APFNet

Asia-Pacific Network for Sustainable Forest Management and Rehabilitation Summary Report

Project Name: Integrated Forest Ecosystem Management Planning and Demonstration Project in Greater Mekong Sub-region (Pu'er Project Site, P.R.China)

Project ID: 2016P1-GMS-PE

Supervision department: Yunnan Forestry and Grassland Administration, Forestry and Grassland Bureau of Pu'er Prefecture

Executive agency: Wanzhangshan Forest Farm, Simao District, Pu'er Prefecture

Project period: 60 months

Pu'er Prefecture, Yunnan Province, P.R.China

July 2022

Basic Information

Project title	Integrated Forest Ecosystem Management Planning and Demonstration Project in Greater Mekong Sub-region (Pu'er Project Site, P.R.China) [2016P1-GMS-PE]
Supervision department	Yunnan Forestry and Grassland Administration, Forestry and Grassland Bureau of Pu'er Prefecture
Executive agency	Wanzhangshan Forest Farm, Simao District, Pu'er Prefecture
Implementing agency	Wanzhangshan Forest Farm, Simao District, Pu'er Prefecture

Project Director: CHEN Wenjie

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Approval Date: December 2016

Project Period:January 2017—December 2021, 60 months(extended to April 2022, 64 months in total)

Total Budget(USD)	1,210,085.40	**APFNet grants (USD)**	829,858.24
Cumulative expenditure(USD)	806,323.30	**APFNet actual allocation(USD)**	732,265.55

APFNet grants	Date of funding allocating	Amount(USD)
WFF Received	2017.05.05	31,7971.80
WFF Received	2018.08.03	105,621.60
WFF Received	2019.04.18	122,587.79
WFF Received	2020.05.09	122,587.79
WFF Received	2021.09.13	67,119.04
To be allocated		71,592.66
To be expended		27,125.44
To be allocated—To be expended		44,467.22
Project balance		0

Project reports	Implementing period	Project progress status
APR1（January—December 2017）	January—December 2017	Good
APR2（January—December 2018）	January—December 2018	Good
APR3（January—December 2019）	January—December 2019	Good
APR4（January—December 2020）	January—December 2020	Good
Summary Report（December 2021）	January—December 2021	Approved extension to April 2022

Supervision department:

(Signature & Date)

Forestry and Grassland Bureau of Pu'er Prefecture
(Seal)

Executive agency：

(Signature & Date)

Wanzhangshan Forest Farm, Simao District, Pu'er Prefecture
(Seal)

Project steering committee & project team

Project implementation office & project technical support team			
Function	**Name**	**Duty**	**Title (contacts)**
Project steering committee	Qi Hai	Chairman	Director-general, Forestry and Grassland Bureau of Pu'er Prefecture Contacts: 17708793988
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	Zhong Mingchuan	PSC member	President, Yunnan Academy of Forestry and Grassland Contacts:13769113712
	Wang Yonggang	PSC member	Deputy director, Forestry and Grassland Bureau of Pu'er Prefecture Contacts:13887965522
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	Tong Qing	PSC member	Professor, Pu'er Forestry Research Institute Contacts:13887963087
	Yang Yongding	PSC member	Director general, Forestry and Grassland Bureau of Simao District Contacts:13887966802
	Yang Yaping	PSC member	Director , Forestry and Grassland Bureau of Simao District, Pu'er Prefecture Contacts:13987979787
	Chen Wenjie	PSC member	Director, Wanzhangshan Forest Farm Contacts:13987090097
	Observer		APFNet

Project implementation office & project technical support team			
Function	**Name**	**Duty**	**Title (contacts)**
Project implementation office	Chen Wenjie	Project director	Director,Wanzhangshan Forest Farm(WFF) Contacts:13987090097
	Yue Hui	Project coordinator	Deputy director, WFF Contacts:13987915785
	Li Xianze	Project executive director	Assistant director, WFF Contacts:13987940522
	Chen Weibo	Efficient *Pinus khasys* resin demonstration forest construction	Management & Protection Section Chief, WFF Contacts:13887978864
	Zhong Hua	Establishment of forest tending demonstration for young-middle aged *Pinus kesiya* and *Betula alnoides* forest stand	Production Section Chief, WFF Contacts:13987961689
	Li Yuncheng	Secondary forest integrated operation and management technology demonstration and South Asia tropical precious plant resources collection	Botanical Garden Management Section Chief, WFF Contacts:15987991765
	Yang Zhenghai	Providing assistance to complete "forestry development planning" and "forest operation plan"	Design Team Leader, WFF Contacts:13987955679
	Li Yanhua	Responsible for project financial work	Financial Section Chief, WFF Contacts:13368791631
	Zhou Linchang	Material purchase and supply	Operation Section Chief, WFF Contacts:13987931402
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	Li Shiping	Project implementation, paperwork	Project staff, WFF Contacts:18287992287

Project implementation office & project technical support team			
Function	**Name**	**Duty**	**Title (contacts)**
Technical support team	Wang Weibin	Chief expert, general technical responsible person	Deputy Director-General/Researcher, Yunnan Forestry and Grassland Administration (Former employer: Yunnan Academy of Forestry) Cellphone:13608857659 e-mail: wangweibin1968@sohu.com
	Zhang Jinfeng	Assisting the chief expert to solve technical problems	Researcher, Yunnan Academy of Forestry and Grassland Cellphone:13700603220 e-mail: 1910323166@qq.com
	Yang Dejun	Forest operation expert	Researcher, Yunnan Academy of Forestry and GrasslandCellphone:13887934935 e-mail: 823431257@qq.com
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	Tong Qing	*Pinus kesiya* cultivation and forest protection expert	Professor, Pu'er Forestry Research Institute Contacts:13887963087

Brief introduction

Pu'er project site of Integrated Forest Ecosystem Management Planning and Demonstration Project in Greater Mekong Sub-region (GMS) is located in Wanzhangshan Forest Farm (WFF), Simao District, Pu'er City, Yunnan Province, P.R.China. The project planning area is 20,859.4 hm^2 and the implementation area is 396.7 hm^2.The goal of the project is, by developing the management planning and implementing the demonstration project of integrated forest ecosystem management in GMS, to establish some demonstrations and models of integrated sustainable management of forest ecosystem in the upper reach region of GMS, so as to improve the forest ecosystem quality and to increase its integrated ecological, economic and social functions. The total budget is USD 1,210,085.40 (originally it's USD 1,094,022, added 116,063.40 in 2019), among which APFNet's grant is USD 829,858.24 (include the additional budget USD 89,552.24 for new activity) and counterpart contribution from WFF is USD 380,227.59 (include the additional budget USD 26,511.16 for new activity).

For 5 years implementation, in principle of scientific planning and efficient management the project has made a series of progress.

1. Developed "Master Plan of Integrated Forest Ecosystem Management of WFF, Pu'er Prefecture (2017－2036)""Forest Management Action Plan of WFF, Pu'er Prefecture (2017－2026)" "Multi-functional Forest Management Plan for WFF's Sustainable Development (2020－2029)", providing scientific guidance for efficient development of WFF.

2. Based on close-to-nature management concept, a forest tending demonstration of 120ha for young-middle aged *Pinus kesiya* and *Betula alnoides* forest stand has been established to demonstrate tending technologies of commercial and non-commercial forest,   ;

3. Constructed an efficient resin production demonstration plot of 30ha and developed an effective resin collection technical manual; Established an integrated secondary forest management demonstration of 50ha; Constructed a precious plant resources collection garden of south-subtropical region of 5ha; Carried out 6 trainings, organized 3 visits to 4 places at home, and 1 visit aboard. The implementation of this project aims to establish some demonstrations and models of integrated sustainable management of forest ecosystem in the upper reach region of GMS, so as to improve the forest ecosystem quality and to increase its integrated ecological, economic and social functions, as well as the development of the region's ecological civilization.

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1. Background

1.1 Project overview

Pu'er project site of Integrated Forest Ecosystem Management Planning and Demonstration Project in Greater Mekong Sub-region (GMS) is located in Wanzhangshan Forest Farm (WFF), Simao District, Pu'er City, Yunnan Province, P.R.China. In 2015, the Asia-Pacific Network for Sustainable Forest Management and Rehabilitation (APFNet) started the preliminary research work of the "Integrated Forest Ecosystem Management Planning and Demonstration Project in Greater Mekong Sub-region", which covers 6 economies including Cambodia, Laos, Myanmar, Vietnam, Thailand and China, in order to strengthen mutual cooperation among the economies of the Greater Mekong Sub-region (GMS), improve the integrated management of forest ecosystems in the Lancang-Mekong River Basin, better utilize the economic, social, cultural and ecological services of forest ecosystems in the basin, contribute to the "Belt and Road Initiative" development strategy, and build a "community of shared future" of solidarity, equality, consultation, mutual benefit and win-win cooperation between China and its neighbors. In 2016, the project was officially launched. Pu'er City of Yunnan Province, known as "Heavenly Pu'er" and "the most perfectly preserved oasis on the Tropic of Cancer", with its superior geographical and environmental location and rich natural resources, was selected as China's demonstration area for ntegrated Forest Ecosystem Management Planning and Demonstration Project in Greater Mekong Sub-region. The largest state-owned forest farm in Pu'er City, the Wanzhangshan Forest Farm(WFF) in Simao District of Pu'er City, was selected as the demonstration site and project implementation unit of the project in China. On April 19, 2017, the Integrated Forest Ecosystem Management Planning and Demonstration Project in Greater Mekong Sub-region (Pu'er Project Site, P.R.China) was launched first among the six cooperating economies.

Pu'er is located in the core area of the hot zone of Southwest China. It is not only the number one forest area in southwest China, but also a key area for commercial timber production and forest industry development in the hot southwest region. The city's climate is warm and humid, with abundant rainfall, sufficient sunshine, deep fertile soil, suitable for the growth of various tropical and subtropical tree species.

Therefore Pu'er is gifted a unique natural environment and climate conditions for forestry development. The project site, WFF in Simao District, Pu'er City, is located in the birthplace of rivers such as Xiaohei River and Dazhong River, which are first-grade tributaries of Lancang River and Mekong River. The average annual rainfall is 1,340.9 mm, the average annual temperature is 17.9℃, and the forest coverage rate is 70.28%. WFF is a state-owned forest farm established by People's Government of Simao District in 2001 to strengthen forest resource management and explore the management mechanism of state-owned forest farm, and is a self-supporting, self-financing, wholly state-owned enterprise. WFF is equipped with 50 active employees and 23 retired employees. There are 40 college and university graduates among the working staff, and 49 of 50 have professional and technical titles. WFF sets 7 sections including administrative office, resource management section, production section, management section, finance section, botanical garden management section and design team, under of which, there are 25 management sites, conducting comprehensive management of the forest area under its jurisdiction. WFF is a leading forestry enterprise in Pu'er and has the foundation and power to complete the project.

