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Review on Sustainable Forest Management and Financing in China

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TABLE OF CONTENTS

ACKNOWLEDGEMENT	2
EXECUTIVE SUMMARY	3
I. BACKGROUND	10
A. Review Objective: Knowledge Sharing on Sustainable Forest Management	10
B. Forestry’s Role in Safeguarding Terrestrial Ecosystem Stability	11
C. Forest Resources Management and Challenges in China	12
II. REVIEW APPROACH AND METHODOLOGIES	15
III. CASE STUDIES ON SUSTAINABLE FOREST MANAGEMENT	15
A. World Bank-Financed Forestry Projects	16
B. Sino-German Forestry Projects	30
C. China Government-Financed Forestry Programs	37
D. Research Program	42
IV. CONTRIBUTION OF SUSTAINABLE FOREST MANAGEMENT TO NDC	43
V. FORESTRY FINANCING REVIEW	45
A. Government Financing Policies on Forest Management	45
B. Evaluation of Forest Carbon Financing	47
C. Forestry Credit Policies	51
D. Forestry Public-Private Partnership (PPP) Financing	54
E. Issues Concerning Forestry Financing	55
VI. LESSONS LEARNED AND POLICY RECOMMENDATIONS	56
A. Adopt Close-to-Nature Forest Management Regimes	56
B. Improve the System of Forest Classification	58
C. Amend Harvesting and Quota-Based Prescriptions and Relax the Logging Ban	59
D. Draw Social and Environmental Considerations into Forest Management	59
E. Diversify Funding Sources and Recalibrate Subsidy Policy	61

Box 1. Lishui County Experience and Approaches Promoting Compensation Usufruct Pledge Loans for Ecological Forests.....	52
Figure 1. SEAP Water Storage and Soil Loss Reduction of Afforestation Models	24
Figure 2.HFRDP Pest Occurrence Rate of Forest Restoration and Rehabilitation Model	25
Figure 3. SEAP Carbon Sequestration of Afforestation Model	26
Figure 4. The Evaluation Index System of Forest Status	35
Table 1. IFDP Benefits of Farmland Protection Shelterbelts	27
Table 2. Economic and Financial Analysis by Project	27
Table 3. Subsidies for the Forestry Reform and Development Programs.....	46
Table 4. Summary of Types of Forest Carbon Transactions, 2009–2016*	48
Table 5. Loans Issued by CBD and CADB, 2016–2018	53
Table 6. Loan Model Guangxi National Timber Reserve Forest Development Project	54

ABBREVIATIONS

CADB	China Agricultural Development Bank
CCB	Climate, Community and Biodiversity
CCERs	China Certified Emission Reductions
CDB	China Development Bank
CDM	Clean Development Mechanism
CERs	Certified Emissions Reduction Certificates
CO ₂	carbon dioxide
CO ₂ e	carbon dioxide equivalent
COP3	The Third Conference of the Parties
EIRR	economic internal rate of return
ERR	economic rate of return
FIRR	financial internal rate of return
FRML	Forest Rights Mortgage Loan
GEF	Global Environment Facility
GIZ	German Corporation for International Cooperation
GoC	Government of China
ha	hectare
HFRDP	Hunan Forest Restoration and Development Project
ICR	Implementation Completion and Results Report
IFDP	Integrated Forestry Development Project
KfW	Kreditanstalt Fur Wiederaufbau
m ³	cubic meter
NDCs	Nationally Determined Contributions
NPV	net present value
O ₂	oxygen
PDO	Project Development Objective
PES	payments for environmental services
PPP	public-private partnership
RMB	renminbi
SEAP	Shandong Ecological Afforestation Project
SFA	State Forestry Administration
SFM	sustainable forest management
SPV	special purpose vehicle
tCO ₂ e	tons carbon dioxide equivalent
UNFCCC	United Nations Framework Convention on Climate Change

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Executive Summary

The purpose of this report is to review and disseminate lessons learned from domestically financed forestry programs in China and from those programs financed by international organizations, and to recommend best practices on sustainable forest management. Projects covered by the review include those supported by the World Bank (the Bank), the German Corporation for International Cooperation (GIZ), Kreditanstalt Fur Wiederaufbau (KfW), and those financed by the Government of China. In addition to conclusions on the most promising models for sustainable forest management (SFM), the review presents an overview of the main sources of financing for SFM and recommendations on what needs to be done to strengthen financial support for SFM.

Forests play a key role in the conservation and protection of a wide range of ecosystems, including water courses, watersheds, wetlands, drylands, and deserts. They also serve important functions in conserving on-farm ecosystems, grasslands, and urban environments. Such is the importance of global forest ecosystems that they are often called the “the lungs of the Earth,” the “kidneys of the Earth,” or the “immune system of the Earth.” They are also regarded as pivotal in stabilizing terrestrial ecosystems by balancing and offsetting changes in global dynamics that adversely affect terrestrial ecosystems, such as the sequestration of carbon dioxide.

Considerable progress has been made in the improvement of the sustainable management of forests in China, its forests still suffer from poor forest quality and reduced ecological functions; large areas of low productivity and degraded monoculture plantations; and overdependence on government sources of financing, which are insufficient to meet SFM needs.

Over the past 20 years, China has made significant changes to its forest policy by moving away from the expansion of timber plantations for industrial use toward the promotion of ecological forestry for environmental conservation and social development. To help the Government of China make this transition, both the Bank and the German government have provided assistance to the incorporation of good practice in the use of mixed-species ecological forests and close-to-nature forest management regimes, which aim at improving forest resilience and productivity with enhanced forest structure. Technological support has also been provided to the forest management in both natural forests and plantations, which have achieved positive results.

At the Conference of Parties of the United Nations Framework Convention on Climate Change (UNFCCC) meeting in Paris in 2015, China committed to reducing its carbon emissions and to increasing its carbon storage stocks through Nationally Determined Contributions (NDCs). Part of this commitment includes increasing its forest stock volume by around 4.5 billion cubic meters by 2030 (over 2005 levels), by increasing forest cover and improving forest quality, the underlying aim being to increase forestland capacity for carbon sequestration and minimize climate change risks.

To improve forestry’s contribution to the achievement of its NDC targets and to facilitate the move from monoculture plantation forests to more sustainable mixed species, close-to-nature forest management, the National Forestry and Grassland Administration (the former State

Forestry Administration-SFA) of China requested the Bank to review the effectiveness of internationally and domestically supported SFM projects for recommending best practices on SFM, which will contribute to the climate change mitigation and adaptation. The exercise is also intended to include a review of financing mechanisms needed to support SFM.

The review found that compared with traditional practice, the forest growth and carbon sequestration levels are higher in mixed-species plantations and close-to-nature managed natural forests, and that they also produce a wider range of environmental benefits. Large afforestation and forest management programs underway in China, with the total plantation forests increased by around 79.54 million hectares by 2018, are mainly of monoculture plantations. The findings of the review and of experimental research suggest that potentially higher productivity could be achieved, and stable forest ecosystem could be rehabilitated with developing mixed plantations of native species combined with forest management and natural generation promotion. Such strategies would yield Co-Benefits in terms of active biodiversity management and higher levels of stability of productivity and ecosystem services, particularly under adverse conditions such as pathogen infestation or future climate change, including extreme events.

The review also found that SFM programs are largely dependent on government funding. To reduce the risks faced by SFM programs, should the availability of such funds be reduced, additional sources of funding must be explored. Expanding successful piloted forestry loan schemes, modifying others, and implementing policy and institutional structures to facilitate lending for multifunction, ecologically focused projects would help reduce this risk and boost the prospects for their sustainability, including that of carbon sequestration activities.

Combining the values of benefits from carbon sequestration with those from public goods such as ecosystem restoration (the multifunction forest management approach) could greatly strengthen the viability of SFM. This viability could also be strengthened by developing lending instruments that better address the needs of multifunctional, ecologically focused forestry projects, expanding trade in market-based, forest-related environmental services, and promoting the use of market-based payments for environmental services.

The key lessons learned from the review and actions recommended to improve SFM are as follows.

