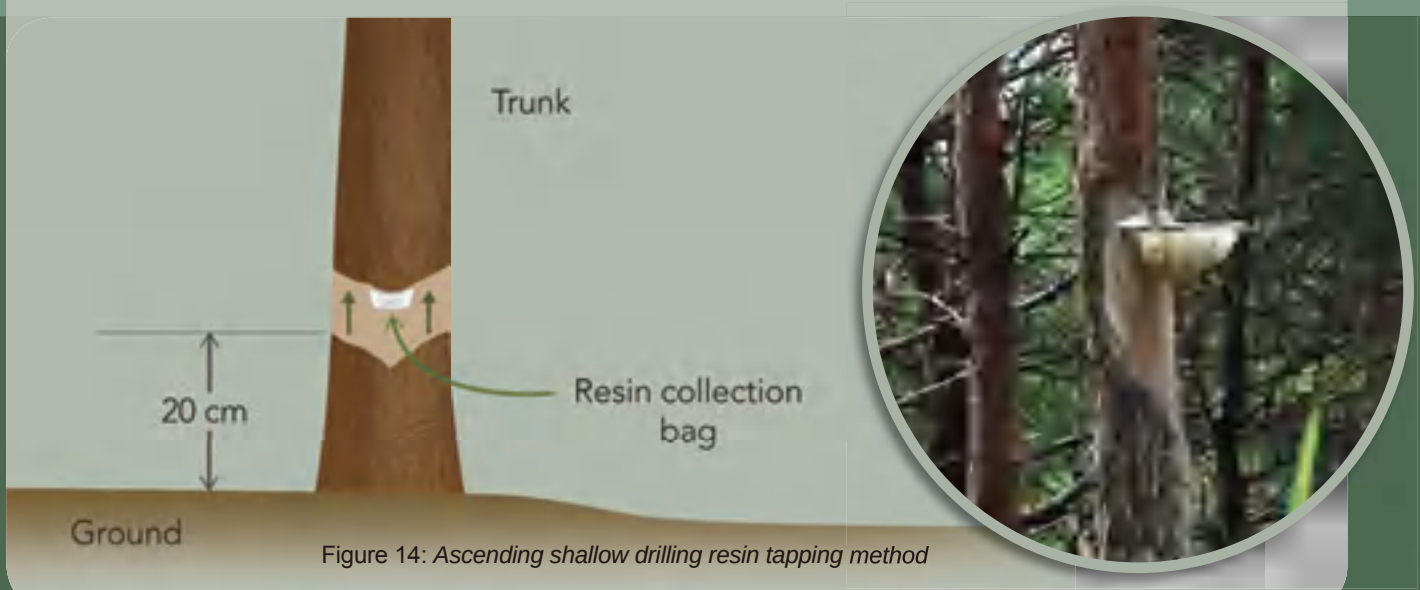


Figure 14: *Ascending shallow drilling resin tapping method*

1 RESIN PRODUCTION USING DIFFERENT THINNING INTENSITIES

The average monthly resin production using the 3 thinning intensities of 15%, 30%, 45% (and the control) are listed in Table 10. The result shows that different thinning intensities had little effect on the yield of resin, and that there was no significant difference amongst the different treatments, but the resin yield decreased year by year with an increase in harvesting years. Thus, for the resin production areas, once the DBH of pine trees reaches the minimum resin tapping size, usually 18 cm at Pu'er for *P. kesiya*, forest thinning should be limited as higher intensity thinning will decrease unit area resin production due to the removal of trees. This means that while the per tree resin yield is not correlated to the thinning intensity, less trees would lead to a stand-level decline of total resin production.

TABLE 10: Average annual resin production using different thinning intensities

Year	Resin production using thinning intensities [kg/(month·tree)]			
	15%	30%	40%	Control
2018	1.52	1.40	1.39	1.37
2019	1.47	1.42	1.39	1.19
2020	1.18	1.15	1.18	1.12
2021	1.12	1.04	1.09	1.04

However, forest thinning will bring positive effects on pine growth in terms of DBH, height and stand volume increase (Table 11). Generally, higher thinning intensities lead to an increased DBH growth, height increase and volume increment of the individual tree. Therefore, although forest tending for *P. kesiya* does not increase the individual tree's resin production, it can promote tree growth which may add to timber value in the long term. But a comprehensive analysis should be conducted to provide a cost-benefit analysis in terms of the cost for thinning and resin collection and the benefits derived from the resin harvest and timber production, because obviously resin tapping decreased the value of the timber to a certain degree.

TABLE 11: Impact of thinning intensities on tree growth performance of *P. kesiya*

Thinning Intensity	DBH Increment (cm)	Height Increment (m)	Stand Volume Increment (m^3/tree)
15%	2.6	3.01	0.12
30%	1.35	4.89	0.13
45%	2.53	4.65	0.15
Control	1.37	1.49	0.06

2 FERTILIZER APPLICATION EFFECTS ON RESIN PRODUCTION

The effects of different fertilizer application amounts on resin yield were compared with the control by applying 500 g, 1,000 g or 1,500 g of NPK compound fertilizer (N : P : K = 15 : 15 : 15) (Table 12) per tree. It shows that fertilization can increase resin yield of *P. kesiya*. The yield increased when the amount of fertilizer increased from 500 to 1,000 g per tree, but there was no significant increase when the amount of fertilizer was more than 1,000 g per tree. Rather, the yield of resin decreased year by year, which was caused by the natural decline of resin production over successive years of resin harvesting.

TABLE 12: Average annual resin production per tree with different fertilization rates

Year	Resin production under various fertilization rate			
	500 g	1,000 g	1,500 g	CK
2018	1.45	1.73	1.74	1.37
2019	1.30	1.49	1.46	1.19
2020	1.16	1.28	1.37	1.12
2021	1.16	1.31	1.36	1.04

Resin production always has a close correlation with the growth performance of the trees. These results show that fertilization can also improve the growth of trees. The performance of tree growth caused by fertilization is in step with the increase in resin production, when the fertilizer application rate is 1,000 g, the growth increases significantly, however importantly when the fertilizer application rate exceeds 1,000 g, the stand volume growth does not increase significantly (Table 13).

TABLE 13: Effect of fertilization rate on tree performance of *P. kesiya*

Fertilization amount (g/tree)	DBH Increment (cm)	Height Increment (m)	Individual tree volume increment in 3 years (m^3/tree)
500	1.67	2.35	0.08
1,000	2.10	3.60	0.11
1,500	2.54	2.80	0.11
Control	1.40	1.61	0.06

3 RESIN TAPPING FREQUENCY

To detect the influence of different frequencies on resin yield, three treatments with different harvesting frequencies of every 2, 3 and 4 days per harvest were designed (Table 14 and Table 15). The results showed that different harvesting frequencies have only a slight effect on resin production, and there is no significant difference between the different treatments. That being said, just like in the other treatments the yield of resin decreased year by year with an increase of harvesting years. Therefore, since total yield does not increase with higher frequency, the harvesting interval is suggested to be longer than 4 days, which can save labor cost. The results show that different tapping frequencies have only a slight differentiating effect on the growth of an individual tree. However, the increment of tree growth in the control area, where no tapping at all was conducted, was significantly higher than in the tapped trees, showing that even sustainable tapping methods will negatively impact overall tree growth.

TABLE 14: Average annual resin yield of sample trees using different tapping frequencies

Year	Resin production using varying tapping frequencies (kg/tree)		
	2 days	3 days	4 days
2018	1.52	1.40	1.39
2019	1.47	1.42	1.39
2020	1.18	1.15	1.18
2021	1.12	1.04	1.09

TABLE 15: Effect of resin tapping frequency on tree performance of *P. kesiya*

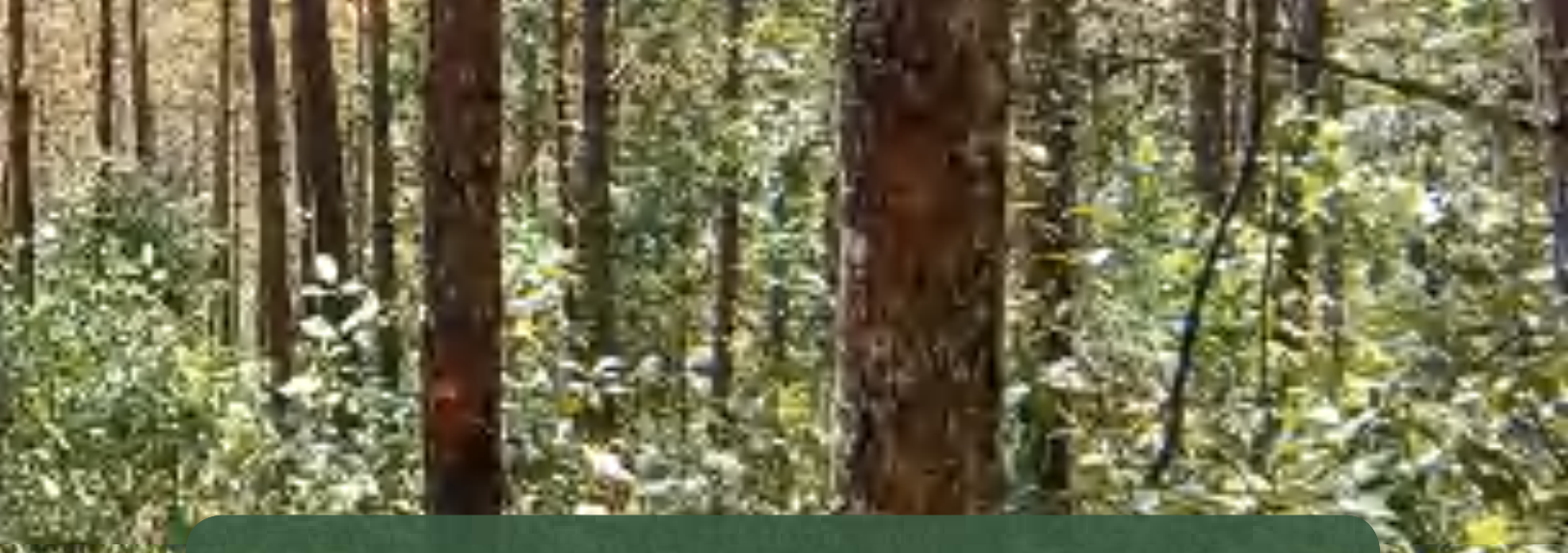
Resin harvest interval	DBH Increment (cm)	Height Increment (m)	Individual tree volume increment in 3 years (m^3/tree)
2 days	2.43	3.63	0.12
3 days	2.03	3.37	0.10
4 days	1.72	2.87	0.09
Control	3.44	3.15	0.14

4 RESIN TAPPING INTENSITY

The average annual resin production of each sample tree using four different tapping intensities, cutting face load rate set at 30%, 40%, 50% and 60% are shown in Table 16. The results show that with an increase of cutting intensity, the yield of resin increased gradually each time, however importantly the yield of resin decreased year by year, and the difference between treatments gradually became smaller in the last project year (which is less than the general total duration of tapping done). The decreasing rate of resin yield under 30%, 40%, 50% and 60% of tapping intensity from 2018 to 2021 are 20.78%, 19.15%, 20.54% and 31.77%, respectively, which indicate the higher of tapping intensity, the higher the annual decrease of resin production.

TABLE 16: Average annual resin yield of sample trees using different tapping intensities

Year	Annual resin yield using different tapping intensities (kg/tree)			
	30%	40%	50%	60%
2018	1.73	1.76	1.94	2.08
2019	1.71	1.75	1.85	1.89
2020	1.40	1.47	1.52	1.60
2021	1.37	1.43	1.54	1.42



The influence of different resin tapping intensities on the growth of pine trees was also investigated. The results (Table 17) show that compared with the control, where it was 0.14m^3/tree, the growth increment (individual stand volume) of the pine trees decreased gradually from 0.1 to 0.1, 0.09 m^3/tree and finally to 0.06 m^3/tree in the 3 project years (2018–2021), respectively, with an increase of the tapping intensity. Especially when the tapping intensity reached 60%, the increment of the stand volume declined sharply by 32.8% compared with the 50% tapping intensity.

TABLE 17: Effect of fertilization rate on tree performance of *P. kesiya*

Tapping intensity	DBH Increment (cm)	Height Increment (m)	Individual stand volume increment in 3 years (m^3/tree)
30%	2.28	2.68	0.10
40%	2.85	1.81	0.10
50%	2.13	1.84	0.09
60%	1.65	1.40	0.06
Control	3.44	3.15	0.14

Based on the above results, in the process of resin harvesting of *P. kesiya*, adopting a **tapping intensity of 40% (cutting-face load rate), 4 days or longer as a tapping frequency, and 1,000 g of compound fertilizer**, are recommended. The resin yields and forest stocking can be significantly increased, while labor cost can be decreased through proper thinning. Based on these experimental results and the demonstration of sustainable forest management-oriented cultivation techniques for efficient resin production, awareness building, and technical training were strengthened. Resin collection techniques of local forest farmers are enhanced through regulated collection activities. A *Technical Manual for Effective Resin Collection of P. kesiya* in Yunnan Province has been developed based on a review of related documents and key results generated from this project. The manual will guide forest farmers' collection operations as the relevant communication activities and technical training are carried out.