However, for a long time, the contradiction between forest protection and development in Pu 'er forest area has been prominent. Due to the historical emphasis on mining over breeding and extensive forest management, the low-quality and low-efficiency forests in Pu 'er forest area have gradually increased, and the overall ecosystem service function has been declining. The project site lacked medium and long-term development strategies and action plans for integrated forest ecosystem management; In the process of tending and managing the main plantations such as *Pinus kesiya* and *Betula alnoides,* management objectives were ignored, and the single tending measure and intensity were adopted. The current technical regulations for resin collection of *Pinus kesiya* adopted the same management technical standard without considering the type of forest land and cultivation target.

The project is to prepare medium - and long-term forestry development plan and forest management plan; To establish forest tending demonstration bases for young-middle aged *Pinus kesiya* and *Betula alnoides* forest stand; To construct an efficient resin production demonstration plot and develop an effective resin collection technical manual; To demonstrate the integrated secondary forest management and the precious plant collection garden of south-subtropical region; To enhance capability

building through technical training, exchange visits at home and abroad.

construction of demonstration bases for the cultivation of young forest in Simao Pine and Southwest Betula; To formulate the construction and extraction standards of high-efficiency demonstration forest for lipid production of Pinus simao; Demonstration of integrated management of secondary forests and collection beds of precious plant resources in South Asia; To solve the three main problems facing the project area, such as the lack of medium and long-term development strategy and action plan of integrated forest ecosystem management, the lack of appropriate integrated forest ecosystem management and sustainable forest management technology and mode, and the low utilization rate of integrated forest management technology.

大湄公河次区域森林生态系统综合管理规划与示范项目区思茅区示意图

Fig.1   Sitemap
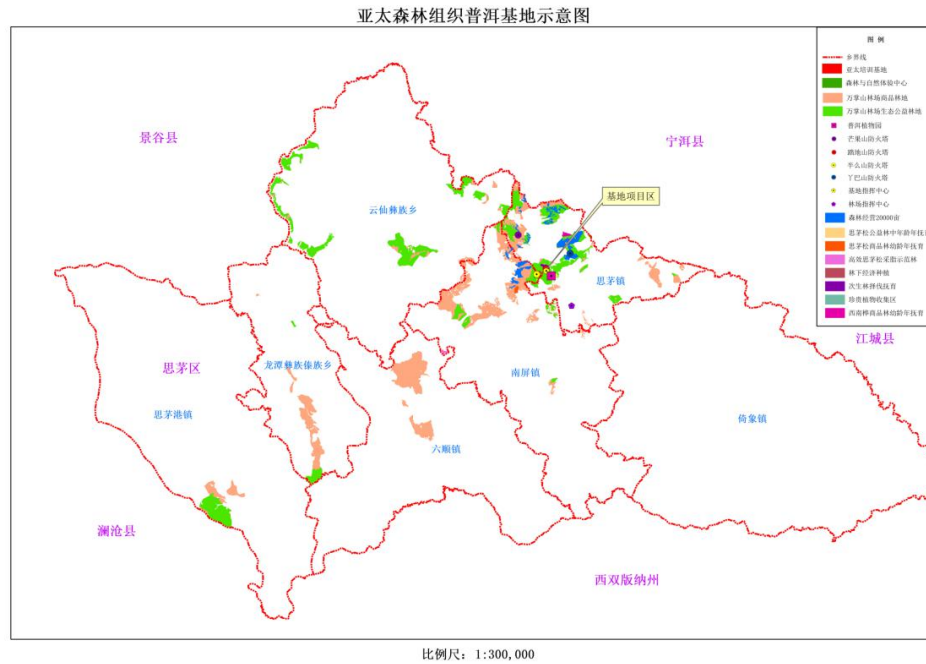
Fig.2 Map of WFF

The 5-year project is implemented by WFF under scientific supervision of Yunnan Forestry and Grassland Bureau (YFGB) and Forestry and Grassland Bureau of Pu'er Prefecture (FGPP), with strong technical supports from Yunnan Academy of Forestry and Grassland (YAFG) and Pu'er Forestry Research Institute (PFRI). Through establishment of demonstration of young-middle aged *Pinus kesiya* and *Betula alnoides* forest tending, efficient resin production, integrated secondary forest management, and precious plant resources collection garden of south-subtropical region, the project aims to explore some demonstrations and models of integrated sustainable management of forest ecosystem in the upper reach region of GMS, so as to improve the forest ecosystem quality and to increase its integrated ecological, economic and social functions. The project objectives are 1) to develop the Master Plan of Integrated Forest Ecosystem Management and the Forest Management Action Plan and conduct scientific planning and effective management in the project site WFF, and act as a demonstration of integrated forest ecosystem management; 2) to establish integrated forest ecosystem management demonstration plots, and select the optimal forest management models based on evaluation of advanced techniques and best practices; and 3) to set the project site as a role model on integrated forest ecosystem management in GMS through project dissemination and capacity building. The project planning area is 20,859.4 hm^2 and the implementation area is 396.7 ha. The total budget is USD 1,210,085.40 (originally it's USD 1,094,022, added

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116,063.40 in 2019), among which APFNet's grant is USD 829,858.24 (include the additional budget USD 89,552.24 for new activity) and counterpart contribution from WFF is USD 380,227.16 (include the additional budget USD 26,511.16 for new activity).

1.2 Project goal and objectives

Project goal

Through designing and implementing the project of Integrated Forest Ecosystem Management Planning and Demonstration Project in GMS (Pu'er Project Site, P.R.China), optimal integrated sustainable forest management models will be set up in the upper reach region of GMS, so as to improve quality of the forest ecosystem and optimize its integrated ecological, economic and social functions.

Project objectives

● to develop the Master Plan of Integrated Forest Ecosystem Management and the Forest Management Action Plan and conduct scientific planning and effective management in the project site WFF, and act as a demonstration of integrated forest ecosystem management;

● to establish integrated forest ecosystem management demonstration plots, and select the optimal forest management models based on evaluation of advanced techniques and best practices;

● to set the project site as a role model on integrated forest ecosystem management in GMS through project dissemination and capacity building

1.3 Project outputs and achievement

1.3.1 "Master Plan of Integrated Forest Ecosystem Management of WFF, Pu'er Prefecture (2017－2036)", "Forest Management Action Plan of WFF, Pu'er Prefecture (2017 － 2026)", and "Mufti-functional Forest Management Plan for WFF's Sustainable Development（2020－2029)"

(1) "Master Plan of Integrated Forest Ecosystem Management of WFF, Pu'er Prefecture (2017－2036)"

(2) "Forest Management Action Plan of WFF, Pu'er Prefecture (2017－2026)"

(3) "Multi-functional Forest Management Plan for WFF's Sustainable Development （2020－2029)"

1.3.2 Establishment of forest tending demonstration for young-middle aged *Pinus kesiya* and *Betula alnoides* forest stand

(1) Establishment of demonstrating base for tending of middle aged *Pinus kesiya* non-commercial forest, with an area of 40ha

(2) Establishment of demonstrating base for tending of young aged *Pinus kesiya* commercial forest, with an area of 40ha

(3) Establishment of demonstrating base for tending of *Betula alnoides* commercial forest, with an area of 40ha

(4) *Pinus kesiya* demonstration forest improvement and upgrading, with an area of 2ha (New in 2018)

(5) B. alnoides demonstration forest improvement and upgrading, with an area of 1ha (New in 2018)

(6) Large diameter class target trees management for P. kesiya, with an area of 4.67ha (New in 2019)

(7) Large diameter class target trees management for B. anoides , with an area of 10ha (New in 2019)

1.3.3 Construction of efficient resin production demonstration plot and development of effective resin collection technical manual

(1) Establish a resin production demonstration plot with an area of 30 ha

(2) Develop an effective resin collection technical manual

1.3.4 Demonstration establishment of integrated secondary forest management

(1) Selective thinning to improve ecological function of the secondary forest with an area of 45 ha

(2) Demonstration of understory planting with an area of 5ha

1.3.5 Construction of precious plant collection garden of south-subtropical region

(1) South subtropical precious plant collection, 100 species within an area of 5 ha

(2) Tree labels

1.3.6 Capability Building

(1) Technical trainings for 6 times

(2) Domestic study and exchange visit of 5 places in 3 times

(3) Exchange and learning on forest ecosystem integrated management to GMS countries for 1 time

2. Project implementation

2.1 Implementation arrangement

The implementation time of the project is from January 2017 to the end of December 2021, a total of 60 months. About 20 activities have been carried out in five aspects: preparing the master plan and action plan for the integrated management of forest ecosystem in WFF, exploring the sustainable management mode of multi-functional forest, capacity-building, publicity and promotion, and project monitoring and evaluation. The project is implemented according to the annual plan, and the technical scheme is formulated under the guidance of consulting experts, which is implemented by WFF. After completion, the project management office of WFF is responsible for the acceptance. So far, the expected activities of the project have been completed. Due to the epidemic, the project summary, closing meeting and closing evaluation activities originally planned for December 2021 were postponed to April 30, 2022. See Annex A for details.

2.2 Project resources and costs

The total project budget is USD 1,210,085.40 (includes the additional budget USD 116,063.40 for new activities), while USD 829,858.24 (includes the additional budget USD89,552.24 for new activities) is funded by APFNet, and USD 380,227.16 is counterpart contribution from WFF (includes the additional budget USD26,511.16).

Till 30th April of 2022, actual funding received totals USD1,162,412.75 while USD732,265.55 comes from APFNet and USD430,147.20 from WFF. Here below is detailed information.

From	Budget	Actual funding		Expenditure	To be allocated
	(USD)	USD	RMB	（RMB）	（USD）
APFNet	829,857.24	732,265.55	5,012,889.72	5,402,366.11	71,592.69

Counterpart contribution	380,227.59	430,147.20	2,881,986.25	2,881,986.25	0

Till 30th April of 2022, the project expenditure reaches 8.28 million yuan, while 5.40 million is from APFNet and 2.88 million is from counterpart.

Due to the impact of the Covid-19, the project closing meeting, terminal evaluation and project summary are yet to be finished, the related budget, which is RMB 152,400 has not been paid, including RMB 91,400 (USD 13,641.79) for project completion meeting and PSC meeting, RMB 50,000 (USD7,462.69) for project publicity fee and RMB 11,000 (USD1,641.79) for audit fee. It is planned to complete the closing evaluation and promotional short videos, brochures / foldouts, project closing, audit and other activities in the near future, and complete the payment of the remaining funds. (Annex B Table of project funds)

In order to strengthen the management of project funds, the forest farm has set up a special fund account for the " Integrated Forest Ecosystem Management Planning and Demonstration Project in Greater Mekong Sub-region(Pu'er project site, P.R.China)" to implement a special fund for special purposes and closed operation. The project funds shall be paid according to the financial requirements of APFNet. The handling personnel shall fill in the application form according to the completion of the project, and the finance department shall pay after the approval of the section leader and director of WFF.