1. Adopting Close-to-Nature Forest Management Regimes. Experience suggests that SFM and the contribution it makes to carbon sequestration can be best realized through the adoption of forestry policies and management regimes aimed at creating mixed-species, ecologically resilient, high-quality, and multifunction forests. This “close-to-nature” approach requires that the creation and management of forests be based on the natural growth cycles of the forests, sustainability, cost-effectiveness, and the production of a wide range of goods and services. It also involves planting and management of mixed-species stands, and maintenance of biologically stable tree species’ spatial arrangements and structures, which jointly create resilient, healthy forest ecosystems. To achieve this objective, the following design principles need to be observed:

- (a) **Protecting site productivity potential by taking account of natural conditions.** The Bank-financed forestry projects and Sino-German programs have demonstrated good practice in this regard by modifying site preparation methods, including the use of planting pits instead of complete ploughing to minimize the disturbance of natural vegetation, and the use of low-density planting to encourage natural regeneration. These practices have been instrumental in reducing costs, improving the diversity of tree species, and strengthening the stability of the forest ecosystem.
- (b) **Matching tree species to site potential, with site potential providing the basis for species selection and forest management.** The Bank-supported programs followed best practice in this respect by better matching site conditions, species selection, and silvicultural management prescriptions. Native tree species with high ecological adaptability always be prioritized for close-to-nature forestation, with the aim of taking full advantage of their capacity to improve biodiversity, conserve soil nutrients, and withstand natural disasters.
- (c) **Using a mixture of species for afforestation and adopting long-term forest management practice.** Mixed species is fundamental to maintaining forest ecological balance. Both the Bank and German Government financed projects are promoting forest ecosystem improvement with the use of mixed species such as a mixture of conifers, broadleaves, shrubs, herbs, and so on, and long-term forest management, thereby creating a highly productive and diverse forest structure, with broadleaf trees serving to build up ground litter, humus, and soil fertility, to yield both ecological and economic benefits.
- (d) **Creating a multistory forest.** The formation of a multistory forest can be achieved by maintaining the indigenous natural vegetation; creating a random distribution of tree species; and tending, thinning and selective cutting of final crop trees. The resulting multistory, uneven-aged forest is more resistant to extreme weather events and will provide better protective and ecological functions.
- (e) **Applying forest selective cutting.** Where the overriding objective is ecological protection, continuous forest cover should be practiced to avoid exposing the soil to erosion and degradation. To achieve continuous forest cover, selective cutting must be used, and large-scale clear-cutting should be prohibited to avoid the risk of irreparably disturbing biodiversity and disturbing the delicate nutrient and hydrological cycles that exist in forestland. The is operation should be an integral to the creation of multistory, uneven-aged forests for sustainable ecological benefits and forest products.

2. **Adjustments to the System of Forest Classification.** The China Forest Law of 1998 divides forests into two categories—ecological forests and commercial forests—according to their ecological and economic needs. Ecological forests are subject to complete protection, while commercial forests comprise intensively managed monocultures for timber production. The United Nations Millennium Ecosystem Assessment Report divides the dominant functions of forests into the following four categories: forest products supply, ecological protection and regulation, ecocultural services, and ecosystem support. Following the international and

domestic best practice, the National Forestry and Grassland Administration (NFGA) promulgated the National Forest Management Plan (2016–2050) in which it proposes the use of three major categories: (a) strictly protected ecological forests, for example, those located in ecologically important and fragile areas needing total protection; (b) multifunction forests, for example, forests with the potential to play an important role in ecological protection, carbon trading, and the production of non-timber forest products and services; and (c) intensively managed commercial forests for industrial uses. The plan also clarified the meaning of multifunction forest management strategies.

The lessons learned from the review strongly support these forest classification adjustments. It is important that the above system of forest classification be adopted to help prioritize the use of government funding, promoting long-term forest management and multiple uses of the forest resources to balance public good services and local community livelihood development. Forest management regimes applicable in each category will be dependent on the forest's dominant functions, and subsidy payments in each area could be based on their capacity in providing ecological services and public goods, and the values of the services provided.

3. Amending Harvest and Quota-Based Prescriptions and Relaxing the Logging Ban.

Based on the proposed new system of forest reclassification, changes should be made to harvesting policy. In ecological forests, final harvest/logging is forbidden, though thinning is permitted as a forest management intervention. However, to manage multifunction forests where the primary focus is the provision of ecological services and non-timber forest products, interventions are necessary to improve forest quality and satisfy the basic requirements of local people. The thinning and harvesting, therefore, should be based on the prescriptions of an approved forest management plan for the area. Such interventions are essential for promoting the long-term health and vigor of forest stands. The existing technical regulations governing forest harvesting should also be revised to favor natural regeneration and replace clearcutting with the selective cutting of individual trees. Such revisions would be highly supportive of the multifunction forest management concept; the development of healthy, stable, and resilient forest ecosystems; and the move toward creating permanent forest cover for ecological services.

4. Incorporating Social and Environmental Considerations into Forest Management

Incorporating social and environmental considerations into forest management will promote the sustainability. The lessons learned are specified as the following:

- (a) Institutionalizing Public Participation and Raising Public Awareness.** Participatory forest management planning was introduced in China through forestry projects funded by the Bank and the German government. Consultation and interviews with village collectives and farmers who hold forestland use rights strengthens links between forest management and rural development. In addition, experience has shown that reflecting the wishes and aspirations of communities and farmers in forest planning, design, and implementation can encourage much greater voluntary participation in project activities. This, in turn, enhances the ecological, social, and economic impacts of the projects.

Participatory forest management planning and public awareness campaigns must be carefully designed to ensure that they serve the purpose of improving community understanding of the rationale and objectives of a project, the role that stakeholders can play in the achievement of the objectives, and the types of project benefits that participants are likely to enjoy. Essential to the task of successfully involving farmers and communities is the formulation of a participatory village-level forest management plan. This will help create a cooperative partnership between government authorities and stakeholders, heighten the sense of ownership of the project participants, and reinforce transparency and confidence in project objectives and management. It will also help ensure the equitable distribution of project benefits and enhance prospects for project sustainability.

(b) Improving Environmental Awareness and Applying Safeguards. Raising public awareness of environmental issues is essential to mitigating environmental risks in forestry projects, and it is important that project agencies recognize this. Forestry professionals in China, as in many other countries, often assume that the impact of afforestation is environmentally positive and not negative. It is also often assumed that environmental assessments are not necessary for afforestation projects. However, large-scale forestry activities can have adverse environmental impacts if the correct technical and managerial regulatory safeguards are not applied and complied with. In Bank-supported forestry projects, strict safeguard measures are applied to minimize their possible negative impacts by having an environmental assessment carried out during project preparation and by having the appropriate environmental protection measures incorporated into project designs, with relevant mitigation measures introduced. This has helped ensure that adequate protection measures are in place to prevent soil erosion, water pollution, biodiversity loss, and pest or fire outbreaks. This approach should be applied to all projects.

5. Diversifying Funding Sources and Recalibrating Subsidies. At present, expenditure on ecological forestry is heavily dependent on flat-rate, area-based payments from government budgets, and the demand for such funding far outstrips supply. The heavy dependence of SFM ecological forestry programs on state sources of funding makes them vulnerable to cuts in times of budgetary restraint. The review reveals that the actual costs incurred under the various mixed ecological forest management models are higher than the subsidies on offer. This, combined with the low financial rates of return from ecological forests, deters social participation in SFM with ecological objectives. Therefore, additional funding and increased payments are needed for financing ecologically focused SFM.

To address the above issues, the following is recommended:

(a) Optimize the Use of Government Subsidies and Incentives. Given the present focus on ecological forests and the limited financial resources available from the central government, it appears logical for the government to focus incentive payments for ecological forest development in key areas. In addition, the existing flat-rate system of government incentive payments should be replaced by a system of payments that reflects the actual costs of ecological afforestation and forest management. For example, in

critical areas where the protection and provision of public goods or services are essential, and in areas where the creation and management of multifunction forests can yield both ecological services and economic benefits, the rate of subsidy payments should be calibrated to reflect the value of the ecological services being provided. In the case of fast-growing commercial forests that show good financial returns but have little or no public service value, incentive payments should be phased out and their development left to market forces under the regulatory framework of government agencies.

- (b) Promote Forestry Carbon Offset Trading.** As an integrated part of Payments for Ecological Services (PES), Forest carbon trading is an important potential source of financing to promote afforestation/reforestation and forest management activities in China. The international and domestic carbon markets are experiencing rapid development, and it is imperative to learn from the successful practices of international forest carbon trading to promote forest carbon projects in China that enable enterprises to offset their emission quotas. There are around 90 million hectares of land in China suitable for multifunction forest management. If only 50 percent of this land met the additionality criteria needed for carbon sequestration and were planted with mixed-species, multifunction stands yielding an additional 2 cubic meters per hectare per year over the baseline value, (a very modest estimate for managed stands), then, using a conversion rate of 1.83 tons of carbon per cubic meter of growth, around 165 million tons of carbon could be sequestered each year when the area is fully planted.

The lessons learned from forest carbon trading under the Clean Development Mechanism (CDM) and the China Certified Emission Reductions credit (CCERs) scheme in China highlight that the time and costs needed to design, implement, and verify forest carbon projects are excessive and constrain the potential of forest carbon trading. To enhance the forest carbon trading process, the following actions are suggested:

- Promote forest carbon trading mechanisms to serve as offsets in the domestic voluntary action;
- Prioritize forest carbon sequestration as an integral part of multifunction forest management and landscape management;
- Simplify technical requirements, methodologies, and procedures for implementation, monitoring, and verification of forest carbon trading projects;
- Develop policies that encourage enterprises to purchase forest carbon offsets associated with forest management;
- Strengthen institutional capacity to enable local communities and farmers participating in forest carbon trading.