CHAPTER 3

FOREST FIRE DETECTION AND MONITORING

3.1 INTRODUCTION

Over the past few years, more frequent and catastrophic forest fires have occurred around the world. Forest fires tore across the Brazilian Amazon, imperiling the world's most biodiverse forests, and even the frozen lands of Siberia and Alaska have suffered unprecedented wildfires. While small-scale fires are a natural process to help the forests clear off shrubs in the understory and allow the forest to regenerate, large-scale, hot fires can cause considerable destruction to both forest ecosystems and human communities and thus need to be prevented.

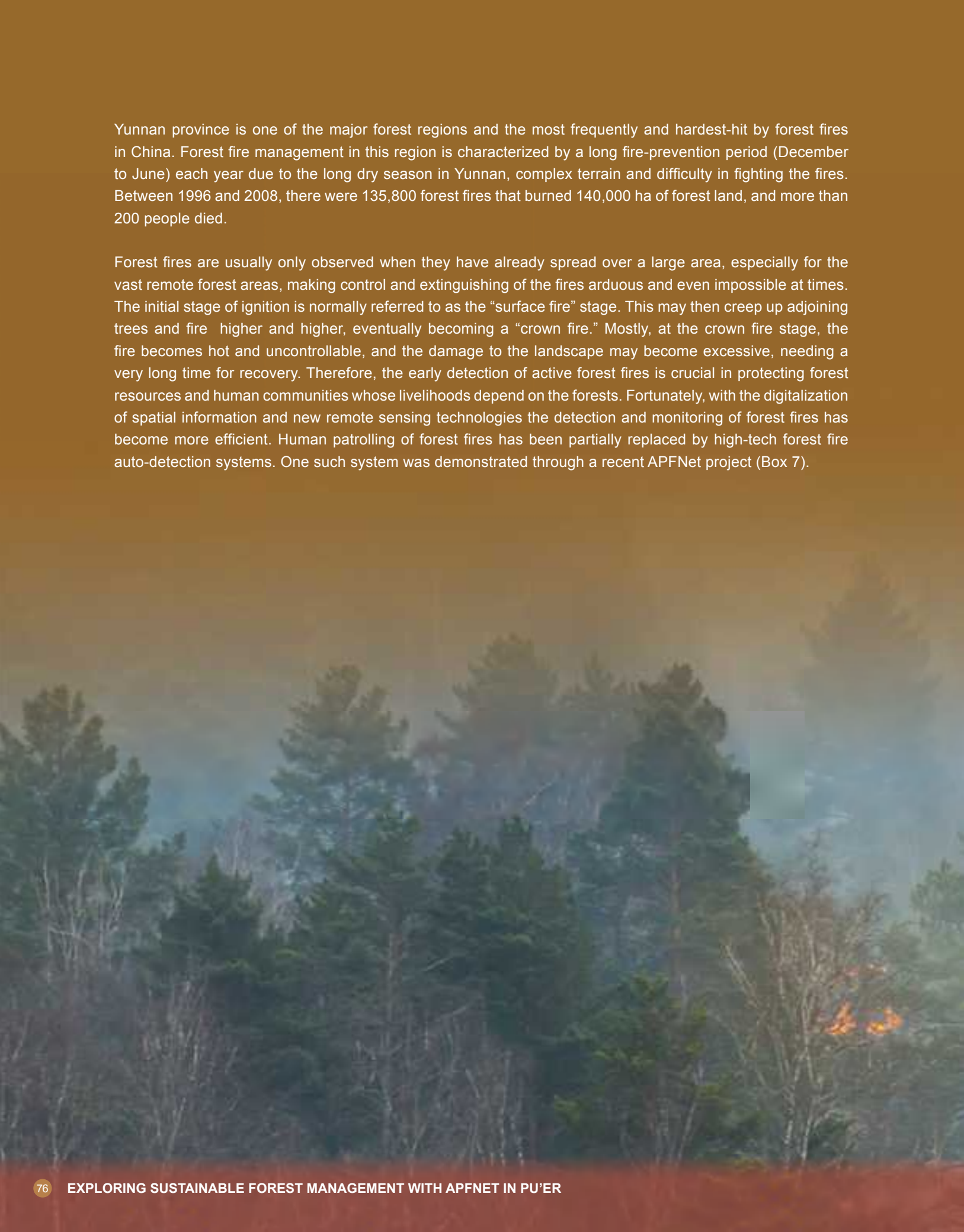
China specifically is also experiencing climatic shifts that are putting its forests at an increased risk for fire. In China, the greatest risk for forest fires is in the winter season (January to April) due to monsoonal influences that cause the lowest precipitation of the year to be in winter, and thus the fire threat remains serious each year during that time. Based on forest fire records provided by the Forest Fire Management Office of the National Forestry and Grassland Administration in China, between 2000 and 2020 6,283 fires occurred on average each year in China and the average burned area was 183,126 ha.

Forest fire occurrence is driven by many factors, including weather conditions, human activities, fuel characteristics, fire management, land use change and climate change. Wildfire is a natural phenomenon, but the problem is that more than 90% of all wildfires nowadays are caused by human activities in China (Zong et al., 2021), which results in significant forest loss, and wildfires emitted 1.76 billion tons of carbon globally in 2021, which is more than double of Germany's annual CO_2 emissions, according to data from the European Union's Copernicus Atmosphere Monitoring Service.

Wild forest fire (Photo: Panther Media)

Yunnan province is one of the major forest regions and the most frequently and hardest-hit by forest fires in China. Forest fire management in this region is characterized by a long fire-prevention period (December to June) each year due to the long dry season in Yunnan, complex terrain and difficulty in fighting the fires. Between 1996 and 2008, there were 135,800 forest fires that burned 140,000 ha of forest land, and more than 200 people died.

Forest fires are usually only observed when they have already spread over a large area, especially for the vast remote forest areas, making control and extinguishing of the fires arduous and even impossible at times. The initial stage of ignition is normally referred to as the “surface fire” stage. This may then creep up adjoining trees and fire higher and higher, eventually becoming a “crown fire.” Mostly, at the crown fire stage, the fire becomes hot and uncontrollable, and the damage to the landscape may become excessive, needing a very long time for recovery. Therefore, the early detection of active forest fires is crucial in protecting forest resources and human communities whose livelihoods depend on the forests. Fortunately, with the digitalization of spatial information and new remote sensing technologies the detection and monitoring of forest fires has become more efficient. Human patrolling of forest fires has been partially replaced by high-tech forest fire auto-detection systems. One such system was demonstrated through a recent APFNet project (Box 7).



BOX 7: Forest Fire Monitoring Techniques

There are a number of ways in which forest fires can be monitored, ranging from simple, low-tech methods to extremely sophisticated high-tech solutions. Some of the main methods are described below:

Traditional human observation

The traditional approach to forest fire monitoring is through human observation, whether from observation towers or by patrolling in forest areas, but this technique is inaccurate and inefficient. It still plays, however, an important role especially in developing economies, where finances and technology are limited.

Satellite-based observation

Satellite remote sensing makes it possible to monitor fires globally in near-real time. The dynamic process of fires extending over large, inaccessible areas, can be readily observed from various satellite sensors such as ATSR (Along Track Scanning Radiometer), Landsat, AVHRR (Advanced Very High Resolution Radiometer), MODIS (Moderate Resolution Imaging Spectroradiometer) and SPOT (Satellite Pour l'Observation de la Terre). Burn scars can be observed if the fire was severe and recent enough and if the canopy is open enough. However, a full scanning for the Earth requires 1–2 days, which is considered a long delay to detect the fire. Satellite image quality is impacted by weather conditions (e.g. clouds), which also affects the monitoring results of forest fires.

Digital camera-based observation

Digital camera surveillance is another available technique for forest fire detection. The technology advancement of cameras, image processing, industrial computers and sensors resulted in advances in automated early warning systems. Different types of detection are used in monitoring forest fires, such as visible light cameras able to recognize a spectrum of smoke and fire during day time and thermal cameras to detect the heat glow of fire, which is more helpful at night or for monitoring the fires in the understory.

3.2 FOREST FIRE MONITORING AND EARLY WARNING SYSTEM

Since 2014, APFNet has supported several economies (including Laos, Cambodia, and China) to install the "Forest Fire Monitoring and Early Alarming System" (FFMEA) through its demonstration projects, which is a camera-based fire detection system aiming to monitor forest fires, detect fires early and prevent them from escalating, thus protecting the forest resources. The FFMEA system is a state-of-the-art solution, which uses an infrared-sensitive camera installed on a tower in the forest (called the "Forest Watcher") and back-end command and control platforms in the control center to automatically monitor fire outbreaks. The forest fire monitoring tower can be left unattended, monitoring in real time throughout the day. The Forest Watcher slowly rotates its head 360° within 30 minutes and can cover a radius of 15 km. It has a target positioning accuracy of within 100 m.

Forest watcher (left) and forest fire monitoring tower (right) in Pu'er (Photo: Li Zhaochen, APFNet)

FIRE PREVENTION PROJECT AT THE APFNET PU'ER TRAINING BASE [2020P5-PE]

Supervisory agency: Forestry and Grassland Bureau of Pu'er City
Executing agency: Wanzhangshan Forest Farm
Total budget: USD 635,912
APFNet grant: USD 591,059
Duration: 12 months, 09/2020–08/2021
Target economy: China
Site location: Wanzhangshan Forest Farm, Pu'er City, Yunnan Province

PROJECT GOAL:

The project aims to install a forest fire monitoring and early warning system at WZSFF. The system uses front-end intelligent monitoring equipment installed in the forest area and back-end command and control platforms in the control centers to monitor and quickly assess any fire outbreaks in the forest area in real time. The system allows the officer at the control center to manage firefighting actions at every level, from calling firefighting forces, to determining the optimal route to the outbreak, to providing technical support for forest fire prevention management and overall reducing the incidence of large fires and losses caused by fires.

As previously mentioned, Pu'er is located in the transition zone between the North tropical and South subtropical climate. Although the annual rainfall reaches around 1,450 mm, 70% of the rainfall occurs during the rainy season (June to September), which leaves the dry season with a relatively high risk for forest fires. Thus, between 2020 and 2021, APFNet installed the FFMEA system in WZSFF, where the APFNet Pu'er Sustainable Forest Management Demonstration and Training Base is located. Four forest fire monitoring towers and two control centers were built at the forest farm, with one control center established at the headquarters of the farm and the other at the APFNet Pu'er Base. The system allows the monitoring of 50%–60% of the forest farm's total forest area (19,120 ha) (Figure 15).

Technological advantages

- **Early detection:** Within a 15 km radius, cruise time of 1 rotation < 30 minutes.
- **Strong recognition capacity:** False alarm less than 3 times per day within an area of 10,000 ha; missing alarm rate less than 1%.
- **High positioning accuracy:** Positioning error less than 100 m.
- **Uninterrupted cruise:** Double-recognition mode of infrared and visible system, 24-hour uninterrupted cruise.
- **Quick recognition algorithm:** Accurately recognize smoke and fires in real time.

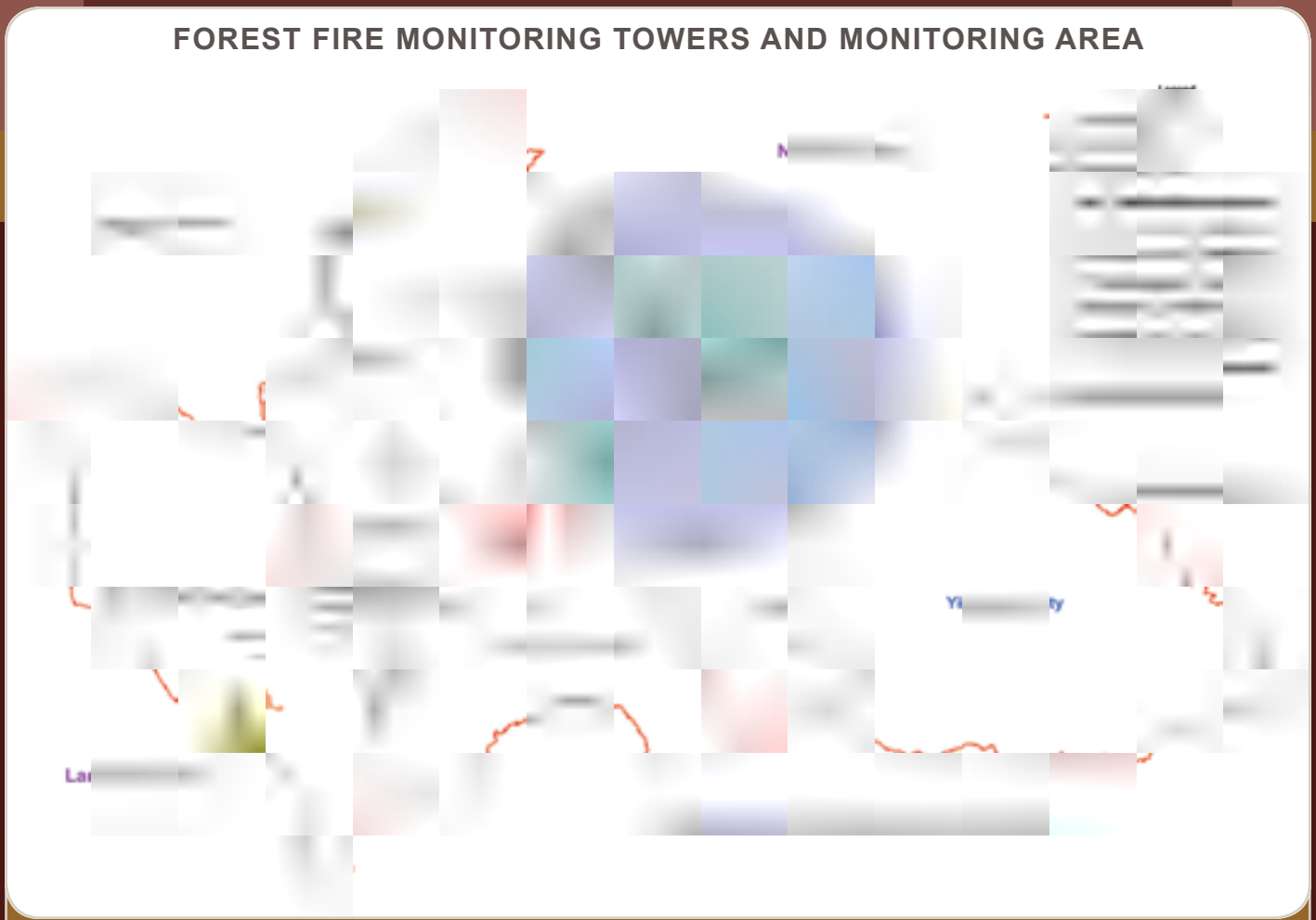


Figure 15: *Forest fire monitoring towers and monitoring area.*

The forest fire monitoring control center at the APFNet Pu'er Base (Photo: WZSFF)