2.3 Procurement and technical support team

2.3.1 Project procurement

The project procurement mainly includes computers, cameras, video cameras, projectors, color maps, ranging altimeters, SUV, etc. (see Annex D Equipment procurement).

2.3.2 Technical support team

The scientific and technological support team of the project is composed of experts engaged in forest management, forest cultivation, forest ecology, forest protection and other disciplines, such as Yunnan Academy of Forestry and Grassland and Pu'er Forestry Research Institute. Responsible for various reports of the project with the assistance of the project implementation office. Set up the chief expert of the project, prepare the project proposal, and provide technical consultation and guidance

for the application of major technical solutions, key technical problems and new technologies in the implementation of the project.

2.4 Project Monitoring, Evaluation and Reports

2.4.1 Project Monitoring

(1) Monitoring on project implementation

The Project Steering Committee (PSC) and external evaluation experts are responsible for external inspection of the project. PSC will carry out an inspection every year after the start of the project. External evaluation experts will carry out project evaluation in the middle of the project and after the completion of the project according to the requirements of APFNet.

PSC and project administrative department are responsible for the supervision and guidance on the project implementation. The project office shall submit annual progress report, annual work plan and budget to PSC. In addition, the project office will carry out continuous project monitoring, regularly submit the internal assessment report to APFNet, this report explains the achievements of the project, implementation status, budget management, potential risks on management. If the project activities cannot be carried out in accordance with the project plan and implementation plan, or the existence of major issues affecting the progress of the project, the project director shall put forward the inspection application for APFNet in order to find out the causes of the problem and the solution.

(2) Monitoring on project activities

The project has established a monitoring network of fixed sample plots and carried out project effectiveness monitoring at the end of each year. The forest management effect and the improvement of the sustainable management level of WFF were monitored scientifically by means of retesting fixed sample plots. Developed a Technical Report on Integrated Forest Ecosystem Management Planning and Demonstration Project in Greater Mekong Sub-region((Pu'er Project Site, P.R.China).

2.4.2 Project Evaluation

Project mid-term evaluation was carried out from September 27 until September 29, 2019 under the coordination of APFNet. Demonstration site visiting, project implementation status inspection, meeting and discussions were carried out during

this period. The Project integrated plan and related documents have been reviewed and they cover the main elements of the goals and objectives of APFNet projects and are appropriate for the situation at WFF. To date, all activities are in line with the project plan, on time and to a high standard. They covered forest management plans at different spatial and temporal scales at WFF, demonstrations for the resin production of *Pinus kesiya* plantations, the thinning of *Pinus kesiya*and *Betula alnoides* plantations for timber production and ecological services, the integrated management of secondary forests, construction of precious plant collection garden of south-subtropical region, project dissemination and capacity building. Sample plots were established to monitor the effects of these silvicultural practices. In summary, the project was in good progress. APFNet provided effective systematic safeguard, well organized management regulation ensures project implementation is moving towards achieving the objectives. For the future improvement, several recommendations were given which include: summarize local tree species characteristics for silviculture practice, whole life cycle silviculture design, workable and efficient forest management plan, project impact monitoring and evaluation.

2.4.3 Project Report

The project annual report and annual workplan were submitted to APFNet for approval every year.

2.5 Project dissemination and information sharing

2.5.1   Media report

Project general information, highlights during implementation, progress, outputs and results were publicized in multiple ways, such as newspapers, TV, network, media, release guide, CD and publications.

(1) Publicity of the project meetings: Pu'er City TV Station "Pu'er News" Column gave reports about the project meeting; had an interview with the Project Section Chief Kong Zhe of APFNet, Xu Zhijiang, Head of International Cooperation Office of Yunnan Provincial Forestry Department, and gave reports in the column "Talks of Experts about Development". Pu'er Daily, China Green Times, Yunnan Daily, Yunnan Law News, etc. gave reports about the project kickoff meeting. Websites of national forestry administration, Yunnan provincial government portal, Yunnan Provincial Forestry Department, Yunnan Provincial Academy of

Forestry, Pu'er Municipal Forestry Bureau, etc. gave reports. China Youth Website, China Garden Website, Greatwall website, 321green.com reprinted the news.

(2) Project publicity billboard: Project Publicity Billboard

8 project publicity billboards were produced and erected during November-December 2017, of which one was about the overview of the project and erected in Pu'er South Asia Tropical Plants Garden; 7 were about project activity demonstration zones and erected in striking positions in respective project and activity demonstration zones. These billboards used stainless steel rack, their sizes were 240cm*160 cm, and outdoor photos were pasted on the billboard. The front sides of the billboards were the project name, executive institutions, sponsoring institutions, supervising institution, technical support, project duration, general objectives and project construction sites, scale and project construction measures, ways, etc.; and the back side of these billboards was a brief introduction to APFNet.

Fixed assets equipment identification management. All the equipment uniformly purchased by the project are pasted with APFNet logo, indicating the project name, executing agency, funding agency, project duration and other information, which plays a positive role in project publicity.
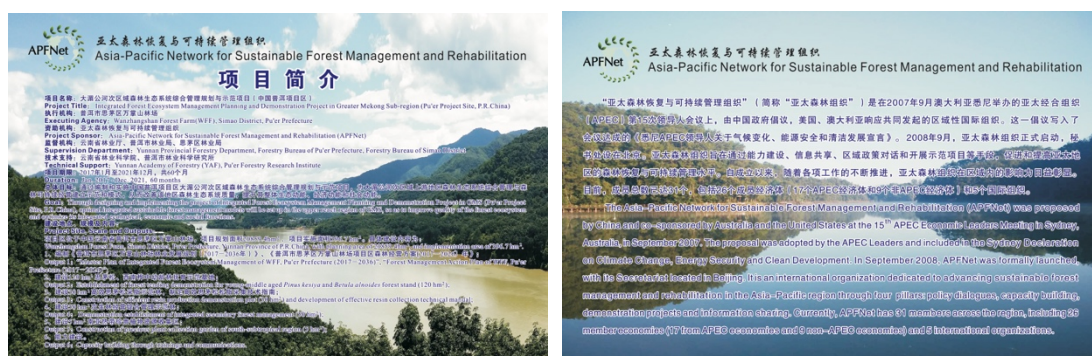
Fig. 2 Project publicity billboard (Front side and back side)

(3) Project brochures: according to the project plan and implementation progress, as well as the main technical highlights in the process of project implementation, the preparation of four project brochures for 2017, 2018, 2019 and 2021 will be completed respectively. The brochure has both Chinese and English versions, which are printed separately, and 800 copies are printed and distributed. The main recipients are visiting foreign guests, relevant personnel of Pu'er Forestry Bureau, Municipal Forestry Research Institute, Simao District Forestry Bureau, Shanzhou forest farm, Haikou forest farm and WFF.

(4) Project dissemination products: Made some jackets and hats with logo of APFNet

and name of the Project in 2020 and 2021, which facilitates the promotion of the project in the area.

(5) English news: one ~two English news were submitted every year by WWF, the news introduced the project summery, bright points and progression. For example, a news report on Understory planting of epiphytes for ecological and economic enhancement was delivered to introduce the exact project activity. The news release of project closing activities will be reported via various media.

2.5.2 Information sharing

Share project experience and achievements in the Asia Pacific region through technical training, domestic and international exchanges, and the development of guidelines.

(1) Technical training

For the forestry technology and management personnel of the project implementation unit, a total of 7 training workshops on forest resources investigation and monitoring, tree classification, forest conservation, forest management, state-owned forest farm management, project management and project publicity were carried out for nearly 400 people, so as to improve the management capacity of state-owned forest farms.

(2) Domestic learning exchange

The technical and management personnel of WFF went to Kunming Haikou forest farm, Baoshan Shanzhou forest farm, Saihanba forest farm, Guangxi Gaofeng forest farm to pay a visit, and carried out in-depth learning and exchange on GMS project activities, forest resource protection and cultivation, industrial development, forest economy, ecotourism, state-owned forest farm reform, etc.

(3) Go to GMS economies for exchange and learning the experience of integrated management of forest ecosystem

The core technology and management personnel of the project went to Thailand and Cambodia during December 16-23, 2019 to carry out an 8-day exchange and study on Integrated Forest Ecosystem Management Planning and Demonstration Project in Greater Mekong Sub-region, and discussed and studied matters related to

project implementation with Thai and Cambodian project related personnel.

(4) Prepare technical guidelines

Based on the resin collection experiment and demonstration carried out by the project, the technical guide for Efficient Resin Production Plantation & Effective Resin Collection is prepared to provide reference for similar forests in the project area, and it is applied in combination with forestry production practice (see Annex E for details).

3. Role of project partners

In order to ensure the smooth and effective implementation of the project, a project management system consisting of the project steering committee, the project management office, the project chief expert, the project technical support team and the project implementation office were established.

3.1 Project management

A project management system is established consisting of a project steering committee (PSC), a project monitoring agency, a project technical support team and a project management office. The PSC is composed of APFNet, forestry administrative departments at the level of province, prefecture and district as well as forestry institutes. PSC inspects annual work plan and activity report, carries out necessary inspection and assessment of project process, research and guides the important issues during the project implementation. The project supervisor panel is composed of the leaders of Forestry and Grassland Bureau of Pu'er Prefecture, Forestry and Grassland Bureau of Simao District and different functional departments, to carry out necessary inspection of the project. The project technical support team is composed of the experts from YAFG, Forestry Research Institute of Pu'er Prefecture who are specialized in forest management, forest cultivation, forest ecology, forest protection, etc., to prepare annual project plans and progress reports. The project steering committee meeting was held every year to listen to the progress report of the project, review the next annual plan, and give full play to the role of project guidance and management.

The project supervision is composed of the leaders of Yunnan Forestry and Grassland Bureau, Pu'er Forestry and Grassland Bureau, Simao Forestry and Grassland Bureau and the leaders of various functional departments to carry out necessary supervision and inspection of the project, monitor the project progress and activity output quality, and ensure the standardized and efficient use of funds. According to the approved project work plan, be responsible for the overall management of the project, supervise the implementation of the project, carry out project inspection and acceptance according to the progress of project activities, and issue the project activity acceptance report after passing the acceptance. Organize the employment of experts in time according to the expert requirements approved in the annual plan of the project, and review the expert output report. Project files have been well organized and classified.

3.2 Executing agency

According to the requirements of the overall plan and annual plan of the project, the executing agency strengthened the organization and management, scientific and technological investment, demonstration and promotion, and fund use, and successfully completed the tasks specified in the project.

(1) Establish a project implementation office to strengthen project implementation management. The project implementation unit, WFF, has set up a project implementation office, including a project director, an executive director and nine professional and technical personnel to be responsible for this work. Work out the project activity plan and reverse the schedule; At the same time, it actively reported and communicated with the project management office and APFNet, which effectively ensured the smooth implementation of the project activities.