- (c) Expanding Innovative Financing Models.** Multifunction forests can produce a wide range of products and services on a sustainable basis. They can also generate income for forest owners, but funding gaps are likely to persist between revenue and expenditure. To help bridge this gap, government support is needed to finance multifunction forest projects to attract social capital. Other instruments can also be used, such as Forestry

Policy Loans and public-private partnerships, as well as mobilizing credit financing through the pledging of usufruct and compensation payments for ecological forests. More details are the following:

- *Forestry Policy Loans* are preferential policy loans provided by national development banks, including the China Development Bank (CDB) and the China Agricultural Development Bank (CADB). These are currently targeted at large-scale forestry projects, such as national park projects, forestry industry projects, and commercial afforestation and forest quality improvement programs. The CDB and CADB provide preferential loans with lower interest rates and longer maturity periods, and the government subsidy certain part of interests of commercial loans. Since 2015, several provinces have launched the projects which are financed with Forestry Policy Loan, however, the CDB and CADB only provide Forestry Policy Loans to large-scale forestry enterprises. To allow a broader range of forest entities, in particular the small-scale forest entities and communities, accessing these preferential policy loans for afforestation and forest management projects, the conditions for applying for these loans need to be amended or be made more flexible.
- *Public-Private Partnership (PPP) Financing Models*. Under PPP-financed forestry projects, a special purpose vehicle (SPV) is responsible for financing forestry operations using social capital. The SPV may use its own assets, equity and earnings under the PPP contract as security or as a pledge against a mortgage or bank loan, and takes responsibility for project implementation and management. The government provides “viability gap funding” through annual financial budgeting in accordance with government obligations under the PPP contract.
- *Loans with usufruct and compensation payments* for ecological forests as security or as a pledge is an innovative loan provided by a financial institution against the pledge of usufruct and compensation payments for ecological forestry services legally owned by the borrower over the long term. The pilot program appears to be successful and can be applied to both large-scale and small-scale forestry operations.

(d) Improving Support Policies on Forestry Investment. Forestry investment differs from most other business investments in that it is for long-term management, with the majority of afforestation costs are incurred in the first three years, and most benefits are realized after about 20-30 years, and the forest management risks are relative higher because of the threats of nature disasters such as fire and insect attack. These factors can be somewhat offset by the development of insurance mechanisms, such as developing forestry credit guarantee schemes to facilitate forestry financing guarantee service; enhancing financial risk management; improving forest resources quality verification system and building-up institutional capacity to carry out forest resources

asset assessment; and optimizing forest harvesting management system by using forest management plan as the basis of making harvest arrangements.

I. Background

A. Review Objective: Knowledge Sharing on Sustainable Forest Management

1. The objective of the study is to improve knowledge on sustainable forest management (SFM) which contribute to the achievement of China's Nationally Determined Contributions (NDCs). The study aims at identifying the path towards establishing sustainable forest management schemes including the recommendations to government on technical models, long-term financing opportunities and mechanisms, strategies and policies for forest resource management in China. Through the provision of case study data, relevant agency decision makers may become aware of the unrealized potential of forestry, the obstacles that constrain the realization of that potential, and the funding options available to help optimize that potential.

2. Forests figure prominently in the 2015 Conference of Parties of the United Nations Framework Convention on Climate Change (UNFCCC) Paris Agreement and in the NDCs of various countries, including China. As an expression of its commitment to addressing the challenges posed by climate change, the Government of China (GoC) formulated the National Program for Addressing Climate Change in 2007, which identified forest management as a priority activity to mitigate climate change. Consequently, the NFGA issued its Forestry Action Plan for Addressing Climate Change in 2009. China's NDCs prescribe an increase in forest stock volume by around 4.5 billion cubic meters by 2030 (over 2005 levels), together with combatting climate change through enhancing mechanisms and capacities to effectively reduce climate change risks in forest management. The "key forestry actions for addressing climate change under the 13th Five-Year Plan," as prepared by the NFGA in 2016, include increasing areas under forest by 13 million hectare between 2016 and 2020, thereby increasing forest carbon sequestration, reducing forestry emissions, strengthening technological support, and improving the potential for forest carbon trading.

3. To promote SFM supportive of ecological environmental improvement and the achievement of the NDCs by 2030, the GoC has made efforts in several priority areas. These include enhancing reforestation, restoring and rehabilitating degraded forests, protecting natural forests, controlling desertification, and promoting forest carbon trading. These initiatives have been intensified to help tackle the challenges facing the forest sector, such as limited forest resources, poor forest quality, monoculture plantations with poor ecological functions, fragile forest ecosystems and those vulnerable to pests, and unsustainable government-dominated sources of forestry financing.

4. The NDC-related initiative represents an important innovation in forestry by focusing on forest quality, especially stock volume, forest structure, forest stability, and forest resilience, as opposed to increasing forest area, as happened under previous programs. However, this shift in focus requires a change in the way forests are planned, established and managed, with management placing more emphasis on the multifunction role of forests, such as soil and water conservation, the protection of biodiversity, carbon sequestration, and rural poverty alleviation.

It is hoped that the findings of this study will facilitate this change and improve forestry's contribution to the delivery of China's NDCs.

B. Forestry's Role in Safeguarding Terrestrial Ecosystem Stability

5. Forests play a key role in the conservation and protection of a wide range of ecosystems, including forests, mountains, wetlands, rivers, drylands, and deserts. They also play a significant role in conserving on-farm ecosystems, grasslands, and urban environments. Such is the importance of global forest ecosystems that they are often called the "the lungs of the Earth," the "kidneys of the Earth," and the "immune system of the Earth." They are also thought to play a pivotal role in stabilizing terrestrial ecosystems by balancing and offsetting changes in global dynamics that adversely affect terrestrial ecosystems. Maintaining healthy forest ecosystems is therefore of global interest. A few examples of the importance of forests to humanity are as follows:

- (a) **Forests act as the chief conditioner of nature by maintaining global ecological balance.** As an important component of the Earth's terrestrial ecosystem, forest ecosystems help maintain the dynamic balance between biosphere, atmosphere, hydrosphere, and pedosphere. This is done by regulating the carbon dioxide (CO₂) content of the atmosphere by sequestering enormous quantities of CO₂ from the atmosphere through photosynthesis, which helps regulate global temperatures. Forests also play an important role in hydrology. By intercepting rainfall and improving the water holding capacity of the soil, forests help regulate stream flow, purify groundwater, and reduce flooding. Ecological monitoring stations located in the four climatic zones and 54 types of forests in China also estimate that each hectare of forest can store approximately 1,000 cubic meters of precipitation.
- (b) **The role of forests in energy and substance exchange in organic and inorganic spheres.** Forests have the most complete trophic-level system of all terrestrial ecosystems; that is, the food cycle is complete from producers (green plants in the forests) to consumers (herbivores, carnivores, omnivores, parasites, and saprophytes) to decomposers (bacteria and fungi). Being vast in area, huge in trunk volume, complex in structure, and large in leaf area index due to the multistory distribution of branches and leaves, forest ecosystems are the most efficient users of light energy in natural ecosystems. In tropical rainforests, the annual average efficiency of light energy utilization can be as much as 4.5 percent, that of deciduous broadleaved forests 1.6 percent, and that of coniferous forests in northern China 1.1 percent. By comparison, grassland uses 0.6 percent and farmland 0.7 percent.

Owing to the vastness of forest ecosystems and the efficiency of photosynthesis, the productivity and biomass of forests are greater than other ecosystems. Total global biomass is estimated to be 185.6 billion tons. Forests produce 6 to 8 tons of biomass per hectare per year, totaling 166.4 billion tons per year, which represents about 90 percent of global production. By comparison, the amount of biomass produced by other ecosystems is very small; grassland ecosystems produce only 4 percent and the tundra and quasi-desert ecosystem only 1.1 percent. The amount of energy captured by the

Earth's forests each year totals 13×10^{17} kilojoules, or 63.4 percent of the total energy conserved each year (20.5×10^{17} kilojoules) by all terrestrial biospheres. Forests are therefore the largest storehouse of natural energy on the planet.

(c) **Forests function as the centrum and lever in maintaining the overall function of the global ecosystem.** At the global level, forests act as an invaluable resource bank, a regeneration reservoir, a gene bank, a carbon sequestration bank, a water storage reservoir, and an energy bank. They are a source of food, medicine, timber, and a wide range of other products and services essential to humanity. They also serve to stabilize climate, conserve biodiversity, retain water, reduce soil and wind erosion, filter pollutants, and provide habitats for wildlife. As a unique terrestrial ecosystem, forests play a significant and indispensable role in maintaining ecological stability and in safeguarding human wellbeing.