Since the system monitors forest fire automatically in real time, it replaced the traditional manual fire monitoring with auto-detection. When the forest fire is detected, the coordinates of the fire will be rapidly located using GIS, and the system will automatically inform the responsible person at the control center, displaying a map with its exact location. Optimized routes to reach the fire area will be suggested, and the system is also able to analyze and forecast possible trends of the fire, such as in which direction it will burn, which supports decision-making on fire fighting. It is expected that the new system will rapidly reduce the time between initiation of the fire and its elimination, thus comprehensively protecting forest resources in WZSFF and at the APFNet Pu'er Base.

The FFMEA system is developed by the China Forestry Star company, which is a supplier of high-end professional video monitoring platforms and equipment. With high integration of advanced information technology, the FFMEA system is characterized by a short cruise period, fast image recognition, accurate positioning capacity, real-time data transmission, and so on, thereby filling a number of gaps in the professional application field, wherein the long radius monitoring and advanced image recognition algorithm of the FFMEA system has reached global standards for advanced forest fire monitoring. The FFMEA system effectively improves the protection of forest resources, especially forest fire monitoring capability, and successfully propels modern forestry management towards the next stage of high-tech monitoring.

CHAPTER 4

APFNET PU'ER BASE

APFNet Pu'er Sustainable Forest Management Demonstration and Training Base (Photo: Zhuo Yufang)

DEMONSTRATION OF SUSTAINABLE FOREST MANAGEMENT AND ESTABLISHMENT OF THE APFNET TRAINING BASE [2020P1-PE]

Supervisory agency: Forestry and Grassland Bureau of Pu'er City
Executing agency: Wanzhangshan Forest Farm
Total budget: USD 5,088,510
APFNet grant: USD 3,771,897
Duration: 36 months 01/2020–12/2022
Target economy: China
Site location: Wanzhangshan Forest Farm, Pu'er City, Yunnan Province, China

PROJECT GOAL:

The project aims to establish the *APFNet Pu'er Sustainable Forest Management Demonstration and Training Base* at Wanzhangshan Forest Farm in Pu'er, Yunnan Province, China. Pu'er Base will focus on demonstrating best practices of sustainable forest management in tropical and subtropical areas through establishing 1,333 ha of demonstration areas, and the base will also offer opportunities to conduct scientific research related to forests and forestry, forestry training, environmental education and provide a platform for information exchange and policy dialogue to promote sustainable forest management in the Greater Mekong Subregion and other regions in Asia-Pacific.

To further promote best practices of forest management in the Asia-Pacific Region, especially the GMS region, and also establish a platform for forestry information sharing and capacity building in the field of forestry, APFNet started the project titled "Demonstration of Sustainable Forest Management and Establishment of the APFNet Training Base" in 2020. The project aims to establish the APFNet Pu'er Sustainable Forest Management Demonstration and Training Base (short: Pu'er Base) at WZSFF. Pu'er Base is one key output of the Strategic Cooperation Framework Agreement between APFNet, the Yunnan Forestry and Grassland Administration, and Southwest Forestry University.

GUIDE MAP OF THE APFNET PU'ER SUSTAINABLE FOREST MANAGEMENT DEMONSTRATION AND TRAINING BASE

Main Attractions

- Yunnan House/Reception
- Asia-Pacific Ecolodges
- Yunnan Minority Village
- Ecoculture Lodges
- Conference Center
- Flag Square
- Woodwork House
- Campground
- Arboretum & Botanical Garden
- Forest Experience Area

Asia-Pacific Ecolodges

- Australia
- Bangladesh
- Brunei
- Cambodia
- China
- Fiji
- India
- Indonesia
- Lao PDR
- Malaysia
- Myanmar
- Nepal
- Pakistan
- Papua New Guinea
- The Philippines
- Singapore
- Sri Lanka
- Thailand
- Viet Nam
- APFNet

Yunnan Minority Village

- Lahu Minority Lodge A
- Lahu Minority Lodge B
- Yi Minority Lodge A
- Wa Minority Lodge A
- Hani Minority Lodge A
- Bai Minority Lodge A
- Jinuo Minority Lodge A
- Jinuo Minority Lodge B
- Bai Minority Lodge B
- Hani Minority Lodge B
- Modern Style Minority Lodge
- Wa Minority Lodge B
- Yi Minority Lodge B
- Dai Minority Lodge B
- Dai Minority Lodge A

Forest Experience Area

- Environmental Education Center
- Eco Rest Resort
- Shangri-la Loft
- Nature Home
- Tea Plantation
- Tea Processing Room
- Fire Monitoring Tower
- Mushroom Picking Area
- Ancient *Betula alnoides* tree
- Bird Watching Platform
- Viewing Platform

N


Symbols
Entrance
Parking Lot
Catering
Leisure Pavilion
Rest Area
Shower Room
Restrooms
Forest Trails
Main Road
Sightseeing Bus Road
Walking Paths
Yunnan Minority Village
Arboretum & Botanical Garden
Yunnan House/Reception
Woodworm House
Flag Square
Conference Center
Ecovillage Lodges
Entrance

4.1 AN INTEGRATED BASE TO PROMOTE THE SUSTAINABLE MANAGEMENT OF FORESTS

The **APFNet Pu'er Sustainable Forest Management Demonstration and Training Base**, short Pu'er Base, is a wildly ambitious project to create an integrated information and training platform for both professionals and the general public with the overarching goal to promote the sustainable management of forests in the Asia-Pacific Region. It is the second of its kind for APFNet as the first one, which is called the "APFNet Multifunctional Forest Management Demonstration and Experience Base", is located at Wangyedian Forest Farm in Inner Mongolia, China, and was put into operation in 2019. However, as that base is located in Inner Mongolia, which is in the North of China, the ecosystems it is representing ranged from temperate to boreal forests, thus only providing direct reference for a subset of the APFNet partners. Pu'er Base will focus on tropical and subtropical areas, and showcase best forest management practices for GMS and similar climate regions.

In order to achieve the aforementioned overarching goal, Pu'er Base focuses on 5 key components.

DEMONSTRATION OF SUSTAINABLE FOREST MANAGEMENT

The base serves as a platform for forestry demonstration. Totally 1,500 ha demonstration plots of sustainable forest management were established to showcase the management of different forest types in tropical and subtropical areas via the various APFNet projects. As mentioned in Chapter 2, effective forest management programs, for example intensive management of commercial plantations, integrated management of public welfare forests, understory planting of commercial species, close-to-nature forest management and multiple use forestry approaches are demonstrated at WZSFF.

CELEBRATING REGIONAL AND LOCAL CULTURE

APFNet has been established to serve its various members in the Asia-Pacific region. As such, at a base focusing on forestry of the members located in the subtropical and tropical regions, the cultures of those members should be celebrated and showcased. Additionally, Yunnan itself is home to a vast diversity of cultures and minorities, which deserve to be represented at the base. As such, a large part of the accommodation established at the base represents either those economies or Yunnan and its different minorities.

REGIONAL FORESTRY INFORMATION SHARING AND TRAINING

APFNet built Pu'er Base as an international platform for forestry information sharing and policy dialogue for professionals in the sector. Situated at a border area, facing the GMS and Southeast Asian economies, Pu'er Base serves as an ideal location for organizing international conferences, trainings and meetings, both organized by APFNet and other entities. Pu'er Base now has two meeting halls with a capacity to host meetings for up to 150 people.

ENVIRONMENTAL EDUCATION

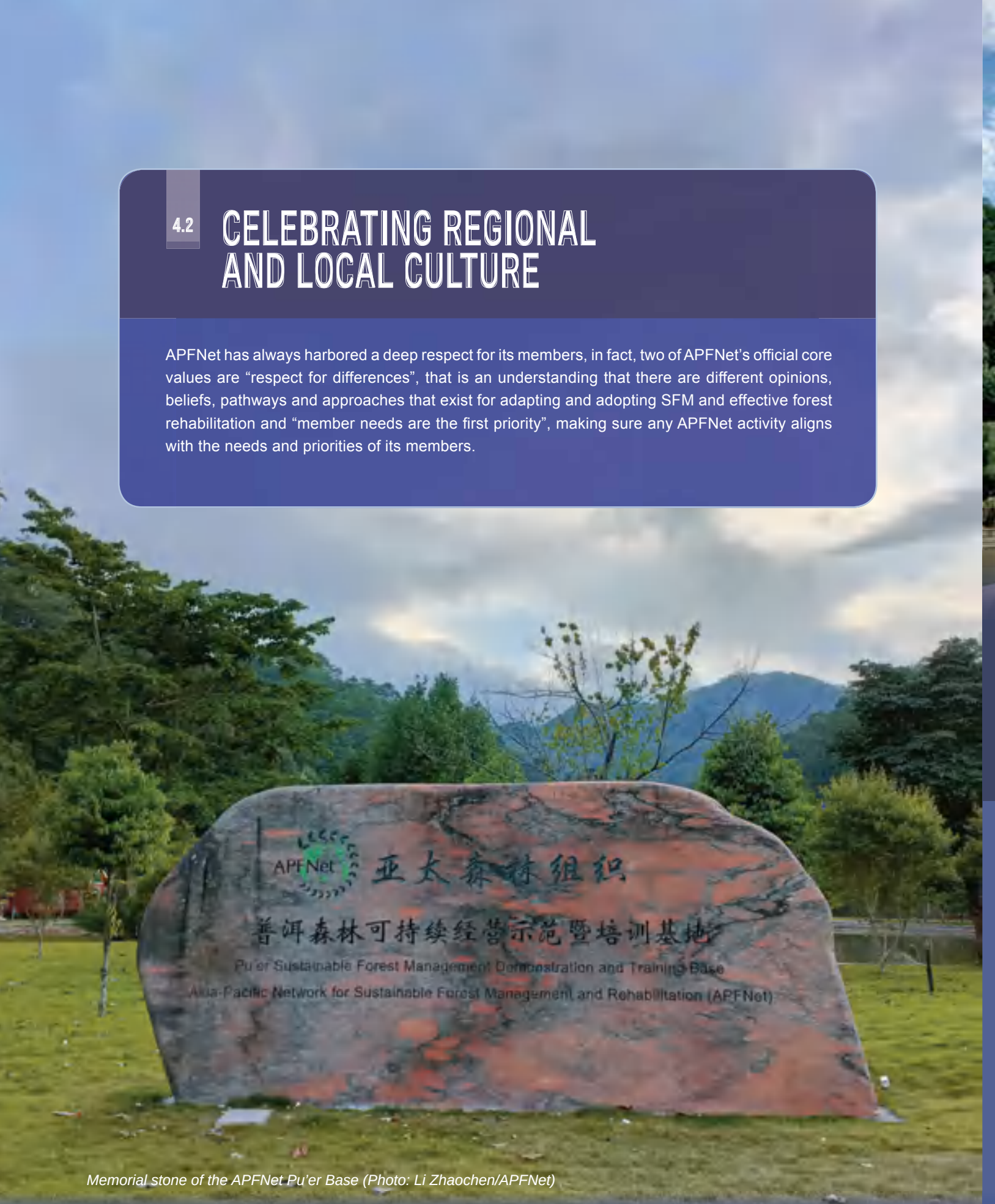
While forestry professionals are the key target audience of the base, the general public is a close second. Pu'er Base provides the perfect location for people to learn about the importance of forests, what they can do to protect their local environment and use the base to experience the beauty of nature themselves. Environmental education initiatives are targeted to both adults and children.