(2) Strengthen scientific and technological support to ensure project quality. A team of technical experts engaged in forest management, forest cultivation, forest ecology, forest protection and other disciplines has been established by YAFG, Pu'er Forestry Research Institute, etc. Complete the preparation of various reports of the project with the assistance of the project implementation office. Set up the chief expert of the project, prepare the project proposal, and provide technical consultation and guidance for the application of major technical solutions, key technical problems and new technologies in the implementation of the project, to ensure the quality of project activities.

(3) The combination of project activities and forest farm management has expanded the effect of the project. During the implementation of the project, the State Forestry and Grassland Administration, Yunnan Forestry and Grassland Bureau, Pu'er municipal Party committee and government, and Pu'er Municipal Forestry and Grassland Bureau supported the project, which expanded the impact and effect of the project.

(4) Strictly manage funds and improve efficiency. Set up special accounts, earmark funds for special purposes, establish separate accounts, and operate in a closed manner to ensure the safe use of project funds. The project reimbursement adopts the reimbursement application form and audit sheet system. After the project activities are completed and passed the acceptance, the specific executor of the project activities shall submit an application, the project executive director shall review it, and the director of the project management office shall approve it before reimbursement and payment. In the whole activities of WFF, the project implementation was put in the first. When the funds cannot be in place in time, funds were actively raised to ensure that the project activities are carried out in a timely manner.

3.3 Other project partners

(1) The chief expert of the project is responsible for the technical problems of the project. It has formulated the tending plan for the middle-aged and young forests of *P. kesiya* and *Betula alnoides*, the technical plan for the integrated management of secondary forests, and the construction plan for the collection garden of tropical precious plant resources, carried out technical checks on the construction plan for the high-efficiency resin collection demonstration forest, and was responsible for the communication and report review of the consulting experts during the implementation of the project.

(2) Technical consulting experts provided technical support for the smooth implementation of the project, mainly providing guidance, consultation and support for forest management, native tree species cultivation, close-to-natural management, large-diameter oriented timber cultivation and other technologies required in the process of project implementation, carrying out training in forest resources investigation and monitoring, forest management, state-owned forest farm management and project publicity, and completing the project monitoring report.

(3) The afforestation, tending and thinning activities during the implementation of the project are completed by the professional team organized by WFF. Before operation, WFF staff were given pre-job training, including forestry production and operation procedures, safety production and other relevant knowledge, and the operation quality, construction period, labor remuneration and so on were clearly stipulated. After systematic training and contract constraints, WFF staff can carry out operation in strict accordance with the provisions of WFF, and the qualification rate of each operation quality has reached more than 95%.

(4) Other activities such as hardware equipment procurement are completed through government procurement.

3.4 Role of APFNet

(1) Project supervision and management

APFNet holds a project coordination meeting every year to organize and schedule the project, review the annual workplan, and change and supplement the content of project activities according to the actual situation. Assign focal point to the project, go deep into the project site to monitor and guide implementation many times, and track the progress of the project. In July 2019, experts were organized to conduct the mid-term evaluation of the project and submit the evaluation report, giving timely feedback and guidance on the problems existing in the project.

(2) Project stakeholder coordination

Coordinate with the Resources Department of the State Forestry and Grassland Administration, Yunnan Forestry and Grassland Bureau, Pu'er municipal Party committee and government, and the Municipal Forestry and Grassland Bureau on issues such as natural forest tending and cutting, efficient resin collection, and coordinate the combination of project activities with the operation work of relevant departments and bureaus of the State Forestry and Grassland Administration to ensure the smooth implementation and effect of the project.

(3) Publicity and knowledge sharing

It organized the second steering committee meeting of the Sino–ASEAN Network of Forestry Research Institutes (SANFRI), the first Early Career Academics Forum, the China forest management protection and utilization seminar, the

ecological and cultural style collection and creation activities of well-known artists, the SANFRI visiting scholar program, etc., and attracted more than 50 foreign guests from the GMS economies to visit the project site, as well as about 400 domestic people to visit and study, and publicize the project achievements and experience.

4. Project performance

In the five-year implementation of the project, on the basis of the preparation of the integrated management of the forest ecosystem in the Greater Mekong Subregion in the Pu'er, China, the demonstration and model have been established for the integrated management and sustainable management of the forest ecosystem in the upper reaches of the GMS, so as to improve the quality of the forest ecosystem in the region and enhance its overall ecological, economic and social functions. Three texts have been prepared: "Master Plan of Integrated Forest Ecosystem Management of WFF, Pu'er Prefecture (2017－2036)" "Forest Management Action Plan of WFF, Pu'er Prefecture (2017－2026)", and "Multi-functional Forest Management Plan for WFF's Sustainable Development"; Established a forest tending demonstration of 120ha for young-middle aged *Pinus kesiya* and *Betula alnoides* forest stand; Constructed an efficient resin production demonstration plot of 50ha and developed an effective resin collection technical manual; Established an integrated secondary forest management demonstration of 50ha; Constructed a precious plant resources collection garden of south-subtropical region of 5 ha; Carried out 7 trainings, organized 3 visits to 5 places at home, and 1 visit aboard.

The implementation of this project aims to establish some demonstrations and models of integrated sustainable management of forest ecosystem in the upper reach region of GMS, so as to improve the forest ecosystem quality and to increase its integrated ecological, economic and social functions, as well as the development of the region's ecological civilization.

4.1 Project outcomes

4.1.1 Developed master plan and action plan

Surveys on existing forest management status of WFF, clarify a reform direction of state-owned forest farm and develop a detailed and targeted planning aiming to

increase forest resources, improve the stand quality, develop the main business, improve management level, enhance community forestry co-construction and the personnel capacity building, so as to improve the quality of management level and the overall benefits of WFF.

(1) "Master Plan of Integrated Forest Ecosystem Management of WFF, Pu'er Prefecture (2017－2036)"

The management scope of WFF covers forest management, afforestation, garden flower, seedling cultivation, fruit cultivation, forestry technical services and community forestry development. WFF has never carried out the planning of forestry development.

The objectives of the master plan are that through 20 years development, the forest resources have been effectively protected, and the forest resources have continued to grow, and the quality has been significantly improved. By the end of the planning period, the area of forest land is larger than 17,399.9hm^2; The forest area shall not be less than 15,600 hm^2; Forest stock increased by 2.57 million m^3 (original stock 2.155 million m^3); The forest coverage rate (originally 80.7%) will be above 81.7%. The annual income of the staff reaches 100,000 yuan.

On the basis of latest data of WFF and investigation on forest resources, an overall planning has been developed at different stages (short, middle and long-term) which covers the following measures:

1) Silviculture: forest plantation; forest tending; forest quality improvement; infrastructure construction; and multifunctional forest management.

2) Forest ecological system conservation and protection: construction of management system; protection of forest land productivity; management of ecological forest; Planning and construction of the South Subtropical Botanical Garden; and conservation of bio-diversity; forest fire, pests and disease control.

3) Forest resource utilization and development: Industry development of non-timber forest products; cultivation of timber forest.

4) Supporting system improvement: security system, institution building, personal capacity building; public environmental awareness building.

(2) "Forest Management Action Plan of WFF, Pu'er Prefecture (2017 - 2026)"

Based on field survey, the "Forest Management Action Plan of WFF, Pu'er Prefecture (2017 - 2026)" was developed by YAFG to establish a forest management system in the project area, clarify the types of supporting forest management measures, and identify management modes. The investigation work has been carried out in strict accordance with the "Detailed rules for the operation of forest resources planning, design and investigation in Yunnan Province (Trial)", and the preparation of the plan has been done in line with "Technical regulations for the preparation of forest management plans (LY/T2007-2012)", which were submitted to the local forestry bureau for approval and implementation. The plan aims to protect, restore and improve the forest ecosystem effectively, scientifically allocate forest resources, standardize and refine management measures in the management plan, improve forestry production efficiency, and improve the overall service function of the regional forest ecosystem.

(3) "Multi-functional forest management plan"

"Multi-functional forest management plan" was developed by technical support partner Nanjing Jialin System Engineering Technology co., LTD. The management plan adopts the "forest simulation and optimization system(FSOS)", sets up the management objectives of WFF, establishes the forest information database, and classifies WFF into five functional zones: 1) forest production area; 2)ecological service area; 3)ecological protection area; 4)landscape area (scenic area, botanic garden); and 5) scientific research demonstration area. The plan is expected to provide decision-making support for multi-functional forest management of forest ecosystem, and establish a demonstration for intelligent management of forest ecosystem and sustainable forest management in GMS region.

4.1.2 Establishment of forest tending demonstration for young-middle aged *Pinus kesiya* and *Betula alnoides* forest stand, with an area of 120 ha

The forestland with the area of 120ha is designed by two management directions: commercial forest and non-commercial forest. The objective of demonstration base of non-commercial forest tending is to preserve and cultivate evergreen broad-leaved plants such as *Fagaceae, Lauraceae, Magnoliaceae* and tea, as a means to achieve a mixed, stratified, uneven-aged stand structure. Try to restore forest ecosystem up to

the zonal climax vegetation-monsoon evergreen broad-leaved forest, and continuously improve ecological service function of non-commercial forest.

During the implementation of the project, in order to improve the ecological and economic functions and demonstration effects of the sample plot in the original plan, it was adopted by APFNet to increase the ecological demonstration sample plots with a total area of 3 ha of *P. kesiya* non-commercial forest (1ha), *P. kesiya* commercial forest(1ha) and *B. alnoides* commercial forest(1ha), to complementarily replant some native broad-leaf species after intensified thinning, and form the mixed forest stand structure with more abundant layers and biodiversity, and therefore play an important role in protecting and stabilizing the forest stand.

Meanwhile, for better demonstration of the project, the technical support team YAFG, added precision fertilization experiments into the project, and successfully carried out the demonstration with its own funds and the cooperation of WFF.

(1) Establishment of demonstrating base for tending of young-middle aged *Pinus kesiya* stands, with an area of 40ha

Four grades tending intensities of 15%, 20%, 25%, 30% and 45% were set up respectively to a 13-year-old *P. kesiya* plantation. The control without cutting was set up as well. The productivity and ecological restoration effect of stands with different treatments were demonstrated. Sample plots investigating were conducted at the end of each year.

A. Growth performance of *P. kesiaya*

The growth performance of 13-year-old ecological *P. kesiya* plantation under different thinning treatment are shown that:

1) All thinning intensity have significant influence on single trees growth. Generally, higher intensity bring higher increment on individual tree's volume.

2) Lower thinning intensities of 15%, 20% and 25% have positive impact on increment of unit area's stand volume after 5 years compare with control. This indicates the thinning measure improved growth conditions and promoted growth of trees.

3) Higher thinning intensities of 30% and 45% however in 4 years of the project have negative impact on stand stoke compare with control, the changing rate of volume is -16.34% and -3.03% respectively. This could be caused by relative high thinning rate lead to lose of more single trees and therefore a higher decline of volume

of the stand, even though volume of individual trees increased.