6. Regrettably, the last century has witnessed an unprecedented reduction in global forest cover. At the beginning of human history, around two-thirds of the Earth's surface was covered by forest, or around 7.6 billion hectares (ha). By the 1850s, forest cover had been reduced to 5.6 billion ha, and over the past 100 years, human-induced deforestation has accelerated greatly. By 2010, global forest cover had been reduced to 4 billion ha or only 30 percent of the land area, with around 20 million ha of forest destroyed or transferred for other use annually over the past 200 years, and 80 percent of primary forest had been destroyed, with the remaining 20 percent becoming fragmented, unevenly distributed, and degraded.

7. This rapid depletion of global forest cover has been accompanied by global temperature rises, a loss of biodiversity, species extinction, an increase in natural calamities such as extreme weather events (hurricanes, droughts, floods), and disturbed weather patterns. These events, the causes of which can be linked in part to deforestation, have serious implications for humanity and require that international action be taken to rebalance terrestrial ecosystems, especially forest ecosystems.

C. Forest Resources Management and Challenges in China

8. **Forests and their functions in China.** China's Ninth Forest Resources Inventory (2014–2018) indicates that the country has 220 million ha of forest area, with forest coverage extending to 22.96 percent and stand volume totaling 17.56 billion cubic meters (m^3), and that plantations cover 79.54 million ha, with a stand volume of 3.39 billion m^3 . As the principal terrestrial ecosystem, forests in China provide significant ecological services. Total forests Carbon sequestration is around 434 million tons of CO_2 every year, equivalent to 8 percent of total greenhouse gas emissions for the entire country over the same period. Forests also play a significant role in the hydrological cycle by intercepting rainfall, increasing groundwater storage, purifying water and thereby improving water quality, and reducing flooding and soil erosion. Each year, forests retain and store 628.9 billion m^3 of water (equivalent to more than 70 percent of the total storage capacity of the country's reservoirs), fix 8.45 billion tons of soil, and retain 462 million tons of fertilizer in runoff

9. In addition to its ecological functions, forests also make important contributions to economic growth and social wellbeing through the production of pulp, paper, mechanical wood products, rural fuelwood and poles, and a host of non-timber forest products such as traditional medicines, herbs, and food products (honey, native fruits, and nuts), many of which are highly valued by rural dwellers and ethnic minorities. The forest sector is also a significant source of employment in China. There are about 45 million forestry jobs in rural areas where job opportunities are scarce and poverty is all too common, and some 400 million farmers occupy around 100 million ha of village-owned forestland. Addressing rural poverty is a formidable challenge, but forestry offers the potential to develop a “win-win” situation through its positive impact on poverty alleviation and ecological restoration.

10. **Recent accomplishments in forest management.** China has made good progress in reversing the decline in forest cover caused by an increase in demand for timber to fuel its rapidly expanding economy. Recognizing that economic expansion had resulted in the overexploitation of forest resources, the government undertook several forestry initiatives in the 1980s, including policy reforms. This included the legal obligation to reforest logged areas, a logging ban in 1998, and forestland tenure in collective forest areas in 2009. Forestland tenure gave collectives the option to reallocate forest rights to individual households with long-term forest management rights of up to 70 years. It also gave them the right to mortgage these rights and the ability to manage and transfer forests and forestland use rights for large-scale forest management if they wished. These measures gave rural households the incentive to invest in the sustainable management of their forestland.

11. To expand forest cover, the central government has substantially increased investments in forestry, including the introduction of eco-compensation programs for ecological forests. Eco-compensation programs provide cash payments and other incentives to farmers to engage in activities such as restoring marginal lands in fragile watersheds, planting shelterbelts to protect against sandstorms, and protecting natural forests. Following the logging ban in 1998, many state and provincial forest farms shifted their focus from timber production to ecosystem restoration, the rehabilitation of critical habitats, and the conservation of biodiversity. These policy reforms and programs resulted in a doubling of forest cover from 115.3 million ha in the 1980s to the current 220 million ha, and an increase in forest conservation area from about 6 percent in 1981 to around 50 percent of total forest area of China in 2018.

12. **Challenges and the focus of future development.** China has made significant achievements in forest management in recent decades, and these achievements provide a solid foundation to improve sustainability in the sector and strengthen its potential to deliver on its NDC commitment. To promote sustainable forest management, the following challenges need to be addressed:

- (a) **Low forest cover.** By international standards, China is still a forest-deficit country. It has only 0.14 ha of forest per capita, or less than one-third the world average; the forest volume per capita is around 10.15 m³, around one-seventh the world average, and around 50 percent of its forest products need to be imported from other countries. To correct this situation, forest cover needs to be increased, forest quality must be significantly

improved, forest volume/biomass must be increased, and dependence on forest product imports should be reduced.

- (b) An overdependence on monoculture.** In recent decades, the GoC has invested heavily in plantation forests, with a total plantation cover of 79.54 million hectares. The majority of those areas are monoculture plantations, with around 80 percent of the total comprising a single species, mainly bamboo, poplar, Chinese fir, Masson pine, and eucalyptus. Unfortunately, pest incidence in many plantations (Chinese fir and Masson pine) is on the rise and this, combined with poor maintenance in the past, has lowered forest ecological function and productivity. The monoculture plantations have also suffered from snowstorms, fire, and other natural disasters. A further threat is posed by climate change, which could increase stress on trees and lower their resistance to pest infestation, fire, and other natural disasters.
- (c) Poor stand quality.** The quality of many plantations is poor, and this has reduced their ecological function and lowered their productivity and potential to sequester carbon. Poor plantation quality in China's forests has depressed overall mean annual increment to around 4.23 m³ per hectare, or 56 percent below the world average for plantations under similar growing conditions. Of 106 million ha of young and middle-aged forest, only 31 percent has achieved 50 percent of its growth potential. The carbon storage capacity in those areas is around 91.7 tons per hectare, which is far below the world average of 157.8 tons per hectare in areas of similar latitude. Research suggests that the better management of those areas could increase growth by 20 to 40 percent; it would also improve forest ecological environmental function, strengthen resilience to pest attacks and climate change, and enhance forest capacity to mitigate climate change.
- (d) Overdependence on government funding.** Most ecological forest planting and forest management activities have been funded through government subsidy. However, the level of payments is arbitrary in that they do not reflect either the value of the environmental services being generated or the cost of providing them. The absence of market-based mechanisms for environmental services is a constraint to mobilizing long-term financing for ecological forestry. It has also failed to tap the potential that exists for private sector entities to invest in ecological forests for either financial or philanthropic reasons. Addressing this shortcoming could make a valuable contribution to upgrading large tracts of poorly maintained, low-quality forest stand in China using alternative sources of financing.

13. The combined effects of low forest cover, poor forest quality, dependence on monocultures, and lack of long-term alternative financing mechanisms for ecological forests have produced large areas of plantation in China with impaired ecological function. As a result, large areas of the country suffer severe soil erosion; the siltation of rivers, lakes, and reservoirs; desertification; reduced farmland productivity due to wind desiccation; damage to infrastructure (roads, bridges, and canals); and reduced carbon sequestration. The total area subject to soil, water, and wind erosion in China is about 2.95 million square kilometers, or approximately 30.7 percent of the country's territory. This alarming exposure to erosion results in annual losses of around 5 billion tons of soil. In addition, the area threatened by desertification has reached to

1.87 million square kilometers, or around 19 percent of the country. Around 400 million people in more than 400 counties have been adversely affected by desertification. Severe sandstorms adversely affect the economy in many areas in China by burying farmland; reducing farm output; and blocking roads, railways, and canals.

II. Review Approach and Methodologies

14. To satisfy the objectives of the study, a broad range of geographic conditions have been taken into consideration to reflect the different forestry conditions in China. Given the size of the country, attention was directed to priority areas where the ecological threats were highest, locations where large areas of suitable land were available for future planting, and locations where large areas of degraded plantation required rehabilitation. Focal areas also ensure access to relevant information and data from well-structured projects and research programs whose objectives were closely aligned with those of the study.

15. This review adopted a case study approach and drew upon the data and results of seven diverse case studies. These were three World Bank-supported projects, the Shandong Ecological Afforestation Project (SEAP), the Hunan Forest Restoration and Development Project (HFRDP), and the Integrated Forestry Development Project (IFDP); two GIZ and KfW-funded forestry projects including Forest Protection and Sustainable Management in Western Area of China Project (also called the Xiaolong Mountain Project) and Ecological Afforestation in Tianshui City; and two government-funded programs, the Grain for Green Program and the National Forest Reserve Program. Work on the case studies included visits to Anhui, Gansu, Guangdong, Guangxi, Shandong, and Sichuan Provinces. Experience from these case studies was also complemented by research aimed at determining the relative advantages that mixed-species, multi-structured forest stands have over monoculture to sequester carbon and improve the ecology. Because assured sources of funding are critical to sustainable forest management, the study also reviewed ways of diversifying funding options to fund sustainable forest management for ecological protection and carbon sequestration.

16. The following tasks were undertaken during the study: (a) a literature review, including documents such as project completion and results reports, feasibility studies, technology promotion reports, policy statements, data and information available in the World Bank's archives, and academic research carried out at home and abroad; (b) semi-structured interviews with project stakeholders on project performance, the adoption of new technologies, project benefits, impacts, environmental implications, and the degree of community/beneficiary participation; and (c) questionnaire surveys to better understand the perspective of beneficiaries, their motives and willingness to participate, management challenges encountered, and resolution procedures followed.