RESEARCH

The vast forests surrounding the base provide optimal conditions for conducting research to better understand how SFM can be best practiced in this region at large. Pu'er Base collaborates with various research institutes, such as the Chinese Academy of Forestry, Southwest Forestry University, the China and the Yunnan Academies of Forestry and Grassland, to expand this knowledge base.

4.2 CELEBRATING REGIONAL AND LOCAL CULTURE

APFNet has always harbored a deep respect for its members, in fact, two of APFNet's official core values are "respect for differences", that is an understanding that there are different opinions, beliefs, pathways and approaches that exist for adapting and adopting SFM and effective forest rehabilitation and "member needs are the first priority", making sure any APFNet activity aligns with the needs and priorities of its members.



Memorial stone of the APFNet Pu'er Base (Photo: Li Zhaochen/APFNet)

FLAG SQUARE

The flag square is an important symbol in honor of APFNet's members represented at the base and includes the flags from all 19 economies the ecolodges represent, that is Australia, Bangladesh, Brunei Darussalam, Cambodia, China, Fiji, India, Indonesia, Lao PDR, Malaysia, Myanmar, Nepal, Pakistan, Papua New Guinea, the Philippines, Singapore, Sri Lanka, Thailand, and Viet Nam.

ACCOMMODATION AT THE BASE

Beyond the flag square to celebrate regional and local culture, as well as to showcase its members and local Yunnan culture, APFNet dedicated a number of accommodation buildings to the different economies of the region and Yunnan and its minorities using different architecture styles representing them. In total Pu'er Base can now provide accommodation for up to 150 people at the same time, which can be booked on Qunar (https://www.qunar.com/), Trip.com (https://www.ctrip.com/) and WeChat (see right).

These accommodations can be broken down into the following.

Scan the QR code for the WeChat account of Pu'er Base for booking

4.2.1 ASIA-PACIFIC ECOLODGES

The Asia-Pacific Ecolodges consist of 20 cottages that represent 19 APFNet member economies of Asia-Pacific, as well as APFNet itself. Each house uses the unique architectural styles from the different economies.

AUSTRALIA

The **Commonwealth of Australia**, often dubbed the "island continent", is the 6th largest economy in the world and known for its megadiversity. It features a wide variety of landscapes and climates, including deserts, the semi-arid land generally known as "the outback", tropical rainforests, mountainous forests and of course the famous reefs, such as the world's largest coral reef, the Great Barrier Reef, home to a huge range of ocean species. Due to Australia's old age and long geographic isolation, much of the biota that evolved there is unique, with 45%–85% of the different species groups being endemic.

While Australia was first inhabited by indigenous Australians about 65,000 years ago, Western settlers arrived in the 17th and 18th century and influenced both the ecology (through hunting and the introduction of non-native species), as well as the culture of the continent.

APFNet collaborates with several Australian universities, such as the University of Queensland or the University of Melbourne, as well as independent experts, to implement innovative projects all over Asia-Pacific.

The lodge represents a typical architectural style in Australia influenced by western aesthetics, and especially influenced by its British colonial past, the USA in the 1920s, often referred to as "bungalow homes" and the typical Queenslander residential housing style. These types of homes suit warm, tropical climates (both in Pu'er and Australia) and generally feature a terrace. It is also inspired by "worker's cottage design", meaning it shows a type of minimalism that focuses on the practical.

The lodge has a terrace, 2 bedrooms (1 twin room and 1 double room), 1 living room, 2 bathrooms and can accommodate up to 4 people.

BANGLADESH

The **People's Republic of Bangladesh**, located in South Asia, is known as one of the most densely populated economies in the world, providing a home for more than 163 million people on less than 150,000 km^2. It is also the third-largest Muslim-majority economy in the world. Most of the area is defined by the Ganges Delta, the largest river delta in the world, which results in fertile rich flat land. Since most of this area is barely above sea level, it is severely threatened by flooding or sea level rise projected by climate change. 17% of the economy is covered by forests, many of which are located in the evergreen hill ranges in the Southeast and Northeast. Bangladesh is home to the world's largest mangrove forest, covering an area of 6,000 km^2, but also hosts tropical and subtropical coniferous forests, freshwater swamp forests and mixed deciduous forests, as well as evergreen and semi-evergreen forests. It is home to the famous Bengal tiger.

The architecture, while using only wood opposed to a combination of wood, bamboo and a local straw called Khar common in this type of style, was inspired by a mix of Mughal architecture and islamic elements, combined with Bengal style bungalow architecture, and adopted a wide veranda, using elements from British colonial housing. Houses in this style are still quite popular in rural Bengal. The lodge has 2 bedrooms (1 twin room and 1 double room), 1 living room, 2 bathrooms and can accommodate up to 4 people.

BRUNEI DARUSSALAM

Brunei Darussalam is located in the north of the island of Borneo in Southeast Asia and is completely surrounded by the state of Sarawak of Malaysia. With a population of less than 500,000 people, but the 2nd highest Human Development Index (HDI) among Southeast Asian nations, it is one of the few economies in the region formally classified as developed.

Of the two parts of Brunei, while the Western part is significantly larger, the Eastern mountainous part is less populated and offers plenty of habitat. Forests cover 81% of the total land area, of which 59% remain primary forests. Both lowland rainforests, but also mountain rainforests occurring most frequently, while at the coast mangrove forests represent the largest remaining intact mangroves in northern Borneo and together with the neighboring economies comprise one of the largest tracts of relatively undisturbed mangroves in eastern Asia. Peat swamp forests can be found as well, most largely still undisturbed.

The architectural style is inspired by the traditional stilt houses built above water, which are generally made of wood and adopt the style of traditional Malay houses. Specific styles of these houses can vary widely since they were historically built privately. Traditionally these houses are then connected with each other via wooden walkways (a famous example is Kampong Ayer), however in this case, as there is no actual water, the house was rather combined into a longer complex, each “sub-roof” symbolizing an individual house, but creating an overall larger living space with 2 bedrooms (1 twin room and 1 double room), 1 living room, 2 bathrooms and a long terrace.

CAMBODIA

The **Kingdom of Cambodia**, located in the Greater Mekong Subregion, is a small economy with a population of about 17 million people. While classified as a developing economy, it is one of the fastest-growing economies in Asia. Agriculture remains a key sector, although new sectors, such as the service sector or ecotourism become increasingly important. Cambodia's landscape is characterized by a low-lying central plain surrounded by uplands and low mountains. The Tonle Sap and the upper reaches of the Mekong River delta flow through Cambodia. Cambodia's climate is dominated by monsoons resulting in tropical wet and dry seasons, and leading to the dominant forest type being seasonal tropical forests.

APFNet has several demonstration projects on topics such as integrated watershed management, agroforestry, forest restoration, fire monitoring and sustainable forest management in different areas of Cambodia, including Siem Reap and Phnom Penh.

The lodge takes elements from traditional Khmer housing, such as stilts and the typical steep, arched roofs. Similar to rural Khmer houses, the basic structure is held together by a wooden frame, however using elements from more contemporary Cambodian houses, instead of the original homemade palm matting, wooden boarding was used for walls.

The lodge has 2 bedrooms (1 twin room and 1 double room), 1 living room, 2 bathrooms and can accommodate up to 4 people.

CHINA

The **People's Republic of China**, covering an area of approximately 9.6 million km^2, and with a population of more than 1.4 billion, is the world's third-largest and also most densely populated economy. China emerged as one of the world's first civilizations in the fertile basin of the Yellow River, as such it has a long and rich history dating from more than 4,000 years ago. While now also one of the world's largest manufacturers and a center for innovation, China is also still an agricultural economy with a long history of farming and the tradition of intensive cultivation with a large rural population. It has succeeded in producing one fourth of the world's grain and feeding one fifth of the world's population on less than 10% of the world's arable land. China is also an economy with relatively poor forest resources. However, during the past several decades China has made tremendous efforts in afforestation and reforestation, which has increased the forest cover from 8.4% in 1950s to 23.04% in 2020. China has an extremely wide variety of forest types due to its diverse geography and these include deciduous forests, boreal, temperature and subtropical coniferous forests, tropical rainforests, bamboo forests and many more.

The headquarter of APFNet is located in Beijing, China. Since its establishment in 2008, APFNet has funded around 10 demonstration projects in China. These include projects that demonstrate multifunctional forestry and desertification control in Inner Mongolia, a project demonstrating close-to-nature forest management and watershed forest management near Beijing, and also the three projects demonstrating integrated forest management and forest fire monitoring in Pu'er, as presented in this book.

The architecture of China is as old as Chinese civilization itself, and has had a major influence on the architectural styles of Japan, Korea, Mongolia, and Viet Nam, and a varying amount of influence on architectural styles in South and Southeast Asia. Chinese architecture is characterized by various features, such as bilateral symmetry, use of enclosed open spaces, and the incorporation of ideas related to Fengshui (e.g. directional hierarchies). The China lodge has taken inspiration from the traditional Chinese courtyard, also known as 'Siheyuan' (Chinese: 四合院). A courtyard is a space enclosed by walls, a yard surrounded by buildings in an enclosed quadrangle area. Throughout Chinese history, the Siheyuan composition was the basic pattern used for residences, palaces, temples, monasteries, *etc*. The China lodge was built bilaterally, with one double-floor building at the rear side, and three coterminous rooms at the left and right side, respectively. Unlike the traditional Siheyuan, which is enclosed by 4 sides, the China lodge has its front side wide open to the public, resulting in an open space in the middle surrounded by buildings from three sides. The lodge has a reception area, 1 living room and 1 tea room in the double-floor building, and 6 bedrooms (4 twin rooms and 2 king rooms) with 3 bedrooms on each side. respectively. The lodge can accommodate up to 12 people. Traditional Chinese gardening can be experienced right in front of the lodge.

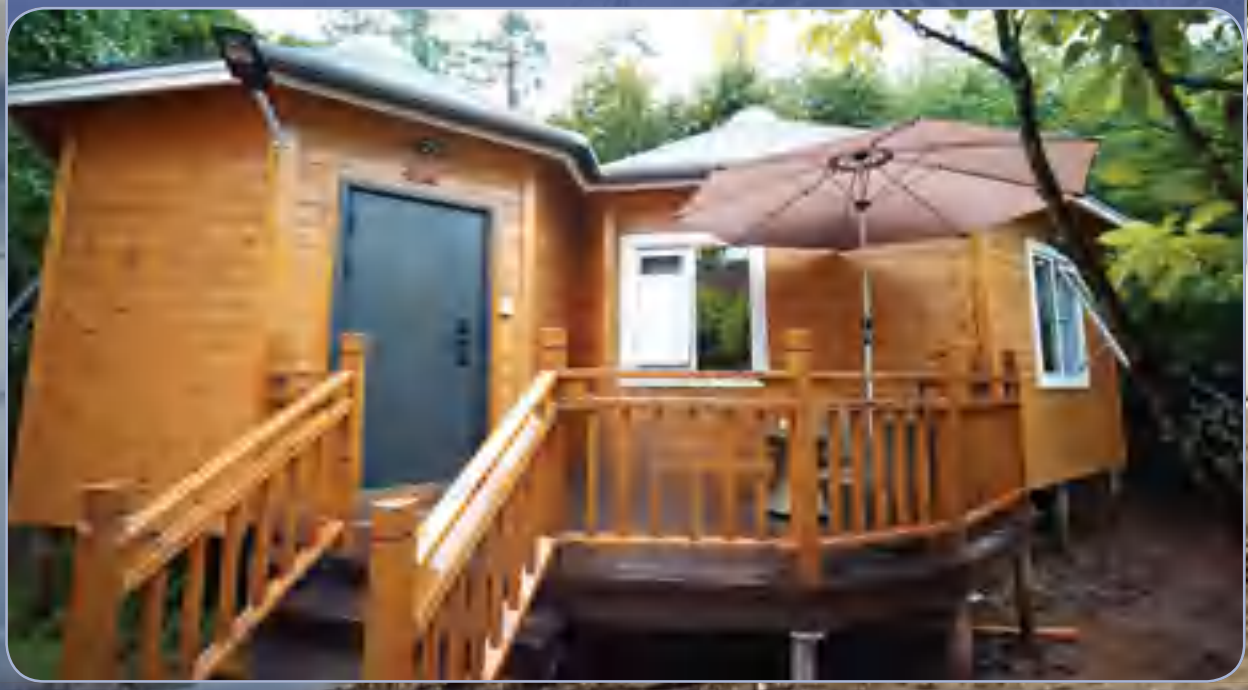
FIJI

The **Republic of Fiji** is an island economy in Melanesia, in the South Pacific Ocean. It consists of an archipelago of more than 330 islands and more than 500 islets. The total population of the economy is less than a million, with most living on the two major islands, Viti Levu and Vanua Levu. While considered one of the most developed economies amongst the Pacific Islands, it relies heavily on the primary sector for income, and still has a fairly sizable subsistence sector.

Fiji is influenced by a tropical marine climate, which is warm all year around with minimal extremes. Rainfall varies depending on the season and island size, where larger islands generally receive heavier rainfall in the southeastern parts of the island and the lowlands of the western portions have a dry season. As most of Fiji's islands were formed by volcanic activity, some of that geothermic activity still occurs today. Moist tropical forests, specifically lowland rain forests, montane rain forests and even cloud forests cover large parts of the islands. Due to its island status many endangered species found are endemic to Fiji, for example about 23% of vascular plants are endemic. In this context climate change is a key concern for the economy, as rising sea levels and extreme weather may severely impact its people, but also its biodiversity.