4) For high density pine plantation (e.g. 2400 trees/ hm^2 in this case) should not give heavy thinning practice which may lead to wind-fall of trees. Instead, repeated and light thinning is suggested to recover canopy size and diameter growth gradually, and then to ensure both stand and individual volume increased simultaneously.

B. Species diversity under forest

Recovery of species diversity is one of important purpose of ecological pine forest management. After 4-year different intensity tending treatments, the plant species diversity in tree layer and shrub layer shows that: 1) generally, there is no significant difference for all indexes of species number, individual plant number, and shrub coverage between tending intensity treatments. This indicates that development and evolution of vegetation is long process, the project period is not long enough to show differentiation of the forest communities. More time is still necessary before the obvious changes happened by different treatment; 2) higher tree and shrub species appears in control. This because the tree and shrub plants with poor growth performance were cut out during tending activity, even though the regenerated native species were required to leave in forest as designed by project; 3) higher tending intensity lead to less plant number of individual trees but higher shrub plant number and its coverage. Once the upper layer tree is removed out, more sun light received by understory, which promote growth of shrub species.

Fig. 4 Before tending(L)and after tending (R) of *P. kesiaya* non-commercial plantation

(2) Tending of commercial *P. kesiya* plantation, with an area of 40ha

Four grades were set up, with the cutting intensity of 20%, 30%, 40%, 50% and control respectively to7 years old *P. kesiya* plantation. There are 3 replicates for each treatment. The productivity and ecological restoration effect of stands with different

treatments were demonstrated. Conduct monitoring at the end of every project year. The growth performance of 7-year-old ecological *P. kesiya* plantation under different thinning treatment shows that:

1) All thinning intensity have significant influence on single trees growth. Generally, higher intensity had higher increment on individual tree's volume.

2) The thinning intensities of 20%, 30% and 40% have positive impact on increment of unit area's (1 hectare) stand volume after 5 years project implementation compare with control. This indicates the thinning measure improved growth conditions and promoted growth of trees.

3) Highest thinning intensities of 50% however have negative impacts on stand stoke compare with control in short run, the volume decreased 32.33%. This caused by 50% loss of single trees, even though volume of individual trees increased. But in the long run, high thinning intensity could promote diameter increment and produce large diameter and high value trees. Long term of monitoring needs to be carried out.

4) It is suggested that for high density (e.g. 2400 trees/ hm^2 in this case) 7 year-old pine forest with, a 40% thinning intensity is the best choice which will bring a best performance for both stand and individual growth.

Fig. 5 Before tending(L)and after tending (R) of *P. kesiaya* commercial plantation

(3) Tending of commercial *Betula alnoides* plantation, with an area of 40ha(actual tending area is 25ha)

Four grades were set up, with the cutting intensity of 25%, 30%, 35% and 40% respectively for a 6 years old *Betula alnoides* plantation. Removing the shrub and liana with negative impact, and promote the growth of target plants. The control without cutting was set up as well. Productivity and ecological restoration effect of

stands with different treatments were demonstrated. Sample plots investigating were conducted at the end of each year.

The tending demonstration shows that different thinning treatments have all positive influence on Betula forest stand growth. Four years' stand volume increment of a hectare under the thinning intensities of 25%, 30%, 35% and 40% are all increased, compared with that of control. Of which, 40% of thinning intensity has more increment on stand volume, followed by 25% and 30% intensities. While the increased stand volume under 35% tending intensities has lowest increasing rate only.

Fig. 6 Before tending(L)and after tending (R) of *Betula alnoides* commercial plantation

(4) Enrichment planting under *P. kesiya* plantation

P. kesiya plantations (13-year-old ecological forest and 8-year-old commercial forest) were selected to carry out enrichment planting experiment. According to the plant density and vegetation coverage in the plantation, the appropriate thinning has been done for *P. kesiya* (4% for commercial forest; 46% for ecological forest) in the sample plot, and the forest gaps formed after thinning was used for enrichment planting using native broadleaved trees. The native broadleaved trees such as *Alnus nepalensis, Toona ciliate, Phoebe puwenensis, and Quercus variabilis* with good ecological and economic benefits were selected.

After 3-year enrichment planting, the species diversity in tree layer and shrub layer and stand volume increment shows that:

1) Enrichment planting in all plantations significantly increased both tree and shrub diversity. One reason is introducing of new tree species into monoculture stand; second reason is high intensity of thinning for the two plantation stands, improved growth condition for understory plants and promoted regeneration and performance of trees and shrub plants.

2) Although tree height are almost the same between enrichment plantings and

CK in two plantations, but increment of DBH and stand volume are significantly larger than it in control plots of *P. kesiya*. This is the result of thinning mitigated competitions of individual tree for light demand, which promoted DBH and stand volume growth.

3) Tree and shrub plant number in both pine and birch plantation generally are greater in control, due to thinning activity removed poor and small plants from forest in enrichment planting stands.

(5) Enrichment planting under *B. alnoides* plantation

A 8-year-old *B. alnoides* plantation was selected to carry out enrichment planting experiment. According to the plant density and vegetation coverage in the plantation, the appropriate thinning has been done for *B. alnoides* (4%) in the sample plot, and the forest gaps formed after thinning was used for enrichment planting using native broadleaved trees. The native broadleaved trees such as *Alnus nepalensis, Toona ciliate, Phoebe puwenensis, and Quercus variabilis* with good ecological and economic benefits were selected.

After 3-year enrichment planting, the species diversity in tree layer and shrub layer and stand volume increment shows that:

1) Enrichment planting in all plantations significantly increased both tree and shrub diversity. One reason is introducing of new tree species into monoculture stand; second reason is high intensity of thinning for the plantation, improved growth condition for understory plants and promoted regeneration and performance of trees and shrub plants.

2) Although tree height are almost the same between enrichment plantings and CK in *B. alnoides* plantation, but increment of DBH and stand volume are significantly larger than it in control plots. This is the result of thinning mitigated competitions of individual tree for light demand, which promoted DBH and stand volume growth.

3) Tree and shrub plant number in both pine and birch plantation generally are greater in control, due to thinning activity removed poor and small plants from forest in enrichment planting stands.

4) Shrub coverage rate in control for both commercial and ecological pine forest stands are larger than it in enrichment planting stands, while shrub coverage rate is smaller in control plots for birch stands. This indicates the environment in *B. anoides* plantation

is more suitable for regrowth of understory vegetation than *P. kesiya* plantation.

(6) Large diameter class target *P. kesiya* trees management

Choosing 8 years and 14 years *P. kesiya* plantation as the research object, to carry out ordinary thinning, mechanical thinning, target tree management under the same thinning intensity. To compare the effects of target tree management and other two thinning methods on DBH, tree height, and volume growth of reserved trees in woodland. Demonstrate the effect of large diameter class target tree management on stand structure and productivity.

The results of different forest management measures on different age pine stands (8-year-old and 14-year-old) shows that in 14-year-old forest, performance under all three forest management measures of target tree management, traditional thinning and mechanical thinning are higher than control significantly in stand volumes. Thus, among 3 management measures, compare with control, mechanical thinning and target tree management had the highest annual stand volume increment, followed by traditional thinning.

In a 8-year-old forest, performance of stand volume under all three forest management measures of target tree management, mechanical thinning and traditional showed a similar situation and trend with 14-year-old stand. The older of the forest, the higher of stand volume increment and increasing rate.

In addition, there were several advantages for large dimension target tree management. These include 1) Only 1-2 competition trees needed to be cut off beside 150 target trees per hectare; 2) less costs for competition trees' cutting; 3) equal maintenance efforts such as weeding, fertilization, pruning need to be paid to all rest of trees after each traditional tending management; 4) attention only gave to few selected target trees for large dimension target tree management; 5) target tree management measure has less disturbance to forest self-development.

(7) Large diameter class target *B. alnoides* trees management

Choosing 6 years *B. alnoides* plantation as the research object, to carry out ordinary thinning, mechanical thinning, target tree management under the same thinning intensity (20%). To compare the effects of target tree management and other two thinning methods on DBH, tree height, and volume growth of reserved trees in woodland. Demonstrate the effect of target tree management on stand structure and productivity.

The target tree management test of Birch tree shows that target tree management, mechanical thinning and ordinary thinning are higher significantly than control in tree height, DBH and stand volume.

Based on the investigate data analysis, the order of cumulative height growth of the stand from 2019 to 2021 was target tree management > traditional thinning > mechanical thinning > CK. This experiment showed that Target tree management had the highest effect on tree height growth.

The order of cumulative DBH growth in 3 years from 2019 to 2021 was target tree management > mechanical thinning = traditional thinning> CK. The results showed that target tree management had the maximum effect on the diameter growth of nine-year-old *B. alnoides* stands in southwest China. Mechanical thinning and traditional thinning showed only a half DBH increment than target tree management, while the control has least DBH growth.

The order of annual increment of stand volume in Wanzhangshan from 2019 to 2021 is target tree management > traditional thinning > mechanical thinning > control, and the stand volume of the three thinning measures increased, compared with the control, indicating the obvious superiority of target tree management. All tending practices greatly improved forest and stand conditions and significantly increased tree growth.

(8) Precise fertilization of commercial *B. alnoides* plantation

For better demonstration of the project, the technical support team, YAFG added precision fertilization experiments into the project, and successfully carried out the demonstration with its own funds and the cooperation of WFF.

Based on soil fertility and nutrient elements content of plant body, a fertilization model was established to determine the amount of fertilizer applied to southwest Birch forest, and the comparison of formula fertilization was designed to show the promoting effect of different fertilizer formulations on the growth of southwest Birch forest. That is to carry out the investigation of forest growth index, stand growth status and forest fertility in different fertilizer demonstration plots. The stems, branches, leaves, bark and roots of dominant trees and the soil of experimental forest were collected and analyzed. The average content of relevant nutrients in dominant trees was determined by calculating dominant and average tree biomass. The relationship between the demand of N, P and K and the target yield and the amount of

fertilizer was calculated.

The precise fertilization shows that under different fertilization rates, the accumulated volume increment of birch per hectare presents a increase from 2017 to 2021. Compared with the accumulated volume of control, the difference of increasing rate were was extremely significant. Moreover, when fertilizer application at the level of expected 40%, the actual increase was the highest. That was urea 303 g, superphosphate 208 g and potassium chloride 118 g per plant have the best effect.

4.1.3 Construction of efficient resin production demonstration plot with an area of 30ha, and development of effective resin collection technical manual

(1) Construction of efficient resin production demonstration plot

Resin collection was carried out in 19-year-old mid-aged *Pinus kesiya* plantation with DBH more than 18 cm (mainly from 18 cm to 20 cm), to compare the effects of cutting intensity, fertilization, tapping measures and tapping frequency.

1) Thinning intensity

The program shows that different thinning intensities had little effect on the yield of resin, and there was no significant difference among different treatments, but the yield of resin decreased year by year with the increase of harvesting years. Thus, once the pine trees reach DBH 18cm, we do not recommend conduct forest tending. Higher intensive tending will decrease unite area resin production.