III. Case Studies on Sustainable Forest Management

17. Since 2000, several initiatives have been launched aimed at strengthening the ecological environment and sustainability of forest resources in China. Some of these were supported by the Bank and the GIZ, while others were funded from domestic resources. The main thrust of all the projects was to pioneer the restoration of ecological conditions in degraded sites through

stand treatments (tending) and their restorative planting with a carefully balanced mixture of native tree species and shrubs. Some projects also sought to improve the ecology of native forest through structure-based and close-to-nature treatments, and to colonize infertile and saline coastal sites through mixed-species planting of trees and shrubs. These interventions produced good results and succeeded in demonstrating that the adoption of best practice in forest management can improve forest productivity, diversify forest product output, and enhance sustainability and economic viability, which can help address the challenges facing sustainable forest management in China. The interventions have also highlighted that mixed-species planting and close-to-nature forest management can improve a forest’s capacity for carbon sequestration, strengthen its contribution to sustainable landscape management by improving forest ecology and biodiversity in landscapes, and diversify and increase revenue streams.

18. With the experience and lessons learned from both internationally and domestically financed forestry programs, the GoC is now well placed to make the transition from monoculture production forests to forests for ecological restoration and climate change mitigation. In particular, the experience and lessons learned from forestry projects funded by the Bank and GIZ and from research operations financed by local resources will help foster a change in forest strategy. This change will involve switching the focus in forestry from production to improving forest quality and growth, promoting multifunction management, enhancing forest resilience, encouraging community participation, and strengthening cost-effectiveness and financial sustainability. In engineering this change, forestry’s contribution to the achievement of China’s NDC target will be much improved.

A. World Bank-Financed Forestry Projects

19. The Bank has been supporting forestry programs in China since 1985. During this period, it has funded 11 projects with credit from the International Development Association (IDA) and loans from the International Bank for Reconstruction and Development (IBRD) totaling US\$1.34 billion. These projects have succeeded in introducing new technologies and best practices, both of which have played an important part in narrowing the gap in forestry development between China and more developed countries, especially on sustainable forest management. Four of the nine projects completed to date have been rated Highly Satisfactory by the Bank, with the remaining four achieving a Satisfactory rating.

20. The positive experience of the Bank-financed ecological forestry projects in China, particularly their technical design and the technical planting model used to achieve their objectives, has made them excellent examples of best practice in sustainable forest management. They can also be used to demonstrate how multifunction forest management can contribute to the achievement of China’s NDCs. The three cases are present below.

Case 1: Shandong Ecological Afforestation Project (SEAP)—Focus on Marginal Land Restoration

Project Brief

21. The SEAP was located in eastern China and was implemented over six years (2010–2016). The Project Development Objective (PDO) was to demonstrate effective afforestation

models for environmentally degraded areas in support of Shandong's environmental afforestation programs. The PDO was to be achieved by demonstrating the viability of 13 site-specific, mixed-species planting models on degraded, marginal mountain slopes and on highly saline coastal sites. The main goals of afforesting the sites were to reduce soil erosion, control runoff, improve soil quality, and reduce the damaging effects of wind, especially in coastal areas. To address the technical difficulties and high cost of afforesting such challenging sites, the Shandong provincial government requested Bank support to develop and demonstrate technically sound and cost-effective afforestation models capable of restoring ecological stability at the sites.

22. The project comprised two components: (1) Environmental Plantation Establishment, and (2) Technical Support and Project Management. Component 1 aimed to increase tree and shrub cover of degraded sandstone and limestone areas and of saline coastal areas in the Yellow River Delta. The aims were to create a dense, multistory vegetative cover to protect and improve the ecological conditions of the project areas through mixed-species afforestation for ecological rehabilitation; promote best forest management practice; train staff and farmers in mixed-species planting; and ensure compliance with environmental and social safeguards.

23. A project Implementation Completion and Results Report (ICR) undertaken in January 2017 rated the project as Highly Satisfactory.

24. **Silvicultural Management Models.** Before designing technical planting models, a land classification exercise was conducted using parameters such as topography, geomorphology, altitude, exposure, rainfall, soil, the driving forces of site environmental change, degree of slope, position on the slope, and existing vegetative cover. A sample survey indicated that the total area of the degraded mountains in need of ecological afforestation in project areas in Shandong was around 3,8340 hectares, consisting of limestone mountain areas and sandstone mountain areas. Using analytic hierarchy process techniques, degraded mountainous land in Shandong was grouped into six site types: (a) high incidence of bare rock/sand, low coverage, very thin soil layer, lower mountain slope; (b) moderate incidence of bare rock/sand, low coverage, thin soil layer, lower mountain slope; (c) low incidence of bare rock/high-coverage sand, thin soil layer, lower mountain slope; (d) low incidence of bare rock/high-coverage sand, moderate soil layer, lower mountain slope; (e) bare rock/high-coverage sand, moderately thick soil, gently slope hilly land; and (f) low incidence of bare rock/high-coverage sand, moderately thick soil, gently sloping hilly land.

25. Field surveys were used to determine soil-type factors such as soil parent material, soil formation time, and the physical-chemical properties of the coastal saline-alkali land in the Yellow River Delta. Land in the coastal areas of the Yellow River Delta mainly comprises saline soils, fluvio-aquic soils, and salinized tidal soils, which account for more than 90 percent of the project land. In these areas, two types of vegetation predominate: wet vegetation and salt vegetation. Wet vegetation includes marsh, reed, *Tamarix chinensis*, flatgrass, and rice grass. Salt vegetation mainly includes *Tamarix chinensis*, *Suaeda glauca*, *Aeluropus sinensis*, and *Limonium sinensis*, and so on.

26. Based on the principles of “the right tree species for the right site,” “the principal tree species + associated tree species + shrubs + herbs,” and “emphasis on forest ecological services,” the above-mentioned system of site classification was used to define eight afforestation models for rocky areas: S1, ecological protection forest on limestone sites on upper mountain slopes; S2, ecological protection forest on limestone sites on middle mountain slopes; S3, ecological and cash crop protection forest on limestone sites on lower mountain slopes; S4, cash crop and ecological protection forest on limestone sites on bottom of mountain slopes; S5, protection forest on sandstone on upper mountain slopes; S6, ecological protection forest on sandstone on middle mountain slopes; S7, cash crop and ecological forest on sandstone on near-lower mountain slopes; and S8, cash crop forest on sandstone on bottom mountain slopes. For each planting model, the following silvicultural requirements were defined: management objectives, forest type, tree species, planting season, species mixture and design, seedling standard, initial planting density, land preparation methods, and planting practice. The primary goal of these models was to prevent soil erosion.

27. Similar procedures were followed in coastal saline-alkali land where five planting models were designed: C1, protection forests on sites with salt content below 2 percent and low fertility; C2, protection forests on sites with salt content below 2 percent on moderately fertile land; C3, protection forest on sites with salt content of 2 to 3 percent; C4, protection forest on sites with salt content above 3 percent; and C5, ditch and road protection. For each model, the following prescriptions were applied: the main tree species and associated tree species to be planted, species mixture and layout, seedling standards, initial planting density, land preparation methods, site preparation specifications, planting practices, and tending requirements. The primary goal of these models was soil improvement.

28. The technical models promoted and demonstrated the use of good species-site matching, the use of appropriate species mixtures, and the development of mixed-species structures on degraded mountain sites and saline coastal sites. Sixty tree species were used to afforest project sites.

29. The project established a broader participation mechanism throughout the project area. A Participatory Planning Manual (PPM) was prepared to guide the project design and implementation. The PPM requires a three-step process to secure local villages and farmers’ voluntary participation in the project: (a) dissemination of detailed information on the proposed project activities in all project villages; (b) establishment of a two-way communication process between households and county PMOs on the selection of plantation models and tree species; and (c) a process of formal application and contracting between the participating villages or households and the CPMOs for project participation.

30. During project preparation, a detailed consultation and participatory design process was carried out in all project villages and with key stakeholders to ensure that all land users would participate in the project on a voluntary and transparent basis and farmers’ and communities’ concerns are appropriately addressed.

Project Achievement

31. The SEAP succeeded in planting 66,920 ha of mixed-species, multistory plantation, 36,900 ha in degraded mountainous areas, and 30,020 ha in saline coastal areas. Owing to a well-developed system of species-site matching, survival rates of 90 percent were achieved. Carbon sequestration was included as a possible financial benefit to determine how significant these benefits were compared with other environmental services or benefits, even though these benefits were not considered critical to project rationale and the economic/financial analysis.