APFNet, previously through the South Pacific Community (SPC), implemented forest policy-focused projects in Fiji and is now supporting the economy in its efforts through a new project focusing on the development of the sandalwood industry.

The most famous traditional architectural styles of Fiji houses are the bure houses, which use palm wood or reed wood for roofing. However, since this type of housing traditionally has no windows is thus quite dark, the more modern Fijian contemporary architectural style, allowing for plenty of windows and a sturdier roof through the use of wood, was selected. The lodge has 2 bedrooms (1 twin room and 1 double room), 1 living room, 2 bathrooms and can accommodate up to 4 people.



INDIA

The **Republic of India**, located in South Asia, is the seventh-largest economy by area and the second-most populous economy in the world. Still considered a developing economy, it is nevertheless a fast-growing major player and is expanding not only its service sector, but also its quaternary sector, especially through the strong development of the information technology sector.

The Indian climate is strongly influenced by monsoons, but also the Himalayas to the north and the Thar desert. As such, a number of main climate types can be found, the tropical wet, tropical dry, subtropical humid and montane climate.

Forests cover 21.7% of its area, mostly reflected in tropical moist forests, temperate coniferous forests, moist deciduous Sal forests and dry deciduous teak forests. India is considered megadiversity, with four biodiversity hotspots, and with a full third of Indian plant species being endemic.

The lodge has been inspired by Indo-Saracenic and Indo-Islamic architecture, especially Mughal architecture, which features the typical bulbous onion domes surrounded by greenery on all sides, as well as some ornaments. The lodge has 2 bedrooms (1 twin room and 1 double room), 1 living room, 2 bathrooms and can accommodate up to 4 people.

INDONESIA

The **Republic of Indonesia** is the world's largest island economy, located in Southeast Asia with a population of about 270 million people. Classified as still developing economy, it nevertheless has the largest economy in Southeast Asia and is also considered as newly industrialized. The service industry is the largest sector, albeit the primary sector, especially agriculture and palm oil, of which Indonesia is the world's largest producer, still represents an important source of income.

Indonesia is dominated by a tropical rainforest climate, which causes temperatures to be relatively even year-round, and two seasons, the wet season and the dry season. Some more cooling climates exist in mountainous regions, while oceanic climates prevail right at the coast and in highland areas adjacent to rainforest climates. Main forest types include tropical rainforests, monsoon forests, peat swamp forests, mountainous forests and mangrove forests.

APFNet implemented several demonstration projects in Indonesia, covering topics, such as forest carbon accounting, integrated watershed management and agroforestry.

The architecture of the lodge was inspired by the traditional Rumah Gadang houses, the traditional homes of an Indonesian ethnic group in West Sumatra, featuring dramatic gonjong horn-like curved roof structures with multi-tiered, upswept gables. Similar to these traditional houses, the lodge is largely constructed of wood.

The lodge has 2 bedrooms with double beds, 1 living room, 2 bathrooms and can accommodate up to 4 people.

LAO PDR

The **Lao People's Democratic Republic** is a landlocked economy in the GMS region, bordered by China, Viet Nam, Cambodia, Thailand and Myanmar. Taken off the list of Least Developed Countries (LDCs) in 2021, it officially graduated from this status and with a population of more than 7 million people, it is now considered one of Southeast Asia's fastest growing economies. That being said, subsistence agriculture still accounts for about half of the GDP and provides 80% of employment.

Laos is dominated by rugged mountains especially in the northern part of the economy, through which the Mekong River flows into larger level areas in the south, with only 4% of the total area classified as arable. A monsoonal climate influences the area, with the dry season lasting from roughly November to April and the rainy season occurring May to October. Main forest types include mixed deciduous forests, dry dipterocarp, dry evergreen, coniferous and broadleaved forests.

APFNet implemented demonstration projects covering various issues, such as forest fire monitoring, forest restoration, NTFP cultivation and transboundary wildlife conservation, in several northern provinces of the economy.

The lodge's architectural style was influenced by the wat temples, which are traditionally made out of wood and feature pitched roofs, but also combined other styles found in Laos, such as the style of traditional Lao homes that are often stilted, French colonial styles and modern architecture. The lodge has a porch, 2 bedrooms (1 twin room and 1 double room), 1 living room, 2 bathrooms and can accommodate up to 4 people.

MALAYSIA

Malaysia, with a population of 32 million people, is located in Southeast Asia, and considered a newly industrialized market economy, ranked third-largest in Southeast Asia. While traditionally relying on its natural resources for the majority of its income, in recent years since tourism (especially medical tourism) and commerce have obtained increasingly important roles. That being said, products like rubber and palm oil still play important roles to this day.

Malaysia is topographically defined by coastal plains rising to hills and mountains, with the mountains being especially heavily forested. The economy is influenced by a primarily equatorial climate, which is hot and humid throughout the year, but also receives some influence from the monsoon. In the mountains local mountain climates dominate, leading to an overall cooler and wetter climate. Most forests in Malaysia are tropical rainforests, the largest share consisting of dipterocarp forests, but also hosting lowland rainforests, swamp forests and mangrove forests. APFNet has supported projects both in Malaysia itself, covering topics such as local livelihood improvement and sustainable forest management, as well as regional projects targeting Malaysia as one of many economies, such as projects aiming to assess climate change impacts on different tree species and forest ecosystems and regional assessments of forest cover.

The lodge, just like traditional Malaysian buildings, primarily uses wood as its main construction material. The design mainly emulated the Malay house architectural style, featuring key architectural forms, such as the vernacular, tropically-suited, gabled roof, stilts in the style of Ruman Pangggung and harmonious proportions, using stairs leading to a veranda and partitioning the rooms inside. The lodge has a porch, 2 bedrooms (1 twin room and 1 double room), 1 living room, 2 bathrooms and can accommodate up to 4 people.

MYANMAR

The **Republic of the Union of Myanmar**, is the largest economy in mainland Southeast Asia and has a population of about 54 million people. It is an economy rich in natural resources, such as gemstones, mineral resources like rare earth elements, oil and natural gas, and forests. It is considered one of the fastest growing economies in the world, however currently the informal economy still makes up one of the biggest shares of the total economy.

Bordering China in the North, most of the mountain ranges run north-to-south from the Himalayas and divide Myanmar's three river systems, the Irrawaddy, the Salween and the Sittaung river. The Irrawaddy is the longest river in Myanmar and empties into a delta rich in mangrove forests. Myanmar is influenced by a monsoonal climate, which, in combination with the aforementioned geography, results in the North being rather cool, the center of Myanmar tending to be dry and the delta and the coast receiving the most precipitation. Forests cover about half of the economy's territory and dominating forest types include mixed deciduous forests, hill evergreen forests, dry forests, deciduous dipterocarp forests, coastal rainforests, mangrove forests. Myanmar is generally well known for its abundant teak resources, which are naturally found in the mixed deciduous forests.

APFNet has several projects in Myanmar, covering topics such as mangrove restoration, integrated watershed management, or the preservation of genetic resources.

The lodge's architectural style has been inspired by the golden cladding of some of the most famous Buddhist pagodas, which is also in general a feature of traditional Burmese architecture. Additionally, elements used in traditional housing rather than temples, such as the traditional farmhouse building, combined with colonial influences, were used, building the lodge on stilted posts and using wood. The lodge has a porch, 2 bedrooms (1 twin room and 1 double room), 1 living room, 2 bathrooms and can accommodate up to 4 people.

NEPAL

The **Federal Democratic Republic of Nepal** is a landlocked economy in South Asia mainly situated in the Himalayas. With a population of less than 30 million, Nepal is considered one of the fastest-growing economies in the world. The primary sector provides more than a quarter of the total income, but importantly the service sector, which includes tourism, makes up more than half of the GDP.

Nepal has a diverse geography that goes beyond just the Himalaya. It is divided into three principal physiographic belts known as “Himal-Pahad-Terai”. The Himal is the snow-covered mountainous region defined by the Himalayas, including the world’s tallest mountain, the Mount Everest, and is situated in the north of Nepal. It is defined by a alpine monsoonal climate that is dry, cold and generally windswept. Pahad refers to the mountainous region that generally does not contain snow, usually mountains ranging from 800 to 4,000 m in altitude, which are subalpine, often forested hills. Alpine to subtropical climates dominate depending on the altitude. The Terai, also known as the southern lowland plains, are fed by three major Himalayan rivers and is defined by a subtropical to tropical climate. With so many high mountains, forests cover less than half of the total area, but include a wide range of forest types from subalpine coniferous forests to temperate deciduous mixed forests to subtropical and even tropical evergreen forests.

APFNet has implemented several projects in Nepal, focusing on key topics, such as community forestry, sustainable forest management, women empowerment and general livelihood improvement.

The architectural style of the lodge, just like typical Nepali architecture, tries to merge art and practicality. The shape was inspired by the pagoda architectural tradition of Nepal, which often features prominently among Hindu temples in the economy. The pagoda style, one of the oldest in Asia, was originally derived from the shape of Himalayan fir trees. Other styles, such as the Newa style, which is an indigenous style and was used in residential housing as well, contributed some features, such as the narrow windows on top. The lodge has overall 2 bedrooms (1 twin room and 1 double room), 1 living room, 2 bathrooms and can accommodate up to 4 people.

PAKISTAN

The **Islamic Republic of Pakistan**, located in South Asia, is the world's 5th most populous economy with a population of more than 225 million people. Pakistan is considered semi-industrialized and is an important export economy, producing more wheat than all of Africa, while being the fifth-largest producer of cotton in the world. That being said, the service sector actually makes up more than half of the national GDP and has emerged as the main driver of economic growth.

The geography of Pakistan is extremely diverse and can roughly be divided into three major areas: the northern highlands, which contain some of the world's highest peaks, the Indus River plain and the Balochistan plateau. The climate, influenced by the monsoon, varies from tropical to temperate and is rather arid in the coastal south. Forest types range from alpine and subalpine coniferous forests in the northern highlands to tropical and subtropical dry and moist broadleaf forests, as well as tropical and xeric shrublands elsewhere in the economy.

The lodge's design was influenced by Indu-Islamic architecture, as well as post-independence modern styles, which both often used white marble for its buildings, and was imitated by painting the wooden lodge white. Mughal architecture specifically is also well known for its use of large bulbous onion domes, of which mini-versions were installed on top of the roof. The lodge has 2 bedrooms (1 twin room and 1 double room), 1 living room, 2 bathrooms and can accommodate up to 4 people.

PAPUA NEW GUINEA

The **Independent State of Papua New Guinea** (PNG) is the world's third-largest island economy that comprises the eastern half of New Guinea and offshore islands in Melanesia. Despite only a population of less than 10 million people, due to its ruggedness and difficulty of traversing, it is one of the most linguistically diverse places in the world with 851 languages recorded to date. It is considered a developing economy, where nearly 40% of the population self-sustain. PNG has a rich variety of natural resources, especially mineral resources, which account for 72% of export earnings. In recent years oil palm production has played an increasingly important role as well.

PNG has an extremely mountainous and diverse landscape, where the New Guinea Highlands run the length of the island of New Guinea and have formed a populous highland region. The island also features lowland and coastal areas, as well as very extensive wetlands. Situated on the Pacific Ring of Fire, several volcanoes are still active and eruptions are frequent. While the climate is mostly tropical, it can vary widely by region. For example, the highlands feature a much milder climate and PNG is one of the few regions close to the equator that experience snowfall, which occurs in the highest parts of the mainland. All of PNG is influenced by the monsoon. Tropical rainforests are the most dominant forest type, which can be subdivided into lowland rainforests and montane rainforests, but others, such as mangrove forests or freshwater swamp forests, are also fairly widespread.

APFNet previously implemented several projects in PNG focusing on involving local communities in restoration efforts while improving local livelihoods in the remote mountain highlands.

The lodge incorporated several elements important to PNG's culture and architecture. For instance, Christianity was introduced to the economy in the late 19th century and has been widely adopted. As such, elements from Christian churches in PNG shaped the lodge. The popular vernacular forms with deep gables and sweeping, pitched roofs influenced the design as well. The lodge has 2 bedrooms (1 twin room and 1 double room), 1 living room, 2 bathrooms and can accommodate up to 4 people.

PHILIPPINES

The **Republic of the Philippines** is an archipelagic economy in Southeast Asia, consisting of about 7,640 islands. The economy has a population of around 109 million people of many different ethnicities and cultures. The Philippines is considered newly industrialized, having transitioned from agriculture as the main contributor to now having the service sector play that role. Regardless, the agricultural sector still employs nearly a quarter of the population. Tourism is an important contributor to the economy, earning more than 10% of the GDP.

The geography of the economy is defined by its many islands, although the eleven largest islands contain 95% of the total land area. Only about 1,000 of the islands are populated. Situated on the Pacific Ring of Fire, all islands are prone to earthquakes and volcanic eruptions. The dominating climate is the tropical maritime climate, which is usually hot and humid. Southwest and northeast monsoon cause roughly three seasons: the hot dry season, the rainy season and the cool dry season. Some locations have no dry season and certain higher-altitude areas can also have subtropical climate. Annual rainfall can vary widely depending on whether it is the mountainous east coast section, which has an annual precipitation as high as 5,000 mm or sheltered valleys, where as little as 1,000 mm per year can fall. Key forest types are mangrove forests, coastal forests, dipterocarp forests, molave forests and cloud forests.