However, forest thinning will bring positive effect on pine growth in term of DBH, height and stand volume after 5 years project implementation from 2017 to 2021. Different thinning intensity has significant influence on individual tree growth especially on stand volume compare with control. Generally, higher thinning intensity has higher influence on average DBH, height and volume increment of single tree. Therefore, although forest tending for *P. kesiya* does not increase single tree's resin production, but it can promote tree growth which may boost resin yield in long-run.

The pine forest used for experiment was 19-year-old, which probably too late to carry out thinning. Because long time over dense young forest lead to excessive natural pruning and small canopy size. The narrow photosynthetic area of trees has only poor photosynthesis and low resin production. So that, we strongly suggest to carry out density control in early stage of plantation.

2) Fertilizer application

Fertilization could increase the resin yield of *P. kesiya*, and the yield increased

obviously when the amount of fertilizer is 1000g, but there was no significant increase when the amount of fertilizer was more than 1000g. However, the yield of resin decreased year by year.

Resin production always has close correlation with growth performance of the trees. Effect of fertilization is first reflected on the tree growth. Fertilization can improve the growth of pine trees. Similar with change trends of resin production, when the fertilizer application rate is 1000g, the growth increases significantly, but when the fertilizer application rate exceeds 1000g, the stand volume growth does not increase significantly.

3) Resin tapping frequency

To detect influence of different intervals on the yield of resin collection, three frequency treatments of 2 days, 3days and 4 days per harvest were designed. Different harvesting frequency has slight effect on the resin production, and there is no significant difference among different treatments, but the yield of resin decreased year by year with the increase of harvesting years. Therefore, in the process of resin harvesting, the interval is suggested longer than 4 days, which can save labor costs.

Different tapping frequency has slight effect on the growth of single tree. While as, the increment of tree growth in control are significantly higher than tapped trees. It revealed a trend of higher harvest frequency leading to higher growth increment. This seems contrary to the conventional outcome. Because frequent tapping is frequent disturbances to trees. One possible reason could be moderate disturbance (tapping) act as stimulation factor which promoted the growth of trees. We still need further research to find out the reasons behind it.

4) Tapping intensity

Four tapping intensities (cutting face percentage of trunk) of 30%, 40%, 50% and 60% were set up and found that with the increase of cutting intensity, the yield of resin increased gradually, but the yield of resin decreased year by year, and the difference between treatments gradually became smaller in the last project year.

The higher of tapping intensity, the higher decreasing rate of resin production. Therefore, moderate tapping rate (40%) is suggested.

The influence of different resin tapping intensity on growth of pine trees was carried out simultaneously. Compare with control, the growth increment (stand volume) of pine tree decreased gradually with the increase of tapping intensity.

Based on the above results, in the process of resin harvesting of *P. kesiya*, we strongly recommend to adopt an integrated resin production measure of 40% of the tapping intensity, 4 days or longer tapping frequency, and 1000 g of compound fertilizer. The yield of turpentine, wood stock and labor cost can be significantly increased by proper thinning.

(2) Development of effective resin collection technical manual

Based on experimental results and the demonstration of sustainable forest management and oriented cultivation techniques for efficient resin production, the awareness building and technical training are strengthened. Resin collection techniques of local forest farmers are enhanced through regulated collection activities.

4.1.4 Demonstration establishment of integrated secondary forest management, with an area of 50ha

According to natural conditions of the forest, to improve the ecological service and comprehensive benefit in a sustainable way. Guided by the theory of "close to nature forestry", through understory planting, thinning and tending measures, the output of the secondary forest will be increased, and the succession process of the secondary forest to the local climax community will be accelerated as well.

(1) Selective thinning to improve ecological function of the secondary forest, with an area of 45ha

According to the situation of forest growth and development, conduct thinning on some *Pinus kesiya* in the forest in a planned way, especially for trees of excessive resin tapping, disease and pest, broken branches, and particularly crooked trunk. Set up three thinning intensity levels to *Pinus kesiya,* the ratio of coniferous to broad leaved trees will be 2:8, 3:7 and 4:6, respectively. After the selective cutting is done, if the single forest gap area is larger than 15m^2, choose native broad-leaf tree species with good ecological and economic benefits for after-replacement, namely *B. alnoides, Alnus cremastogyne Burk, Toona ciliata Roem.* and *Phoebe puwenensis*, and form the multi-layer, uneven-aged mixed broadleaf-conifer forest. Meanwhile, protect the under-forest shrubs and herbaceous plants, finally form the multi-layer uneven-aged structure with the combination of ground arbors, shrubs and grass, and realize water and soil conservation and water source conservation. Protect under-forest litters, improve the water holding capacity of litter layer, improve the forest ecosystem

stability, and give play to the forest ecological service functions to the maximum extent.

Fig. 7 Before and after selective thinning of secondary forest

● **Tree layer**

After 4 years implementing of removing of Pine trees from site, number of tree species in three treatments increased slightly, while it decreased a bit in control plot. This indicates that cutting of upper layer pine trees promote development of broad-leaved trees, due to more light come down to lower forest.

Generally, number of individual trees in 3 treatments decreased in a certain amount, caused by cutting of upper pine trees.

Tree height has almost no increase compare 4 years ago. This is because removing of pine tree in the 1st year decreased average height of the forest. Four years' growth of the forest made its height just catch up with the previous one.

Diameter (DBH) of trees in upper layer increased in obviously degree for different treatment, especially for plots of ratio of coniferous to broad leaved trees 2:8, because more upper trees cut off, provided more growing opportunity to lower layer trees. Meanwhile, most of pine trees in upper layer have passed their fast growing period, this lead to a very less DBH change for control plot.

● **Shrub layer**

Both number of shrub species and individual in three treatments increased in a certain degree after 4 years of clear away of upper layer pine trees. This is caused by remove of upper layer pine trees leading more light come down to shrub layer. Larger cutting rate bring more lights and better growing condition for shrubs.

Shrub height has little increase compare 4 years ago for all treatments. But the coverage rate declined unexpected which need further observation and research.

● **Grass layer**

Number of grass species decreased in 2 treatment 2, treatment 3 and control, only

increased a bit in treatment 1. However, number of individual in three treatment increased significantly after 4 years of clear away some pine trees. The situation in control has only a slight increase, keeps almost unchanged. This is because more light the better growing condition for herbs.

(2) Demonstration of understory planting, with an area of 5ha

5 ha of secondary forests with good humidity and heat condition and convenient transportation was selected as demonstration site, to produce ecological and healthy products, give consideration to landscape effects and economic benefits. Dendrobe, *Anoectochilus formosanus, rhizoma bletillae* and other Orchidaceae medicinal plants are planted.

After 4 years of imitation wild planting, dendrobe have good performance. The highest net weight of fresh plant was found in *Dendrobium chrysotoxum*, 3777g /clump, followed by *Dendrobium nobile* (719g/ clump) and *Dendrobium aurantiacum* (622g/clump). *Dendrobium pendulum*, *Dendrobium thyrsiflorum*, *Dendrobium primulinum* and *Dendrobium crepidatum* present lower production with net weight of 523 g/clump, 430 g/clump, 397 g/clump, and 314 g/clump, respectively.

Table 2 production and values of planted understory dendrobe species

Species	Yield		Reproductive rate (%)	Price （¥/kg）	Output value	
	plant/clump	g/clump			¥/clump	¥/hm²
D. chrysotoxum	55	3777	506	10	37.8	158634
D. aurantiacum	7	622	69	15	9.3	39158
D. nobile	26	719	282	15	10.8	45303
D. crepidatum	26	314	674	15	4.7	19754
D. pendulum	18	523	321	15	7.8	32969
D. thyrsiflorum	14	430	514	15	6.4	27081
D. primulinum	28	397	575	15	6.0	25037

According to the market price of fresh stem of dendrobe, which is 10 yuan/kg for *D. chrysotoxum* and 15 yuan/kg for others, the best economic benefit comes from *D. chrysotoxum*, with an value of 37.8 yuan/clump and an 158,600 yuan/hm² (about US ＄24,000/hm²), followed by *D. nobile* (45,300 yuan/hm²) and *D. aurantiacum* (39100 yuan/hm²), the least one is *D. crepidatum* with an benefit of 19700 yuan/hm².

Planting dendrobe under the forest can not only improve the ecological function

and comprehensive benefits of forest land, but also enable forest farmers to get benefits and improve their livelihood. In the long run, it is of certain significance to improve the quality of the forest ecosystem in this region and enhance its overall ecological, economic and social functions.

4.1.5 Construction of precious plant resources collection garden of south-subtropical region, with an area of 5ha

The project construction will be based on Pu'er Subtropical Botanical Garden and take the south subtropical precious timber species, small population species and other herbs, spicery and forest vegetable tree species as main targets, combining with the landscape of the garden to collect and introduce at least 100 species. The species collected will be labeled to carry out popular science education, to promote biodiversity conservation and sustainable development of forestry.

(1) South subtropical precious plant resources collection

Three zones were established in the project site, including precious timber species, small population tree species and other tree species（medicinal, spicery and forest vegetable, etc.). The number of each species collected is not less than 50, to ensure the safety of the species, avoid the extinction caused by the environmental stress; another purpose is for biology research to collect and preserve precious plant germplasm resource and provide the test material for the research.

Table 3 Precious Tree Species Resources for Preservation

No.	Family	Chinese name	Latin Name
1	Magnoliaceae 木兰科	长蕊木兰	*Alcimandra cathcartii*
2		思茅玉兰	*Magnolia henryi*
3		华盖木	*Manglietiastrum sinicum*
4		乐昌含笑	*Michelia chapensis*
5		金叶含笑	*Michelia foveolata*
6		观光木	*Michelia odora*
7		乐东拟单性木兰	*Parakmeria lotungensis*
8		云南拟单性木兰	*Parakmeria yunnanensis*

9		山桂花	*Paramichelia baillonii*
10	Annonaceae 番荔枝科	刺果番荔枝	*Annona muricata*
11	Lauraceae 樟科	云南樟	*Cinnamomum glanduliferum*
12		普文楠	*Phoebe puwenensis*
13		桢楠	*Phoebe zhennan*
14		石楠	*Photinia serrulata*
15	Myristicaceae 肉豆蔻科	云南肉豆蔻	*Myristica yunnanensis*
16		滇南风吹楠	*Horsfieldia tetratepala*
17	Lysimachiaceae 千屈菜科	大叶紫薇	*Lagerstroemia speciosa*
18	Daphneceae 瑞香科	白木香	*Aquilaria sinensis*
19	Proteaceae 山龙眼科	澳洲坚果	*Macadamia ternifolia*
20		假山龙眼	*Heliciopsis henryi*
21	Flacourtiaceae 大风子科	红花天料木	*Homalium hainanense*
22		海南大风子	*Hydnocarpus hainanensis*
23	Theaceae 山茶科	普洱茶	*Camellia sinensis var. assamica*
24	Dipterocarpaceae 龙脑香科	望天树	*Parashorea chinensis*
25		羯布罗香	*Dipterocarpus turbinatus*
26	Myrtaceae 桃金娘科	红千层	*Callistemon rigidus*
27		松红梅	*Leptospermum scoparium*
28		白千层	*Melaleucaleucadendron*
29		嘉宝果	*Plinia cauliflora*
30		乌墨	*Syzygium cumini*
31		思茅蒲桃	*Syzygium szemaoense*
32		红车	*Syzyglum hancei*
33		金蒲桃	*Xanthostemon chrysanthus*