32. The project either achieved or exceeded all the PDO indicator targets. The project demonstrated effective afforestation models for environmentally degraded areas by (a) increasing vegetative cover in degraded mountainous and saline coastal areas, (b) increasing the number of plant species growing in project sites, (c) increasing vegetative cover in targeted watersheds, and (d) improving environmental conditions by decreasing soil erosion in mountainous areas and decreasing wind velocity in coastal areas. These indicators provide clear evidence of the demonstration models' effectiveness in improving forest and vegetative cover and other measures of environmental conditions in different types of highly degraded forestland.

33. The participation of communities and households early on in the project planning process (the bottom-up approach), and ensuring that project implementation is responsive to beneficiary needs is essential to fostering ownership and to maintaining beneficiary interest in ecological forestry projects; it is also essential to project sustainability.

34. Studies have been conducted on the project interventions on water retention, runoff, and sediment loads in river reduction, which analyze the implications of these improvements for downstream water treatment. Preliminary conclusions indicate that conifers make a more limited contribution to soil quality improvement than do broadleaf trees, and that multistory stands with good groundcover have the greatest positive impact on soil quality improvement. In addition, the project monitoring results showed that the occurrence of pest disaster in the project sites has been reduced and carbon sequestration has been increased compared with control sites, thereby demonstrating that mixed-species plantations are more resilient to pests and diseases than are traditional monocultures.

Case 2: Integrated Forestry Development Project (IFDP)—A Focus on Multifunction Forest Management

Project Brief

35. The IFDP covered the provinces of Anhui, Hebei, Liaoning, Shanxi, and Zhejiang, and its PDO was to demonstrate the establishment and management of sustainable, multifunction forest plantations in project provinces. The afforestation models developed under the project had to accommodate not only the widely differing growing conditions in the five project provinces, but also the different socioeconomic and development needs of each province. For example, Zhejiang Province is well developed, and its priority was to transform monoculture plantations around the Hangzhou Bay area into mixed stands to improve the forest ecological system rehabilitation of the surrounding landscape. In contrast, Shanxi is economically less well developed and is located on the Loess Plateau, where rural poverty and wind erosion are serious

issues, and as a result, erosion control, watershed management, and rural income generation were their main priorities.

36. To achieve the PDO, the project had three components: Component 1, which aimed at establishing new multifunction plantations in four of the five project provinces—Anhui, Hebei, Liaoning, and Shanxi—to create windbreaks and sand-fixing belts of trees on erosion-prone lands, improve soil and water conservation, and provide shelter belts for adjacent farmlands; Component 2, which aimed at improving degraded plantations in Anhui and Zhejiang, with activities that included the enrichment planting of existing degraded monoculture plantations to convert them into multifunction plantations with better resilience to pests, diseases, and climate change; and Component 3, which comprised institutional support, project management, monitoring and evaluation, and support to the forestland tenure reform process.

37. Most project sites were located in ecologically fragile and densely populated areas, and the challenge faced during project design was to address environmental issues and increase farmer income in an area where pressure on land is intense. During project formulation, an extensive information dissemination and consultation campaign was conducted in the project area, which confirmed that farmers were extremely enthusiastic about the project proposal. Thereafter, each village in the project area was systematically involved in the design of detailed project proposals. They were also invited to express their views on how the project could best improve forest ecosystems in the area and how it could best respond to local development needs. Their views were also sought on which species should be planted.

38. Twenty-seven multifunction planting models were developed to rebuild natural forest ecosystems adaptive to local natural conditions, aiming to improve and diversify vegetative cover, strengthen stand resistance to natural disasters, reduce erosion, increase soil water storage capacity, protect farmland, and increase householder income. Planting models were designed to address a wide range of environmental conditions, and a mixture of species-planting designs (strips and block plantings) were used to enhance stand diversity. More than 40 species, most of which were indigenous, were planted.

39. An ICR prepared for the project in 2017 rated it Satisfactory.

Project Achievement

40. The IFDP exceeded its targets slightly by planting 93,840 hectares of new plantation and completing the enrichment planting of 39,600 hectares of degraded forest. All areas were tended in accordance with the approved tending schedule, and the quality of planting met the set standards.

41. Project models succeeded in demonstrating that technical solutions can be developed to address environmental and social needs in a wide variety of climatic and socioeconomic conditions. It also demonstrated that multiple benefits can be generated, including environmental improvements, forest landscape restoration, and rural poverty alleviation. Convinced by the success of the project approach, Shanxi Province is now using the project's watershed management model in hilly and gullied areas elsewhere on the Loess Plateau. On the

upper and middle slopes, the focus is on ecosystem restoration and stability, whereas on the lower, flatter areas, the focus is on land use management systems for sustainable production to alleviate poverty. The project has shown that the use of multifunction forests could balance community and environmental benefits. These combined benefits were obtained by incorporating economic species in the planting mix on suitable sites, which produced both income and environmental benefits. For example, fruit and nut production in some areas increased farmers' income by RMB 1,300 per hectare annually at five years after planting, which will be gradually increased, and this has encouraged farmers to expand the use of planting models demonstrated by the project. The impact of the project on farmer income depends on which economic crops can be planted in the different project locations, but overall, the project was highly successful in pioneering the conceptual change from monoculture planting for a narrow range of products to multifunction planting for a broad range of products and services. The project also showed that mixed-species afforestation would generate good environmental benefits. The presence of these trees and the vigorous growth resulted in an increase in environmental benefits provided by these multifunction forests.

42. The introduced social and environmental safeguards measures have also contributed to the project success. An environmental assessment was carried out, after which an Environmental Management Plan was prepared that included Environmental Protection Guidelines for Plantation Establishment and Management, and a pest management plan. Local species were used for planting and these, coupled with strict site selection criteria, ensured that plantations did not impair or pose threats to either forest ecological functions or biodiversity. Mitigation measures were put in place to offset potential environmental risks associated with soil disturbance and erosion during planting, the possible use of herbicides and pesticides, and pest damage. There were no outbreaks of pests in planted areas, but the pest management plan ensured that patrols quickly detected any possible risks, and that physical control measures were implemented.

Case 3: Hunan Forest Restoration and Development Project—A Focus on Close-to-Nature Forest Management

Project Brief

43. The recently completed HFRDP is located in southern China and was implemented over six years (2013–2018). The PDO was to enhance the resilience and environmental functions of selected storm-affected ecological forest in Hunan Province. This was to be achieved by increasing species diversity and vegetative cover in snow- and frost-damaged forest areas.

44. To realize the PDO, the project had two components. Component 1 consists of the reforestation and rehabilitation of damaged ecological forest plantations through the replanting of completely destroyed forests, the enrichment planting of partially damaged forests, and the natural regeneration of damaged forests considered capable of regenerating naturally. Component 2 consists of institutional support and technology enhancement, including nursery upgrades, tree seed and seedling improvement, strengthening of farmer co-ops, research and extension, project monitoring, and improvements to project management capacity at the provincial, county, and city levels.

45. Eight mixed-species models were used for planting, four for replanting, and four for enrichment planting. The key principles guiding models were as follows: they should comprise species mixtures, use native species to restore a natural climax, uneven-aged stand, subsequent management should aim to strengthen the ecological resilience of stands and facilitate their multiple use, and full advantage should be taken of any natural regeneration.

46. The research program was conducted, which optimized fertilizer regimes, germination and cultivation techniques for the project's newly-developed cultivars. Research activities improved seedling substrates and container shapes for cultivation of indigenous broadleaf species, increasing the survival rate by 7.9 percent relative to traditional techniques (reported by PPMO). The research program refined the project's forest models and establishment techniques (for example, establishing optimal planting densities, fertilizer regimes, and conifer to broadleaf species ratios), delivering extensive scientific output.¹

47. All planting and forest rehabilitation work is complete. A total of 61,990 ha of forest were reforested or enriched, representing 108 percent of the PDO target. This includes 32,650 ha of reforestation, 21,670 ha of enrichment plantations, and 7,660 ha of natural regeneration promotion. Forest plantation included 53 species, including 38 rare and high-value species. New and improved plantation approaches have been adopted in project areas, including a reduction of planting density to promote understory vegetation, use of local broadleaf tree species, species-site matching, site preparation approaches that prevent soil erosion, mixed species structure, and containerized seedling use. Broadleaf tree species accounted for 7 of the 10 most frequently planted species, representing 44 percent of total planted seedlings. These achievements represent an important contribution toward the realization of the PDO.

48. The extensive training program has been conducted with around 14,000 project staff trained at provincial and county levels, and around 620,000 farmers trained at communities level, including on-site training, which promoted the project's techniques and research findings. Training covered forest design and establishment, financial management, fertilizer use, tending, and pest and disease control, among other topics. About 92 percent of surveyed project beneficiaries reported in surveys for the project M&E program that they obtained skills and knowledge from the training, and 85 percent reported that their working efficiency had increased as a result. In addition to formal training, *ad hoc* field training was provided through a network of demonstration forests that were established by the project in each of the 22 project counties.

49. The project has been closed in December 2018 and the project's ICR was prepared, which is rated as Higley Satisfactory.