The lodge's architecture incorporates many Spanish elements, as the arrival of the Spaniards in 1571 introduced European colonial architecture. The lodge has a porch, 2 bedrooms (1 twin room and 1 double room), 1 living room, 2 bathrooms and can accommodate up to 4 people.

SINGAPORE

The **Republic of Singapore** is a sovereign island city-economy in Southeast Asia. Despite a population of less than 6 million people, due to its small size it has the third-greatest population density in the world. It is considered to be a highly developed economy with the 2nd highest GDP per capita in the world, mainly relying on the finance sector, maritime shipping and other highly developed businesses. Opposed to most other economies in Asia-Pacific its primary sector plays a negligent role in the national GDP.

While the main island is the most famous, Singapore actually consists of 63 islands. Further land reclamation projects have increased Singapore's land area by 22% to date. Singapore is influenced by a tropical rainforest climate with a wetter monsoon season from November to February. While 95% of Singapore's natural forests are gone, more than half of the naturally occurring fauna and flora is preserved in nature reserves. Furthermore, Singapore is internationally renowned for its advanced urban forestry, commonly known as the "Garden City", where trees and greenery are tightly integrated with much of the newer architecture.

The lodge's architecture was inspired by the popular shop houses in Singapore, as well as colonial elements and the traditional Kampong architecture, which raised buildings above the ground. The lodge has a small porch, 2 bedrooms (1 twin room and 1 double room), 1 living room, 2 bathrooms and can accommodate up to 4 people.

SRI LANKA

The **Democratic Socialist Republic of Sri Lanka** is an island economy in South Asia. It has a population of less than 23 million people. Previously known as a “plantation economy” famous for its production of cinnamon, rubber and Ceylon tea, industrialization and tourism have increased in importance, so that now the service sector makes up 60% of the GDP, while the agriculture sector only contributes about 12%. Sri Lanka is one of the few economies officially pursuing a “100% organic farming” program, which imposed an economy-wide ban on inorganic fertilizers and pesticides.

Sri Lanka is a pear-shaped island, consisting mostly of flat to rolling coastal plains lined with 103 rivers. However, in the south-central part elevation rises up to 2,524 m above sea level. The climate is generally tropical and warm, but temperatures are comparatively lower in the central highlands, where even frost can occur for a few days each year. The islands is, like most of Asia, influenced by the monsoon, resulting in a wet zone that can receive up to 2,500 mm of rainfall per year, while the dry zone only receives between 1,200 and 1,900 mm per year, and the arid northwest and southeast coasts receiving as little as 800 mm per year. Forest types vary widely due to the different climates, but lowland rainforests, montane rainforests, dry evergreen forests, scrub forests and mangrove forests make up the majority.

The lodge’s shape was inspired by the round shape of the stupas of Sri Lanka, while colonial architectural designs, such as the roof design, were considered for the building of the other elements of the house. The lodge has a small porch, 2 bedrooms (1 twin room and 1 double room), 1 living room, 2 bathrooms and can accommodate up to 4 people.

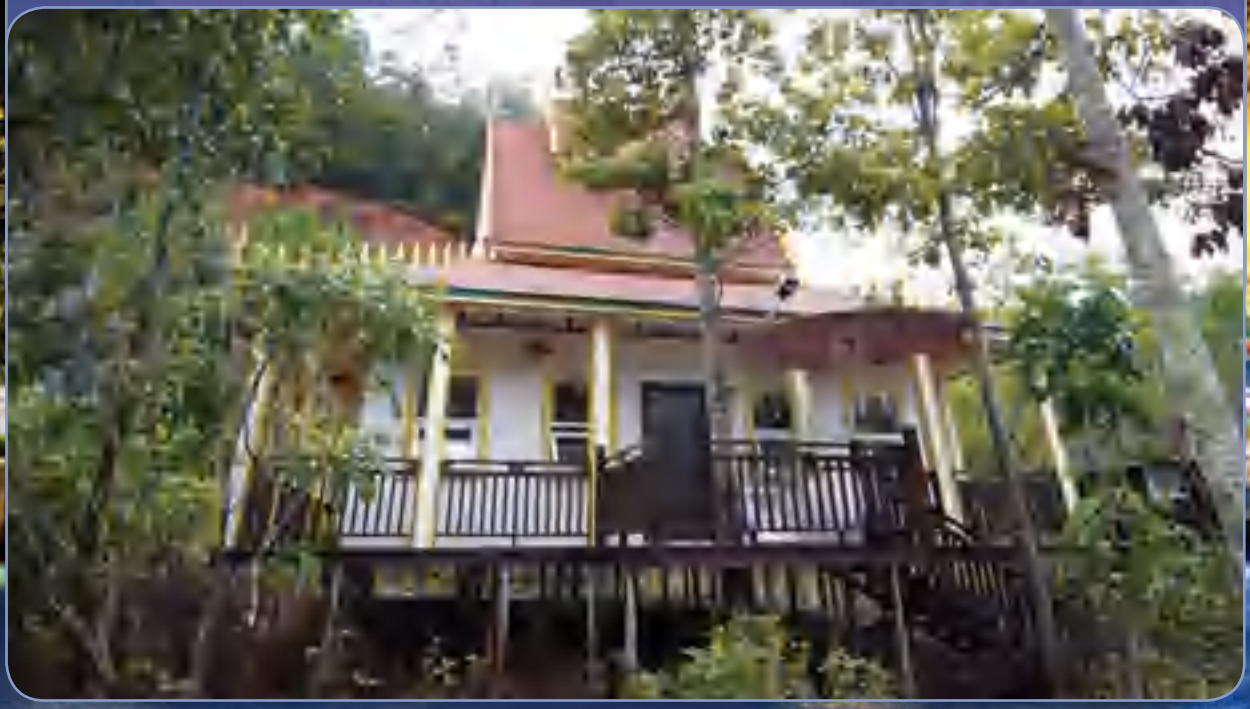
THAILAND

The **Kingdom of Thailand** is located in the Greater Mekong Subregion and has a population of nearly 70 million people. It has the second-largest economy in Southeast Asia and is considered newly industrialized. Thailand is extremely export-dependent, with exports accounting for more than $^{2}/_{3}$ of the GDP. These are largely products from manufacturing, such as cars, computers, electrical appliances, and textiles, but also products from agriculture, such as the famous Thai rice, or precious stones. Aside from manufacturing and agriculture, Thailand is especially well-known as a popular tourism destination, including for eco-tourism focusing on trekking and adventure travel.

Thailand has several distinct geographic regions, with the mountainous Thai highlands in the north, a plateau in the northeast and the predominantly flat Chao Praya river valley in the center of the economy. Finally, the narrow southern Thailand is part of the Malay Peninsula. The dominating climate in Thailand is a tropical savanna climate, with the southern parts and parts of the East being influenced by a tropical monsoon climate and a tropical rainforest climate. Additionally, These monsoonal influences cause Thailand, causing it to have three seasons: a rainy season, a dry season and a summer season. Thailand classifies its occurring forests into two main types, tropical evergreen forests and deciduous forests. Of these each has several sub-types, such as tropical rainforest, semi-evergreen forest, hill evergreen forest, pine forest, mangrove forests, mixed deciduous forest and dry dipterocarp forest.

APFNet has previously conducted several projects in Thailand, covering topics such as urban forestry and carbon accounting.

The lodge imitates the architectural style of traditional Thai houses, which are generally built on stilts to around head height, made of a variety of wood, and feature a large terrace and high gable roofs with long overhanging eaves. The roof finials called lamyong represent an element generally found on more religious buildings. The lamyong is sculpted in an undulating serpentine shape evoking the fins of the Nāga (a divine race of mythical half-human, half-serpent beings) and the feathers of Garuda (a Hindu god resembling a bird also mentioned in Buddhist faith). The lodge has 2 bedrooms (1 twin room and 1 double room), 1 living room, 2 bathrooms and can accommodate up to 4 people.



VIET NAM

The **Socialist Republic of Viet Nam**, with a population of 96 million, is located in the eastern part of the GMS region. It is considered a lower-middle-income economy and one of the fastest-growing economies of the 21st century. Much of the economy is centered around agriculture, especially rice production. However since the early 2000s the secondary sector has played an increasingly large role, with Viet Nam now producing large parts of the world's consumption of manufacturing goods, such as clothing items. Additionally, the IT sector and other high-tech industries are forming a fast-growing part of the economy lately.

Viet Nam is mostly hilly and densely forested, and can be subdivided into coastal lowlands, mountains and plateaus. Level land covers less than 20% and mountains cover about 40% of the total area. The economy is famous for its stunning karst landscapes that also feature the largest cave in the world. The climate is a tropical monsoon climate with two seasons, a wet and dry season. Additionally, temperate climates prevail in mountainous areas. Annual precipitation can range widely from 700 to 5,000 mm, with the northern parts of the economy generally receiving more rainfall than the southern parts. Key forest types in Viet Nam include evergreen broadleaf forests, semi-deciduous forests, deciduous forests, bamboo forests, coniferous forests and open broad-leaved forests.

APFNet has implemented several projects in Viet Nam, focusing on topics such as integrated wetland management, forest restoration and livelihood improvement.

The lodge's architecture was inspired by traditional houses in Viet Nam, which were characterized by stilted wooden structures, an odd number of rooms and gabled roofs. The lodge has a porch, 2 bedrooms (1 twin room and 1 double room), 1 living room, 2 bathrooms and can accommodate up to 4 people.

APFNET

The Asia-Pacific Ecolodges would not be complete without a building dedicated to the organization connecting them all: APFNet. Generally built in a modern architectural style, the lodge was aimed to use wooden materials, while creating a maximum of light in all rooms. As such, all rooms feature large windows and the second floor also has a spacious terrace for group gatherings. Aside from that, the lodge has 2 bedrooms (1 twin room and 1 double room), 1 living room, 2 bathrooms and can accommodate up to 4 people and even more for gatherings in the evening on the 2nd floor terrace.

APFNet Ecolodge amenities

4.2.2 CELEBRATING YUNNAN CULTURE

YUNNAN HOUSE

Yunnan itself is not only the part of China in which the base is located, but also one of China's most exciting provinces. As such, there could be no better choice for the main building than to dedicate it to Yunnan. The Yunnan house, which is actually a series of adjoined buildings, serves as the main reception area, the dining area and provides minor conference rooms, but also introduces Pu'er Tea culture to visitors and provides accommodation. The overall design is inspired by traditional Yunnan log houses, which provide good insulation and have a good anti-seismic structure.

The following key areas are part of the Yunnan House.

RECEPTION

The reception is in the main building of the Yunnan House. It provides a wide range of guest services, like welcoming guests to the base, making reservations for accommodations and meals, assingning rooms, helping to arrange meeting rooms, and other necessary services that are instrumental to the guests during their stay. There are two rest areas with sofas and tables for guests to rest and relax.

Reception (left) and rest area (right)

The Yunnan Lodge (left), Pu'er Lodge (middle) and the Tea House (right)

ACCOMMODATION

The second floor of the main building of the Yunnan House is designed for accommodation and has 5 twin rooms with a big balcony in each room to provide the guests with a beautiful view of the base and the forests surrounding it. Besides, there are two individual lodges next to the main building which can also be used for accommodation. These two lodges, named Yunnan Lodge and Pu'er Lodge were designed using the traditional Yunnan architecture style. The Yunnan lodge has 2 double rooms and 1 living room, and is able to house a total of 4 people, while the Pu'er lodge has 1 double room, 1 twin room and 1 living room, and is also able to host up to 4 people. Both lodges have a big balcony with a view of the pond.

CONFERENCE AND MEETING ROOMS

From conferences and meetings to intimate weddings, Pu'er Base can provide both indoor and outdoor spaces to meet the needs of visitors intending to hold large scale events. Specifically, the base provides a small meeting room and a large conference room.

The small meeting room, which is also the forest fire monitoring center at the base, is located in the main building of the Yunnan House and is equipped with all facilities needed to be used for small-scale meetings and trainings. This multi-functional room is 60 m^2 large and can hold meetings for up to 40 people by day, or serve as a private dining room for small-scale dinners and parties at night.

One building located behind the Yunnan house is a state-of-the-art conference center that includes meeting facilities, a coffee break area, a big LED screen and free WiFi, totaling up to 150 square meters (m^2) of space to accommodate a group of 100–150 guests seated comfortably. The second floor of the conference

An ongoing meeting at the small meeting room

center is an open air terrace providing space for a variety of events, such as company celebrations, evening parties or outdoor dining. It can be decorated based on the customers' needs and make their events a stylish success. The base also has open spaces, like a large grassy area for romantic outdoor weddings or outdoor conferences and ceremonies. In such cases the coffee break could also be held under the forest canopy near the conference center.