34	Lecythidaceae 玉蕊科	红花玉蕊	*Barringtonia racemosa*
35	Combretaceae 使君子科	油榄仁	*Terminalia bellirica*
36	Rhizophoraceae 红树科	竹节树	*Carallia brachiata*
37		山红树	*Pellacalyx yunnanensis*
38	Guttiferae 藤黄科	长裂藤黄	*Garcinia lancilimba*
39		莽吉柿（山竹）	*Garcinia mangostana*
40		大叶藤黄	*Garcinia xanthochymus*
41		铁力木	*Mesua ferrea*
42	Bombacaceae 木棉科	瓜栗	*Pachira macrocarpa*
43	Sterculiaceae 梧桐科	美丽火桐	*Erythropsis pulcherrima*
44	Malvaceae 锦葵科	澳洲火焰木	*Brachychiton acerifolius*
45		景东翅子树	*Pterospermum kingtungense*
46		梭罗树	*Reevesia pubescens*
47		可可	*Theobroma cacao*
48	Euphorbiaceae 大戟科	重阳木	*Bischofia polycarpa*
49		木奶果	*Baccaurea ramiflora*
50	Rosaceae 蔷薇科	桃	*Amygdalus persica*
51		栘依果	*Docynia delavayi*
52		冬樱花	*Prunus cerasoides*
53	Salicaceae 杨柳科	黄金柳	*Salix alba*
54	Myricaceae 杨梅科	杨梅	*Myrica rubra*
55	Fagaceae 壳斗科	榉木	*Fagus Sylvatica*
56		娜塔栎	*Quercus nuttallii*
57		柳叶栎	*Quercus phellos*
58	Moraceae	红桂木	*Artocarpus nitidus*

59	桑科	菠萝蜜	*Artocarpus heterophyllus*
60	Simaroubaceae 苦木科	椿树	*Ailanthus altissima*
61	Meliaceae 楝科	非洲桃花心木	*Swietenia mahagoni*
62	Sapindaceae 无患子科	红翅槭	*Acer fabri*
63		鸡爪槭	*Acer palmatum*
64		栾树	*Koelreuteria paniculata*
65		绒毛番龙眼	*Pometia tomentosa*
66		无患子	*Sapindus*
67	Anacardiaceae 漆树科	芒果	*Mangifera indica*
68		清香木	*Pistacia weinmannifolia*
69	Nyssaceae 蓝果树科	八蕊单室茱萸	*Mastixia euonymoides*
70		云南蓝果树	*Nyssa yunnanensis*
71	Sapotaceae 山榄科	牛油果	*Butyrospermum parkii*
72		紫荆木	*Madhuca pasquieri*
73	Acanthaceae 爵床科	火焰花	*Phlogacanthus curviflorus*
74	Elaeocarpaceae 杜英科	杜英	*Elaeocarpus decipiens*
75		水石榕	*Elaeocarpus hainanensis*
76	Bretschneideraceae 伯乐树科	伯乐木	*Bretschneidera sinensis*
77	Pinaceae 松科	雪松	*Cedrus deodara*
78		华山松	*Pinus armandii*
79		湿加松	*pinus elliottii×p. caribaea*
80	Taxodiaceae 杉科	柳杉	*Cryptomeria fortunei*
81	Cupressaceae 柏科	藏柏	*Cupressus torulosa*
82	Podocarpaceae 罗汉松科	竹柏	*Podocarpus nagi*
83		百日青	*Podocarpus neriifolius*

84	Bignoniaceae 紫葳科	木蝴蝶	*Oroxylum indicum*
85		黄花枫铃木	*Handroanthuschrysanthus*
86	Leguminosae 豆科	海红豆	*Adenanthera pavonina*
87		红花羊蹄甲	*Bauhinia blakeana*
88		粉花山扁豆	*Cassia nodosa*
89		铁刀木	*Cassia siamea*
90		交趾黄檀	*Dalbergia cochinchinensis*
91		黑黄檀	*Dalbergia fusca*
92		降香黄檀	*Dalbergia odorifera*
93		奥氏黄檀	*Dalbergia oliveri*
94		凤凰木	*Delonix regia*
95		格木	*Erythrophleum fordii*
96		印度紫檀	*Pterocarpus indicus*
97		无忧花	*Saraca dives*
98		油楠	*Sindora glabra*
99		酸豆	*Tamarindus indica*
100		细籽海黄豆	*Adenanthera pavonina* var. *luteosemiralis*

(2) Tree species recognition

A brief description on tree was made for better communication and popular science publicity.

4.1.6 Capacity building

Carried out 6 training workshops with themes covering from forest resources inventory and monitoring, the classification of the trees, forest management, forest farm management, project management and publicity etc.. Conducted 3 exchange visits for 4 places at home and 2 places aboard, targeting the staff related to the project implementation, to improve the management capacity for WFF.

5. Conclusions, lessons learned and suggestions

5.1Conclusion

The project has completed all activities as planned, and achieved the goal of establishing demonstrations and models for the integrated management of forest ecosystems and sustainable forest management in the upper reaches of the Greater Mekong Subregion through designing and implementing the project of Integrated Forest Ecosystem Management Planning and Demonstration Project in GMS (Pu'er Project Site, P.R.China), optimal integrated sustainable forest management models will be set up in the upper reach region of GMS, so as to improve quality of the forest ecosystem and optimize its integrated ecological, economic and social functions.. Specifically include:

(1) Developed 3 texts: "Master Plan of Integrated Forest Ecosystem Management of WFF, Pu'er Prefecture (2017－2036)" "Forest Management Action Plan of WFF, Pu'er Prefecture (2017－2026) ""Multi-functional Forest Management Plan for WFF's Sustainable Development"

The 3 texts are important achievements of the project, which will be carried out to guild implementation of sustainable forest management of WFF in following 20 year to reach objectives of forest resources well protected and continuously increased; the forest quality, productivity and income of the staff significantly improved through measures of appropriate forest plantation, tending, forest stands improvement, infrastructure construction, multifunctional forest management, forest ecological system conservation and protection, landscape construction, sustainable forest resource utilization, industry development of non-timber forest products, cultivation of timber forest, institution and personal capacity building, and public environmental awareness building. Based on optimal simulation result from Forest Simulation Optimization System (FSOS), the best forest management practices are suggested that under 12,701m3 annual timber harvest rate, 9.63 million RMB can be achieved with

annual increasing rate of 9.1T/a of carbon storage.

However, the recommended management measure in the "Master Plan", "Action Plan" and the "Multi-functional Forest Management Plan" does not match well with the current forest management regulation, relative high thinning intensity and cultivation activity in ecological forest for example, which brings quite some difficulty to fully carry out the planned activities into practices. The plans are still on paper. It may takes some time before the management of the WFF could follow the plans and optimal simulation results. Fortunately, we are happy to see that the awareness and consciousness on sustainable and effective forest management of the WFF's leader have been enhanced significantly after implementation of the project. We believe in near future, the three "management plan" will become guidelines of management action of WFF.

(2) Established a forest tending demonstration for young-middle aged *Pinus kesiya* and *Betula alnoides* forest stand, with a total area of 120ha

During the implementation of the project, it's found that:

1) All thinning intensity have significant influence on single trees growth. Generally, higher intensity bring higher increment on individual tree's volume, because thinning measure improved growth conditions and promoted growth of trees. However, only lower thinning intensity has positive impact on increment of stand volume while higher thinning intensity has negative impact within 5 years project implementation.　So, lower intensity and high frequency thinning (4-6 years per time) is suggested to promote canopy and diameter growth gradually, and then to ensure both stand and individual volume increased simultaneously all through forest cultivation circle.

2) Different from commercial forest, the management purpose of the artificial ecological forest is mainly focus on ecological services, including bio-diversity, multilayered structure, water conservation, erosion control, soil fertility. Therefore, higher intensity thinning practice is suggested in ecological forest to ensure more light obtained by forest undergrowth, to promote better performance of the regenerated native flora, fauna, and micro-organisms under canopy.

3) "Large Dimension Target Tree Management" has obvious positive effect on diameter growth and performances of the young-middle aged *P. kesiya* and *B. alnoides* artificial forest stand in southwest China. Individual volume increment under ordinary tending measures and mechanical thinning has only one-third of it in target tree management. This is because there are several advantages for target tree management: a) only 1-2 competition trees need to be cut off beside target trees each time which lead to less cost for thinning and more useful trees; b) precise maintenance efforts such as weeding, fertilization, pruning paid only to target trees, while attention have to be given to all remained trees for other traditional tending management; c) target tree management measure has less disturbance to forest environment and promote forest self-development.

4) Precise fertilization method is an innovative technology on soil control. compare with conventional fertilization method, this technology is not just concern about soil fertility (N, P, K contents in soil) but also take nutrient element's content (N, P, K) in plant body into account. Meanwhile, biomass and nutrients element content differences between dominant and average tree is analyzed. Based on all these results, this precise fertilization model is formulate to calculate amount of N, P, K fertilizer combination. The model can be used to calculate the demand of N, P and K under different target yield.

5) Enrichment planting showed a considerable result in increasing species diversity, stability, ecological function and timber productivity of the plantation by the applied management measures of thinning, cluster planting of native valuable broadleaved trees, promoting of regenerated target tree species. However, some key points for enrichment planting are that appropriate tree species selection (to tolerant shade condition under canopy), timely maintenance on planted and regenerated target trees (to avoid cutthroat competition with weeds and vines), and density control of upper layer trees (to ensure necessary sunlight for target young growth).

(3) Constructed an efficient resin production demonstration plot with a total area of 30ha, and developed an effective resin collection technical manual

Efficient rosin production technology is essential measure for sustainable rosin

industry development in the region to overcome contradictions between short-term income and forest health in the long run. The project solve this problem from two aspects: a) Developing rosin oriented cultivation techniques which integrated fertilization and density control to promote the performance of pine trees in good condition; b) developing "less impact rosin collection technique (LIRC)" to minimize damage to pine trees while to have a certain amount of rosin production. This LIRC technique contains advanced tapping knife, appropriate collection frequency (e.g 3 days/rossing), and optimum collection intensity (40 % of perimeter per rossing).