¹ The project published three handbooks: (1) Cultivation Techniques for Major Indigenous Tree Species in Hunan Province (2) Colored Illustrations of Hunan's Major Indigenous Tree Species and Seedlings, and (3) Sustainable Forest Management Handbook of Hunan Province. In addition, the Project's research activities led to 20 scientific publications (principally in national journals), was granted one patent. The Project's researchers won two science and technology awards (3rd prize Science and Technology Progress Award of Hunan Province; second prize Science and Technology Progress Award of Changsha city).

Project Achievement

50. Close-to-nature forest management approaches were adopted. Of the eight planting and forest management models developed under the project, four were for the replanting of completely destroyed areas and four were for the enrichment planting and tending of natural regeneration in partially destroyed areas, with the aim being to improve species composition, diversify stand structure, promote natural regeneration, and enhance the multifunctionality of stands. The management model for priority ecological forest areas such as water and soil conservation used the “target tree” and “selective cut/tending” system piloted by the Sino-German projects. In lower-priority ecological forests, “small-area mosaic clear-cuts” were used. To restore degraded forests with large gaps, “mixed-species gap planting” was used, while “alternate line planting of species mixtures” was used to restore open woodland. In all cases, land preparation, planting, fertilization, weeding, and tending were carried out in accordance with prescriptions prepared for the technical models.

51. Diversified species planting and long-term forest management under the Project has improved the resilience and environmental function of ice-storm-damaged ecological forest plantations in line with the PDO. More broadly, the project has succeeded in precipitating a change in focus from traditional timber plantation for production to close-to-natural management approaches for environmental services provision in the Hunan forestry sector. By diversifying tree species in the forest stand and structure and protecting understory vegetation, stand resilience has been strengthened and ecological function and carbon sequestration have been improved.

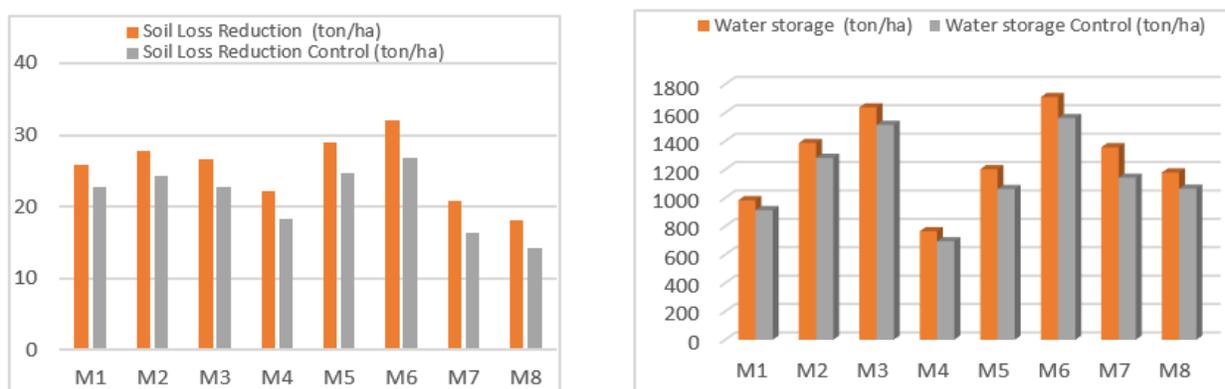
52. Analysis was carried out on carbon sequestration uptake of different models by the Hunan Academy of Forestry and the results show that the carbon sequestration rates in mixed-species stands are higher than those in conifer monocultures; the project monitoring also presented that the water and soil conservation of the project mixed plantations have generated promising results in water holding and soil erosion control; the research on wood properties indicates that the mixed forest stands have significant impacts on wood density, flexural strength, flexural modulus of elasticity, and compression strength, which will improve forest tolerance to the negative impacts from wind and snowstorms and increase the stability of forest stands, including enhancing their resistance to natural disasters.

Overall Impacts Assessment on the World Bank-Financed Projects (Case 1 to Case 3)

53. Based on the above case review of the Bank-financed project design, implementation, results, and impacts, it is concluded that the project concept and technical approaches would promote sustainable forest management, which contributes to the improvement of forest quality, forest growth, forest ecological function and resilience, forest capacity in carbon sequestration, which will contribute to achieving China’s NDC, and the livelihood of local communities and farmers. More specifically, the project monitoring and research programs evidenced that the projects have demonstrated the sustainable forest management regime, which can significantly improve forest ecosystem functions while balancing the income generation for sustainable development.

54. **Soil erosion rates and runoff rates under the projects are substantially lower than under traditional forest models.** For three mentioned Bank financed projects, the soil loss lower than traditional monoculture forests for around 10 to 19% at the project level; and water retention capacity is higher than monoculture forests for around 5.5% to 17.5% at project level. For instance under SEAP, , for the cumulative soil loss reduction over the six-year project period within afforestation intervention were between 18.0 to 32.0 tons per ha compared to rates within traditional (control) stands of 14.1 to 26.8 tons per ha during the project period.² Correlated with this outcome, six-year cumulative water storage were similarly higher for afforestation models with water storage of 764.3 to 1709.6 tons/ha over a six-year monitoring period, compared to 693.3 to 1561.2 tons/ha recorded under traditional (control) stands. Reduced runoff and soil erosion are expected to confer water catchment management benefits by reducing siltation and pollution, flooding, and water treatment costs. See the Figure 1.

Figure 1. SEAP Water Storage and Soil Loss Reduction of Afforestation Models



Forest Model ³	M S1	M S2	M S3	M S4	M S5	M S6	<u>M S7</u>	M S8
Forest age (Year)	6	6	6	6	6	6	<u>6</u>	6
Soil Loss_Reduction_ (ton/ha)	25.83	27.71	26.6	22.07	28.89	31.99	20.78	18.04
Soil Loss Reduction Control ⁴ (ton/ha)	22.78	24.36	22.77	18.23	24.73	26.82	16.28	14.13
Model compared to control on soil loss (+%)	13.4	13.8	16.8	21.1	16.8	19.3	<u>27.6</u>	27.7
Water storage (ton/ha)	982.62	1385.65	1636.96	764.34	1201.63	1709.63	1355.84	1178.5
Water storage Control (ton/ha)	912.8	1281.4	1513.8	693.25	1061.4	1561.25	1141.25	1064.25
Model compared to control on runoff (+%)	6.6	8.1	8.1	10.3	13.2	9.5	<u>18.8</u>	10.7

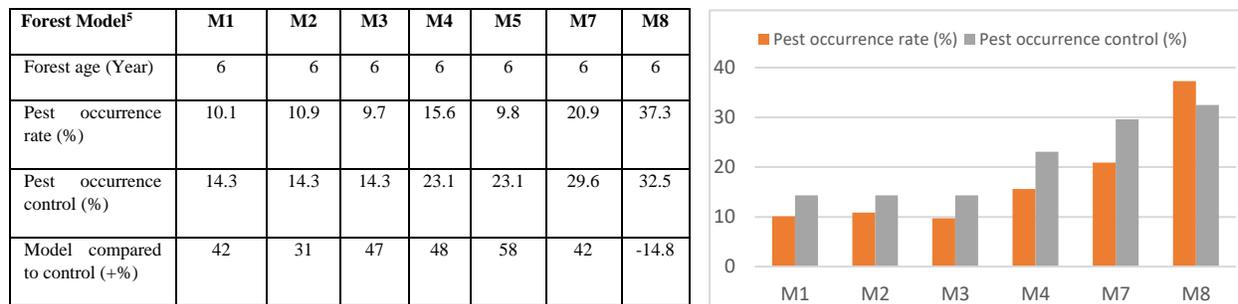
² Calculation is based on project M&E data and assumes (1) monitoring sites are representative project-wide, and (2) the counterfactual would be a project with traditional monoculture for afforestation sites, and no reforestation on restoration sites.

³The various technical models have been defined in the section of case study of SEAP.

⁴Control is the traditional (monoculture) forest sites selected to as comparison with sites adapted mixed planting models.

55. **Damage from diseases, pests and weeds was reduced.** A direct measure of resilience is the extent to which a forest can withstand attack from harmful organisms that would otherwise reduce the forest's productivity and value. While project M&E data showed that afforestation models had a higher *diversity* of diseases, pests, and weeds than their equivalent control forests, overall *occurrence* levels were 29-75 % lower than the traditional monoculture forests. Take HFRDP as an example, the pest occurrence of the mixed plantations are lower than the monoculture forests for around 31 to 58%. See the Figure 2.