Conference center

CAFETERIA AND DINING ROOMS

Pu'er Base provides both traditional Yunnan food and Western cuisine to satisfy all tastes. In the mornings an abundant buffet is provided, which offers homemade Yunnan noodles, fried bread sticks, different varieties of cake, yogurt, milk, fruit juices, and jam. Guests can choose to eat inside the big dining room, or sit outside to enjoy the beautiful scenery outside while eating. The public dining area can hold between 80 and 100 people at the same time. There are also three private dining rooms located in the Yunnan House, perfect for small gatherings as each can accommodate up to 18 guests. The private dining rooms provide a good view of the scenery, and are furnished with traditional Chinese wood furniture, TVs and have WiFi connections.

Dining area in the Yunnan House

Private dinner room (circle) and dining area outside Yunnan House (below)

PU'ER TEA HOUSE

Drinking tea is tightly weaved into the cultural fabric of China, it is a way to slow down, relax and connect with friends. The Pu'er Tea House is located on the second floor of the Yunnan House, where it is a cozy place to enjoy tea while observing the scenery. The Pu'er Tea House is decorated with traditional Chinese furniture in dark red or wooden colour. Tea tables and all equipment for tea services are provided. Tea can either be brewed by the guests themselves or a tea service can be booked.

Pu'er Tea House

POND

Chinese gardens aim to serve as a miniature of larger natural landscapes, while blending ornate buildings with natural elements. As such, a pond with Koi, which is generally associated with Japan, but actually originated from Central China, is a key element and a perfect addition for guests enjoying drinking their tea in the Pu'er Tea House. The pond is 180m^2 large.

YUNNAN MINORITY VILLAGE

While APFNet's members' cultures are front and center, local culture should not be forgotten, especially in a place like Yunnan, where so many minorities co-exist within one province. In fact, Yunnan is home to 25 ethnic minorities and each minority has more than 6,000 people, many of them still living traditionally and maintaining their own languages, dresses and customs. Celebrating this incredible diversity, APFNet built the Yunnan Minority Village in the south of Pu'er Base, with 15 cottages representing the following 7 minorities through their unique architecture.

The Yi people dancing wearing traditional clothes

YI MINORITY

The Yi people (Chinese: 彝族, also known as Nuosuo or Lolo) are an ethnic group not only in China, but also Viet Nam and Thailand. They live primarily in rural areas of Yunnan, Sichuan, Guizhou and Guangxi, usually in mountainous regions. They have a total population of about 9 million people and are one of the biggest of China's 55 official ethnic groups. Almost 2/3 of the Yi living in China live in Yunnan. The Yi traditionally speak Loloish languages, which are closely related to Burmese. They have their own calendar, which is comprised of ten 36-day months. Traditionally Yi society was divided into four castes, of which an individual's membership was determined through patrilineal descent. Traditional Yi culture is based on agriculture, livestock herding and hunting.

There are two Yi lodges, each lodge has 2 bedrooms with double-sized beds, 2 bathrooms and can accommodate up to 4 people.

HANI MINORITY

The Hani people (Chinese: 哈尼族, also known as Ho people) are another Lolo-speaking ethnic group living in South China, northern Laos and Viet Nam with a total population of about 2.7 million. Over 90% of the Hani people live in Yunnan across the Ailao mountains. Hani oral traditions state they are descended from the Yi people. They may be the most traditional and least assimilated ethnic minority in China. The Hani are famous for their vocal polyphonic singing, accompanied by traditional musical instruments, such as the flute *labi* and the three-stringed lute *lahe*. Terraced fields are a common feature of their agricultural practices and the Hani are well-known tea producers, especially of Pu'er tea. Their staple foods are rice and corn and they pick wild vegetables to make soup. Heated wine and teas are a preferred drink.

There are 2 Hani lodges, each lodge has 2 bedrooms with double-sized beds, 2 bathrooms and can accommodate up to 4 people.

A Hani woman with traditional clothes at Yuanyang terraces

Lahu girls in traditional clothes

LAHU MINORITY

The Lahu people (Chinese: 拉祜族) are another ethnic minority mainly living in China, Myanmar, and Thailand with a total population of about one million, of which nearly three quarters live in China. Their language is part of the Loloish languages as well. Their religion is polytheistic, although Buddhism took on an important role after it was introduced, especially amongst the Lahu living in China. They are primarily subsistence farmers, growing rice and corn, but as per heritage as a hill tribe understand themselves as hunters as well. Compared to other ethnic groups, the Lahu are perhaps the most gender equitable, where women play an important role in marital relations and other aspects of life.

The lodge uses elements of traditional Lahu architectural style, which is similar to Dai architecture. For example, the houses were built on stilts in the hilly areas of the base, as most houses are traditionally located in the mountains. Additionally, mostly wood was used to build the lodge and similar to a traditional Lahu house it is surrounded by a railing. There are two Lahu lodges, each lodge has 2 bedrooms with double-sized beds, 2 bathrooms and can accommodate up to 4 people.

DAI MINORITY

The Dai people (Chinese: 傣族) are an ethnic minority with the majority of the 8 million population living in Myanmar and Vietnam, but more than 1 million also living in China. The Dai are closely related to the Lao and Thai people, as such their language, Tai, is also closely related to the Thai and Lao languages. The Dai follow their traditional religion, as well as Theravada Buddhism and have similar customs and festivals as other Tai-speaking groups. The staple food of the Dai is rice, a famous snack is bamboo rice, which is made by putting glutinous rice in a fragrant bamboo tube, soak it with water for 15 minutes and bake it in fire. The Dai also enjoy eating spicy and sour foods, and consider acid the most delicious flavor.

While traditional Dai homes are built with bamboo, wood was used to build the lodge, however the characteristic square shape, the high sloping roofs that sometimes connect several buildings and the stilts of the building have been incorporated. A bright and airy front porch, another characteristic feature, has been incorporated as well. There are two Dai lodges, each lodge has 2 bedrooms with double-sized beds, 2 bathrooms and can accommodate up to 4 people.

The Dai people celebrating the Water-Sprinkling Festival

WA MINORITY

The Wa people (Chinese: 佤族) are an ethnic minority of only 1.2 million people, who mainly live in Myanmar, but about 400,000 of them also leave in China's Yunnan province. The Wa speak the Wa language, which belongs to the Mon-Khmer language group. The Wa traditionally practiced subsistence agriculture cultivating rice, peas, beans, poppies and walnuts. They also bred water buffaloes mainly for sacrificial purposes. Most Wa are animists, which was traditionally centered around ritual blood sacrifices to appeal to the gods to e.g. increase the fertility of the rice fields or cure a sickness. Traditional Wa society practices monogamous marriage, however there is sexual freedom for both men and women before marriage. The chewing of betel nuts was a widely practiced custom. The Wa have a famous drinking culture, and are believed to consume on average the largest amount of alcohol in China.

Similar to Wa architecture, the lodge is stilted and uses wood. There are two Wa lodges, each lodge has 2 bedrooms with double-sized beds, 2 bathrooms and can accommodate up to 4 people.

Wa people with traditional clothes

Traditional dancing of Jinuo people

JINUO MINORITY

The Jinuo people (Chinese: 基诺族) are an ethnic minority mostly living in the Jinuo mountains in Xishuangbanna, Yunnan. With a population of only 22,000 people they are one of the smallest ethnic minority groups and the last to be formally recognized in China in 1979. Although most speak Mandarin, their traditional language is the Jinuo language, which belongs to the Tibeto-Burman group and does not have a written script. The Jinuo people are traditionally an egalitarian, matrilineal culture. Prior to marriage, special houses for unmarried men and women to spend the night together are built as premarital sex is not frowned upon. However, marriages are expected to be monogamous. They live in the subtropical rainforest. One of their traditional cultural practices is tooth painting, the practice of coloring one's teeth black using soot made from local pear trees. They mostly eat rice and corn, also glutinous rice is cooked to treat guests and feed field laborers. Similar to the Wa, the Jinuos like brewing and drinking wine and chewing betel nuts.

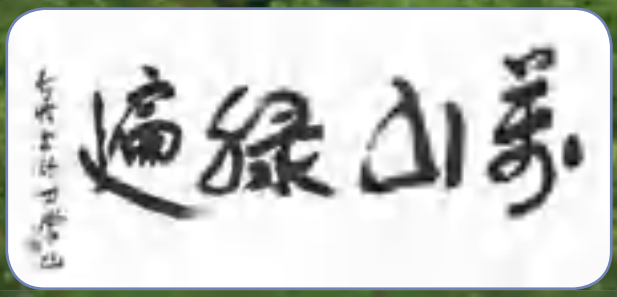
The lodge was built using typical features of Jinuo architecture. As they mostly live in the mountains, the lodge was erected on a mountainous site on stilts, using dry-bar-style buildings, rectangular in shape, all made of wood and wooden stairs. There are two Jinuo lodges, each lodge has 2 bedrooms with double-sized beds, 2 bathrooms and can accommodate up to 4 people.

BAI MINORITY

The Bai people (Chinese: 白族) are an ethnic minority native to the Dali Bai Autonomous Prefecture of Yunnan and some other Chinese provinces. Around two million people belong to this minority. Their traditional language is Bai language, which is suspected to be a sister language of Chinese or a part of the Sino-Tibetan family. These days, however, Bai language is mostly spoken by members living in the mountains. The Bai both adhere to Azhaliism (a form of Buddhism) and Benzhuism, which worships “benzhu” (a hero, prince and/or tiger), local gods and ancestors. Most, however, would not clearly align themselves with any given religion. Gender roles are relatively equal in Bai society and women are not considered inferior to men. Bai are traditionally subsistence farmers, cultivating mainly rice, but also wheat, vegetables and fruits. Unlike most other Chinese groups, the Bai always ate cheese, which they make from cow or goat milk. The Bai people, in line with their name, hold the color white (Chinese: bái 白) in high esteem. As such most of their traditional clothing features white.

In line with their traditional architecture, the Bai lodge was kept in white and made out of wood. Furthermore, the overall design of the lodge was inspired by the “three rooms and one wall screening” style. There are two Bai lodges, each lodge has 2 bedrooms with double-sized beds, 2 bathrooms and can accommodate up to 4 people.

Traditional clothes of Bai people



Chinese calligraphy by Chen Changyin: "Getting the beautiful mountain green" (top) and a painting by Zhao Baokun, titled "Wanzhangshan's Immortal Residences"

ECOCULTURE LODGES

Another important part of Yunnan culture are the local artists residing in the province. Local handicrafts, paintings, Chinese calligraphy or poems are a key component of not only Yunnan, but Chinese culture at large. In order to celebrate and support this important sector, as well as to promote the idea of "Forest Art", APFNet established a set of 5 cottages specifically designed to get the creative juices flowing. This includes the provision of artist tools, such as drawing boards, writing brushes, ink sticks, paper and inkstones, *etc*. During the "Art Ecoculture Creation Workshop", for instance, several famous artists, such as Chen Changyin, a revered Chinese calligrapher or Zhao Baokun, a Chinese painter, stayed at the lodges and produced artwork inspired by Pu'er Base and its forests, which now can be seen in the lodges. The 5 individual cottages have a total of 6 living rooms, 15 bedrooms with double-sized beds and can accommodate up to 30 people.

Ecoculture Lodges (Photo: WZSFF)

4.3 REGIONAL FOREST INFORMATION SHARING AND TRAINING

As previously mentioned, Pu'er Base provides the ideal location to share information regarding forestry in subtropical and tropical areas. This is realized through the provision of meeting rooms, demonstration sites and accommodation, which provide the base with the ability to hold multi-day meetings and trainings on its own grounds, immersing trainees fully in the experience.


APFNet

4.3.1 MEETING ROOMS

Two meeting rooms are provided at the base. One is, as previously mentioned, located in Yunnan House and can host smaller meetings for up to 40 people. The multimedia screen and audio-visual equipment make it the ideal location for smaller seminars, discussion or break-out groups.

The other meeting room has its own separate building, located next to the Yunnan House (see map) and can host large meetings for up to 150 people. It provides an even bigger screen, a podium and a roof terrace, all of which can host outdoor events or be switched to a dining facility at night. It also provides a separate VIP room for speakers to get ready.

The big meeting room (top) and small meeting room (bottom) (Photo: WZSFF)

4.3.2 TRAININGS

With APFNet demonstration sites surrounded showcasing different forest management practices, Pu'er Base is also an ideal place for conducting forestry-related training. Several trainings have been held at the base focusing on various themes. For example, to help grassroots-level forestry officials grasp the concept and implementation of carbon neutrality, APFNet cooperated with the Pu'er Forestry and Grassland Administration to co-organize a training workshop on the themes of forest carbon sinks, carbon neutrality, and forest carbon accounting methodology in the base in July 2021. About 100 local forestry officials and technicians participated in the training. The workshop was also in response to China's goal to have carbon dioxide emissions peak before 2030 and achieve carbon neutrality before 2060. Pu'er Base is expected to conduct more forestry-related thematic trainings and especially collaborate with the APFNet Kunming Training Center in the future.

Field trip of the "Forest Management in China: Balancing Conservation and Utilization" seminar (Photo: Zhang Shiyi/ APFNet)

The forest carbon accounting training for local forestry officials (Photo: Liu Chengye/APFNet)

4.3.3 CONFERENCES

Pu'er Base is the ideal location for forestry conferences that aim to create immersive experiences. Same-day field trips and lectures can be combined easily as demonstration sites are relatively close. A range of topics can be covered with practical examples, including biodiversity conservation, forest policy, SFM, agroforestry and so on. Participants can even reach forest paths through walking, giving them the opportunity to explore their surroundings and take breaks in the best environment to learn about forestry – forests.