(4) Established a demonstration of integrated secondary forest management, with a total area of 50ha

Natural secondary forest in the project are is pine dominated mixed coniferous forest developed from degraded forest mainly by human disturbance. This secondary forest belongs to ecological forest with the main function of ecological services, e.g. biodiversity, erosion control, recreation etc. The project aims to accelerate succession process of secondary forest towards zonal climax community (monsoon evergreen broadleaved forest) by convert coniferous forest into broad leaved forest through felling certain amount of *Pinus kesiya* and enrichment planting of broad leave trees in windows formed after logging in forest. The preliminarily results of the project shows that forest structure significantly changed from coniferous forest into broadleaved forest; the structure of forest community can be shifted in short period by change species composition; number of tree species and number of individual trees increased slightly after 4 years of pine tree removed from community indicated cutting of upper layer pine trees promote development of broad-leaved trees.

(5) Established a precious plant resources collection garden of south-subtropical region, with a total area of 5ha

Forest germplasm resources especially precious plant species have high risk of extinction due to high social and economic value, and ecological importance, e.g. timber, horticulture, research, gardening, biodiversity conservation etc. These plant

species are also considered strategic resources for socioeconomic development. In order to mitigate the decline of precious plant resources, a plenty of efforts have been paid from legislation to village regulation, from research to plantation. However, the effect of these efforts still limited. Construction of precious plant resources collection garden can serve as shelter for valuable forest genetic resource, propagation and more endemic and endangered plant resources. Through the implementation of this project, more than 100 precious plant resources have been collected that can be used for future scientific research on propagation, cultivation, ex-situ conservation, population reintroduction, and utilization. Meanwhile, the established garden will most likely to be new attraction in Wanzhangshan Forest Farm (WFF) for forest recreation, health care, tourism and environmental awareness education.

(6) Carried out 7 training workshops in various forms, 3 domestic exchanges, and 1 international exchange in Thailand and Cambodia, which has strengthened the implementation ability of the international project of the forest farm, improved the sustainable management ability and level of the forest farm, and expanded the influence of the project and effectively disseminated and promoted the results of the project.

On the whole, the above activities have achieved the expected goals set by the project, and are submitted to APFNet for evaluation.

5.2 Lessons learned and suggestions

(1) **A good project management and communication mechanism is an important guarantee for the successful implementation of the project.** The project has established a management system composed of the project steering committee, the project management office, the chief expert of the project, the project technical team and the project implementation office. Led by APFNet, each of them performs his own duties, ensuring the standardized and efficient operation of the project.

(2) **The professional technical team is an important support for the smooth implementation of the pilot demonstration project. T**he project invites YAFG and Pu'er Forestry Science Research Institute as technical support units to be responsible

for project design consultation in the application stage, and providing guidance and technical monitoring in the implementation stage. They can find problems in time and constantly put forward suggestions for improvement, which presents the well design and excellent demonstration of the project.

(3) **Strictly classify two types of forests, and further strengthen the tending and management of *Pinus kesiya* pure plantation.** For the *Pinus kesiya* pure plantation with large area in WFF, different forest management measures should be taken according to different forest types of non-commercial forest and commercial forest to highlight its ecological or economic functions. The non-commercial forest should take the maximization of ecological function as the starting point, through measures such as high intensive tending and thinning, directional cultivation or replanting of broad-leaved trees with certain ecological or economic value, to create needle and broad-leaved mixed different aged multi-layer forest, accelerate its succession to monsoon evergreen broad-leaved forest, further increase species diversity, and give full play to its ecological function; Commercial forests should be guided by market demand, through intensive management, with the goal of obtaining the maximum economic benefits, scientifically define the cultivation direction, and adopt target tree management method or reasonable tending and management measures to effectively improve the yield of forest properties and promote the economic development of forest areas.

(4) **Remarkable achievements have been made in collection of precious plant of south-subtropical region.** According to the project plan, from 2017 to 2019, WFF collected and planted more than 100 species of subtropical precious tree species in the Pu'er base of APFNet in the Pu'er Botanical Garden, such as *Manglietiastrum sinicum , Nyssa yunnanensis, Erythrophleum fordii , Mesua ferrea,* and *Pterospermum kingtungense*, and made signboards with the APFNet logo and QR code for tree species identification. The collected tree species include national key protected wild plants, precious timber tree species, rare and endangered tree species, rare and small population tree species, medicinal plants, spices, forest vegetables, etc. Now most of the tree species are growing well. This ensures the safety of the species to a certain extent and avoids the complete extinction of the species under environmental stress; In addition, through collection and preservation, a germplasm resource bank has been formed, which provides experimental materials for biological research and popular science education, especially for the activities related to the Pu'er base of APFNet, and

effectively promotes biodiversity conservation and the sustainable development of forestry.

(5) **The establishment of fixed sample plots provides data support for the project's activities.** Through five years of project implementation, the fixed sample plot of demonstration forest has established a fixed plant monitoring network. At the end of each year, the fixed sample plants in the sample plot are monitored for tree height, DBH, volume and crown width, forming a relatively complete monitoring database. Through the analysis and comparison of monitoring data, a strong scientific basis is provided for the decision making of project and the WFF.

(6) **The resin collection needs to be further standardized.** The project collected a large number of observation data on the yield and quality of resin and forest growth through the comparison of different thinning intensities, harvesting intensities, harvesting methods and different DBH. Based on the analysis of the survey data of the project, combined with the inquiry of historical documents, this project summarizes the resin collection technology of *Pinus kesiya*, and completes the compilation of the technical guide for resin collection of *Pinus kesiya* in Yunnan Province. The implementation of the project has laid a foundation for applying for the local standard of Yunnan Province, "Technical Manual on Construction of Efficient Resin Production Plantation & Effective Resin Collection". However, the data needs to be supplemented, and the first draft still needs to be modified and improved before it can be used for review and approval. Only after passing the review and obtaining the approval can we really use it to guide the practical operation, so as to further standardize the resin collection activities of *Pinus kesiya*.

(7) **The effect of selective cutting and tending dominated by improving the ecological function of secondary forests is not significant.** According to the project design, in 2017, WFF carried out selective cutting and tending of 45ha secondary forest, and replanted the forest gap with a single area of more than 5m^2 formed after selective cutting. At present, from the analysis of field and monitoring data, the project has not achieved the desired effect. The reason is that on the one hand, it is difficult to replant understory, and in addition, Pu'er has been encountered with drought for three consecutive years in 2018, 2019 and 2020, resulting in a serious decline in the survival rate of replanted species; On the other hand, because the project has only been done for 4 years, it still presents no effect in the short term.

(8) **The continuity and long-term nature of the project implementation.** In

the past five years since the implementation of the project, we have adhered to scientific planning and efficient implementation. Through implementation, WFF's capacity building of international project implementation has been enhanced, and the level of forest sustainable management has been improved as well. To a certain extent, we have summarized and refined a number of advanced technologies and successful experiences for the sustainable development of forestry, and established a demonstration and model for the integrated management of forest ecosystems and sustainable forest management in the Greater Mekong sub-region. A "Pu'er plan" or "Yunnan plan" even "China plan" has been provided for the construction of regional ecological civilization. However, due to the long construction cycle of forestry projects, the short-term project activities can not fully display their results. Therefore, it is suggested that after the completion of project phase I, there should be phase II, phase III... Or even longer term in terms of project design and funding.

Annex

A   Project progress sheet

B   Project funding and expenditure

C   Technical report

D   Equipment procurement

E   Technical manual for Efficient Resin Production Plantation & Effective Resin
    Collection

F   Master Plan of Integrated Forest Ecosystem Management of WFF, Pu'er
    Prefecture (2017－2036)

G   Forest Management Action Plan of WFF, Pu'er Prefecture (2017－2026)

H Multi-functional Forest Management Plan for WFF's Sustainable Development

I   Photos

Annex A   Project progress sheet

Outputs/Activities	Projected Completion Date	Actual Completion Date	Delivery rate %
Output 1 "Multi-functional Forest Management Plan for WFF's Sustainable Development"			
Activity 1.1 Develop "Master Plan of Integrated Forest Ecosystem Management of WFF, Pu'er Prefecture (2017-2036)"	Jan.-Dec.2017	Sept. 2018	100%
Activity 1.2 "Forest Management Action Plan of WFF, Pu'er Prefecture (2017-2026)"	Jan.-Dec.2017	Sept. 2018	100%
Activity 1.3 Develop "Multi-functional Forest Management Plan for WFF's Sustainable Development" (New in 2019)	Jan.2020 -Dec. 2020	Jan.2020	100%
Output 2 Establishment of forest tending demonstration for young-middle aged *Pinus kesiya* and *Betula alnoides* forest stand			
Activity 2.1 Establish a tending demonstration base of middle aged *P. kesiya* non-commercial forest, with an area of 40ha	Jan.2021 -Dec. 2021	Jan.2021-Dec. 2021	100%
Activity 2.2 Establish a tending demonstration base of young *P. kesiya* commercial forest, with an area of 40ha	Jan.2021 -Dec. 2021	Jan.2021-Dec. 2021	100%
Activity 2.3 Establish a tending demonstration base of *B. alnoides* commercial forest, with an area of 40ha	Jan.2021 -Dec. 2021	Jan.2021-Dec. 2021	100%
Activity 2.4 *Pinus kesiya* demonstration forest improvement and upgrading (New in 2018)	Jan.-Dec. 2021	Jan.2021-Dec. 2021	100%
Activity 2.5 *B. alnoides* demonstration forest improvement and upgrading (New in 2018)	Jan.-Dec. 2021	Jan.2021-Dec. 2021	100%
Activity 2.6 Large diameter class target trees management for *P. kesiya* (New in 2019)	Jan.2021-Dec.2021	Jan.2021-Dec. 2021	100%

Activity 2.7 Large diameter class target trees management for *B. anoides* (New in 2019)	Jan.2021-Dec.2021	Jan.2021-Dec. 2021	100%
Output 3 Construction of efficient resin production demonstration plot and development of effective resin collection technical manual			
Activity 3.1 Establish a resin production demonstration plot with an area of 30 ha	Jan.2021 -Dec. 2021	Jan.2021 -Dec. 2021	100%
Activity 3.2 Develop an effective resin collection technical manual	Jan.2021 – June 2021	August 2021	100%
Output 4 Demonstration establishment of integrated secondary forest management			100%
Activity 4.1 Selective thinning to improve ecological function of the secondary forest	Jan.2021 -Dec. 2021	Jan.2021 -Dec. 2021	100%
Activity 4.2 Demonstration of understory planting	Jan.2021 -Dec. 2021	Jan.2021 -Dec. 2021	100%
Output 5 Construction of precious plant collection garden of south-subtropical region			
Activity 5.1 South subtropical precious plant collection	Jan.2019 -Dec. 2019	Jan.2019 -Dec. 2019	100%
Activity 5.2 Tree labels	Oct.2019 -Dec. 2019	Oct.2019 -Dec. 2019	100%
Output 6 Capability Building			
Activity 6.1 Technical trainings	Dec. 2020	Dec 2020	100%
Activity 6.2 Domestic Study and Exchange	Dec. 2020	Dec 2020	100%
Activity 6.3 Domestic Study and Exchange	Dec. 2019	Dec. 2019	100%