An excellent example of the kind of opportunities provided to conferences was right at the launch of the base in July 2021, where several adjoined workshops and seminars, focusing on topics such as "Forest Management in China: Balancing Conservation and Utilization" and "Forestry Cooperation in the Greater Mekong Subregion", hosting a total of 150 people at the same time. The first conference of the three, which enabled critical exchange and exploration of the policies and regulations regarding different Chinese forest types while contrasting it with experiences of sustainable forest management on the ground, also combined half-day seminars with half-day field trips each day to better illustrate the concepts discussed and incite additional discussion throughout and after the field trips. This was especially useful for the policy makers attending as real-life issues could be showcased within the forest. The resulting report, *Forest Management in China — Protection and Utilization* (currently available only in Chinese), gave several innovative recommendations to Chinese policy makers.

The "Forest Management in China: Balancing Conservation and Utilization" seminar held in July 2021 (Photo: Zhang Shiyi/APFNet)

Workshop on carbon neutralization and forest carbon sequestration (Photo: Liu Chengye/APFNet)

4.4 FOREST EXPERIENCE AND ENVIRONMENTAL EDUCATION

Professionals are not the only target audience of Pu'er Base. Educating the general public about forests, environment and sustainable forest management, but also providing them with opportunities to directly experience forests, practice forest therapy or engage children in nature, are important goals. To realize this goal, with the support of the Hainan Nature Foundation (HANAF, Box 8), an area focused on forest experience and environmental education was established at Pu'er Base, which includes a forest experience area with different hiking trails, an environmental education center on the top of the mountain of the base, a tea plantation and an organic agricultural product cultivation experience area.

Guide map for the forest experience and environmental education area


ANTA FOOTBALL

4.4.1 FOREST EXPERIENCE AND FOREST THERAPY

The forest experience area is located in the southwestern part of Pu'er Base with an overall size of 2,000 ha and a key forest experience area of 100 ha. It's mostly covered by natural secondary forests with mixed broadleaved and conifer species, like *B. alnoides*, *P. kesiya*, *Quercus variabilis, etc*. And this area is also home to a variety of birds, for example the Eurasian blackbird, the silver pheasant, the crested myna and the black-headed laughingthrush, some of which are protected species.

Bird watching platform (Photo: WZSFF)

FOREST HIKING TRAILS

The winding trails around the base provide the perfect opportunity for visitors to directly experience forests and the benefits they can bring. This can either be done through self-guided hiking tours on the two main trails (3 km and 5 km) or via specially organized tours provided by the base that guide adults or children in the experience of the forest. The trails mostly lead through the protected areas surrounding the base, along steep cliffs and trailing forest streams to arrive on the mountain top where the forest vegetation transforms into a more mountainous kind, finally allowing hikers a splendid view of the area next to one of the Forest Watcher towers at Ban'me mountain. Visitors can also pick mushrooms, watch birds or practice identifying trees and other plants.

Forest trail (Photo: WZSFF)

CAMPING

What better way to experience the natural surroundings more directly than through camping? As such, APFNet constructed 20 camping platforms, uniting the best of camping (being outdoors), while mitigating the worst aspects (flooding, especially in the rainy season). Water, electricity, showers and other key facilities are provided in the camping area, including the option to rent a tent from the base. The camping platforms can also be used for casual gatherings outdoors as they can be provided with tables, chairs and shading umbrellas.

There is a service center near the camping site, which can provide Yunnan-style traditional meals, Pu'er tea and other groceries as needed by the camping guests. It is also close to the start point of the two forest trails, so the visitors can rest before starting a hike in the forests.

The camping platform with sunshade umbrella, table and chairs (Photo: WZSFF) watching platform (Photo: WZSFF)

The service center near the camping site (Photo: WZSFF)

BOX 8: Hainan Nature Foundation

The Hainan Nature Foundation (HANAF) is a non-profit organization established by APFNet in 2019. HANAF's mission is to help promote the harmony between humans and nature, as well as to develop environmental education, and is committed to: 1) supporting capacity building activities in the area of environmental education and ecological conservation, plus domestic and international cooperation; 2) support activities in the area of ecosystem conservation, restoration and sustainable management; 3) support bird protection and habitat restoration and promote harmony between humans and nature. HANAF actively collaborates with different government agencies, organizations and other related stakeholders to conduct environmental education-related trainings and workshops, especially in Inner Mongolia, Guangxi, Yunnan and Hainan. It also plans to establish an environmental education center on Hainan island in 2023.

Scan to follow the official HANAF WeChat account

4.4.2 ENVIRONMENTAL EDUCATION

Pu'er Base aims to teach visitors, especially children, about the environment and forests with the support of HANAF. This goes beyond boring classroom lectures and aims to directly engage participants with the "object" they are learning about: nature. This means the main goal is to teach visitors not only via theory, but engage them with the living environment. For instance, during a half-day event in July 2021, the foundation invited 20 children from local schools to go to the forest to experience nature. During the excursion, the young students used names from nature like names of trees or birds or other animals to represent themselves, which helped them to establish a connection with nature. During the half-day event, the teacher taught the kids to feel and experience nature by touching different trees, shrubs or herbs, listening to birds and the wind in the forests, smelling various flowers, and more. The teacher also showed how to plant dendrobes on tree trunks, how it grows and is harvested.

The natural education program for primary school students (Photo: Wang Qian/HANAF)

ENVIRONMENTAL EDUCATION CENTER

Half-day lessons sometimes don't provide enough time to let participants truly soak up all the knowledge the surrounding nature can provide. In order to enable longer periods of interactive learning, HANAF built an environmental education center on the top of the mountain of the base, which can host visitors in its lodging area and thus is able to offer multi-day environmental education camps. The center has a multiple-use 250 m^2 building named the *Eco Rest Resort*, which is used for reception, catering, small scale trainings and nature experience activities. There are other 2 buildings for accommodation, one named the Forest Home with an architectural style similar to that of a traditional Chinese courtyard (Siheyuan). It has 9 bedrooms that can accommodate up to 18 people. The accommodation building is named Nature Home and has 3 bedrooms that can accommodate up to 6 people. Each room has an individual bathroom.

Nature Home (top) and Forest Home (bottom) (Photo: WZSFF)

TEA PLANTATION

The environmental education center also provides visitors the opportunity to pick tea leaves and participate in the initial steps of Pu'er tea processing. The tea plantation is around 4 ha large and situated in a mountainous area, the management goal is to produce high quality organic tea without using chemical fertilizers and pesticides. A one-time thinning was conducted in 2021, and the spacing of the reserved tea trees is 1.5 m × 2 m. Soy beans and alfalfa were planted under the tea tree to provide ground cover in order to reduce soil and water loss, and increase soil fertility. Visitors can pick tea leaves from spring to autumn and the leaves picked in different seasons can be used for producing different kinds of teas that taste differently. A Pu'er tea processing experience room provides opportunities for visitors to see all steps of making Pu'er tea, and even experience it by themselves (Box 9).

Tea leaf picking (Photo: WZSFF)

BOX 9: Pu'er tea processing

Pu'er tea processing, although straightforward, is complicated by the fact that the tea itself falls into two distinct categories: the "raw" shēngchá (Chinese: 生茶) and the "ripened" shóuchá (Chinese: 熟茶). The whole process can be sub-divided into the following steps:

Raw Pu'er tea: 1) Picking the fresh leaves; 2) Indoor wilting, which triggers enzymatic oxidation via the plant's intracellular enzymes and causes the leaves to turn progressively darker as their chlorophyll breaks down and tannins are released, 3) Sha Qing (杀青 or "Kill The Green"), a process where the leaves are exposed to a high temperature to stop enzyme (wilting) activity and prevent further oxidation of the leaves; 4) Tea rolling to damage cell walls and distribute moisture evenly on the outside of the leaves; 5) Sun drying for the tea to become shelf-stable and enhance its flavor; 6) Compression to make tea bricks.

Ripened Pu'er tea: 1) Picking Fresh Leaves; 2) Indoor wilting; 3) Sha Qing; 4) Tea rolling; 5) Sun Drying; 6) Wet piling (Chinese: 渥堆) to accelerate the aging process by prolonged bacterial and fungal fermentation under a controlled warm humid environment; 7) Compression.

The only difference between raw and ripened Pu'er tea is that the ripened tea has the additional wet piling step. This step was added to speed up the the aging process as in ancient times the tea, often due to the long journeys it took via horse transportation to arrive at its destination, had more time to age and develop its smooth and sweet flavor or was simply stored at tea houses for several years. These days, however, the tea is in higher demand, so the speeding up the aging process can be beneficial.

The tea processing experience room (Photo: WZSFF)

ORGANIC FARM

The organic farm is located next to the tea plantation, on which suitable leafy vegetables, beans, roots and other varieties of vegetables were planted according to different seasons. It aims to produce high quality organic vegetables to ensure the local of most vegetables for cooking in Pu'er Base. Fruit and nut trees will also be planted in this area to establish and demonstrate agroforestry. Other possible activities include vegetable and fruit picking, bee keeping and mushroom picking.

Seasonal vegetables planted (background) and bee keeping (above) (Photo: WZSFF)

4.4.3 ARBORETUM AND BOTANICAL GARDEN

As part of the environmental education efforts of early APFNet projects in 2017, an arboretum and botanical garden was established to provide visitors with the ability to learn about trees from tropical and subtropical areas, especially the southern subtropical areas. Three types of tree species have been collected, including precious timber species, small populations or endangered tree species and other medical and culinary tree species. Trees were planted at suitable sites in accordance with their biological and ecological requirements. Each species has its own plate and QR code, via which more information about the species can be viewed. It's also an ideal spot for visitors to improve their ability to identify different species and distinguish them from one another.

The arboretum and botanical garden (Photo: WZSFF)

Wood processing equipment (Photo: WZSFF)

4.4.4 WOODWORK HOUSE

Established by the Yunnan Forestry Technical College, the Woodwork House focuses on spreading knowledge about Chinese traditional wood culture and its woodworking techniques to the wider public, as well as visitors from other economies. It is also used for the college to carry out professional training activities, such as wood product design and manufacturing. The Woodwork House has a wood culture exhibition area, a wood handicraft exhibition area, a woodwork interactive experience area and a woodwork teaching area. Currently, there are more than 30 wooden artworks exhibited in the house, such as wood carvings, cartoon horses, or tea pots, created by college students. Visitors can experience this unique culture and enrich their knowledge and understanding of Yunnan's characteristic wooden handicrafts, wooden structures and Chinese wood culture.

The Woodwork House (Photo: WZSFF)

4.5 RESEARCH

Pu'er Base, with the existing demonstration projects and the facilities on site, provides the ideal conditions to support research. As such, it is collaborating with Southwest Forestry University and Yunnan Academy of Forestry and Grassland to further knowledge on forestry, specifically regarding the intensive management of plantation forests, integrated management of natural forests, biodiversity research and protection, germplasm resources collection and genetic breeding, and other relevant topics.

CHAPTER 5

CONCLUSION AND LOOKING FORWARD

Over the past several years, APFNet has put much effort into developing comprehensive and integrated activities in Pu'er. Especially with the establishment of the training base, the overarching goal of providing a one-stop-shop for demonstration and training for forestry in subtropical and tropical forests, has moved much closer. A wide range of topics can now be directly learned about by both professionals and the wider public, such as SFM, integrated forest management, understory planting, local woodwork, forest fire monitoring, forestry planning, sustainable resin tapping, forest experience, tea leaf picking and processing, environmental education, forest art and much more. However, this is not the time to be complacent with current achievements, but rather to steadily move forward to provide an even better and more comprehensive experience.

Pu'er Base was only launched in July 2021 and due to the pandemic could not yet reach its full regional potential. The ultimate goal of the base is to become a regional center for best practices on sustainable forest management, forest information sharing, forest policy dialogue and capacity building. It aims to become a regional key hub for subtropical forestry able to host trainings for people from the entire Asia-Pacific region, host international conferences and forums and provide multi-day experiences to interested parties. It is expected that the base will reach this goal post-pandemic, when borders are once more open. Important lessons learned from the forestry demonstration projects at Pu'er, while already reaching preliminary conclusions, will only become fully valid via monitoring over longer time periods. As such, APFNet has committed itself to continue to monitor and collect data post-project. Additionally, APFNet aims to use lessons already learned to influence current forest policy and management in both China and the region, disseminating important insights and useful techniques to both practitioners and policy makers. Forest experience and environmental education at the base are still in their infancy and HANAF will work over the coming years to increase its outreach and provide comprehensive experiences to visitors, especially children for whom it is so important to connect to nature.

While much work is ahead, the achievements to date are nothing less than impressive and could not have been done without close cooperation with and the great support of APFNet's partners, especially WZSFF, the Yunnan Forestry and Grassland Administration, the Pu'er Forestry and Grassland Bureau, Southwest Forestry University and the Yunnan Academy of Forestry and Grassland. We would like to take this opportunity to thank all the countless people working to make all the activities happen. APFNet is nothing without its members and Pu'er Base is the best example of this. The future looks bright and APFNet is excited to continue on this path of demonstrating how integrated forest management can be conducted on the ground.

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