Figure 2.HFRDP Pest Occurrence Rate of Forest Restoration and Rehabilitation Model

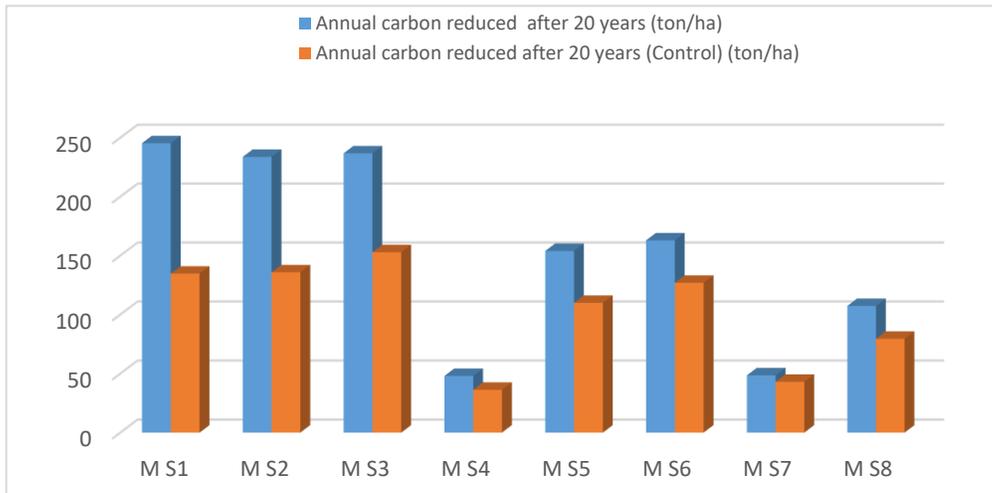


56. **The project's mixed-species models demonstrated improved mechanical wood properties.** The project assessed strength and flexibility metrics for *Cunninghamia lanceolata* (Chinese fir), one of the most common commercial species in Hunan (and the most common species utilized in the project, comprising around a third of plantings). Project M&E data allowed for a comparison of the physical characteristics of Chinese fir raised in a mixed model to those raised in a monoculture. Individuals in mixed models were found to have statically significant higher density (by 8-9 percent), flexural strength (65 to 68 percent), elasticity (71 to 73 percent), and compression strength (11-13 percent) in the main trunk. These improved physical properties are expected to increase the wind and snow resistance of mixed stands relative to traditional monocultures of this commercially important species.

57. **Carbon sequestration rates were substantial over the life of the project,** which are expected to be higher than those under comparable traditional forest models around 19.3% to 63.8% for HFRDP and 9% to 82% for SEAP. For the case of SEAP, the forest carbon sequestration capacity would be around 41.8% in average higher than the monoculture forests with the range from 9% to 82% from different afforestation models. See the following Table. It notice here that the higher growth of forest stands are the results from integrated intervention including adopting mixed forest structure, diversified species, good site and species matching, improved seedlings and adequate forest tending. See the Figure 3.

⁵ The various technical models have been defined in the section of case study of HFRDP. The research team was reported that due to pest outbreak in some areas the results of M5 monitoring plots were impacted with no accurate data were available.

Figure 3. SEAP Carbon Sequestration of Afforestation Model



Forest Model	M S1	M S2	M S3	M S4	M S5	M S6	M S7	M S8
Forest age (Year)	10	10	10	10	10	10	10	10
Stand volume at 10 year (m ³ /ha)	42.39	37.69	44.71	9.55	27.7	33.4	12.33	15.61
Stand volume at 10 year (Control) (m ³ /ha)	22.95	19.84	29.51	7.92	14.96	15.21	8.15	12
Annual average stock in life period in 20 years (m ³ /ha)	134.04	127.73	129.36	21,60	84.11	89	26.51	58.63
Annual average stock in 20 years (Control) (m ³ /ha)	73.59	74.17	83.51	19.82	60.07	69.32	23.5	43.42
Annual carbon reduced after 20 years (ton/ha)	245.3	233.75	236.74	48.01	153.93	162.88	48.51	107.3
Annual carbon reduced after 20 years (Control) (ton/ha)	134.68	135.74	152.83	36.28	109.92	126.85	43.01	79.46
Model compared to control on Carbon sink (+%)	82.1	72.2	54.9	9	40	28.4	12.8	35

58. **Social Benefits.** While the projects improved the ecological environment, they also contribute to job creation and income generation through both labor inputs and final product benefits. For example, in the SEAP, the project direct beneficiaries were the approximately 26,560 households who participated in the establishment and management of plantations through the estimated 40,000 person years of employment and the approximately RMB 2,400 of additional income each household received per year, in addition to the increased income from improved crop production and non-timber products; in IFDP, approximately 158,340 households participated in and benefited from the project, as did the approximately 79,990 households that participated in the HFRDP. In addition to labor inputs, management of the multifunction afforestation would generate additional income to farmer households from forest and non-forest products.

59. The monitoring data from the IFDP showed that the effect of mixed-species planting in shelter belts can have a significant positive impact on agricultural output in the areas of

influence of shelter belts. Fixed plot experimental data in marginal, low-yield farmland in project areas in Hebei and Liaoning showed that the crop yields under the protection of the project forests increased by around 10 percent (see table 1).

Table 1. IFDP Benefits of Farmland Protection Shelterbelts

Province	Crop	Crop Production with Forest Shelter Belt (kg/ha)			Crop Production – Control (kg/ha)		
		2012	2013	2016	2012	2013	2016
Hebei	Peanut	3,000	3,075	3,303	2,670	2,745	2,980
Liaoning	Peanut	2,220	2,730	1,921	2,220	2,625	1,659
IFDP in average	Peanut	2,780	2,970	2,920	2,535	2,715	2,611

Note: a. The weighted averages are adopted for crop yield and the area of the afforestation models.

b. Control is the site selected as comparison with sites adapted mixed planting models.

60. **Financial and Economic Benefits.** A financial and economic analysis conducted also concluded that the afforestation and forest management models under the Bank financed projects will generate promising financial and economic benefits. The analysis showed that the project will also generate economic benefits to farmers with the FIRR obtained from 8.4% to 17.1% by developing the multiple functions forests. To encourage farmers and communities to participate in the project and manage the forests on a sustainable basis, the government decided to provide the Bank loan funds as a grant to farmers. With such a funding arrangement, it is expected that the FIRR of farmers’ and local communities’ activities would increase by over 6 percentage points to more than 15 %. Additionally, some participating farmers also raised mountain chickens, planted medical herbs and other non-timber products under forest stands to increase income further (not included in economic analysis). See the table 2.

Table 2. Economic and Financial Analysis by Project

Activity or Model	EIRR (%)		FIRR (%)	
	At Appraisal	At ICR	At Appraisal	At ICR
	SEAP	23.8	22.3	15.2
IFDP	17	17.4	11.8	9.6
HFRDP	17.6	21.32	8.4	8.32 ⁶
In Average	13.6	13.23	11.8	11.67

Key Lessons learned from the Bank Finance Forestry Projects (Case 1 to Case 3)

61. The key interventions brought to the projects that contribute to the sustainable forest management are summarized as the following.

⁶ As the Bank loan proceeds were provided as grant to farmers to subsidize the establishment cost of forest restoration, as such all plantation model provided the financial attractive to farmers with FIRRs above 12 %.

62. **Technical Innovation**

- (a) **A systematic site survey is the prerequisite for the appropriate matching of tree species to a site.** The SEAP, for example, establishes a site classification system for the entire project through detailed site investigation studies for which an alkalized land afforestation models were developed in strict accordance with the subcomponent on alkali contents. For the transformation of existing low-quality forest, the basic conditions of the forests that need to be reconstructed are analyzed, including the density of forest stands, coverage, reasons for poor growth, environmental conditions, and undergrowth, which formed the basis on which decisions would be made for replacement or enrichment planting measures.
- (b) **The characteristics of tree species should be studied and the comparative advantages of mixed afforestation over monoculture widely acknowledged.** The uses of native tree species, domesticated tree species, and exotic tree species should be distinguished, as should the differences for adopting different growth cycles (long, medium, or short) and different wood values (ordinary value timber compared to precious timber). The adaptability of native tree species is conducive to increasing the forestation preservation rate and to forming a resilient forest ecosystem.
- (c) **Promotion of natural regeneration.** Studies have shown that the ratio of root height to seedling height of natural regeneration seedling is three times that of the artificially raised seedlings (Lamb 2014), indicating that the natural regeneration seedlings have higher resistance and anchoring strength. Use of natural regeneration is also a basic component of “near-natural forest management,” as it is both an ecological protection measure and a forest management measure to protect rare and endangered animals and plants and to promote undergrowth.
- (d) **Multifunction forest management.** The projects achieved multifunction forest management by balancing the ecological benefits and income generating opportunities for forestland owners. Forestland and forest owners are more likely to protect their forestland if they benefit from its management. Multiple function forest management provided an incentive and strengthened the sense of ownership of local communities and farmers, which contributed to the sustainable forest financing and sustainable community livelihoods.
- (e) **Long-term forest management and selective cutting.** Afforestation for ecological service benefits needs to maintain the continuous coverage of site vegetation and reduce any possible land denudation exposure. The long-term forest management method is adopted with the harvesting method of progressive and selective cutting to avoid clear-cutting.

63. **Institutional Capacity Building to Enable Adoption of New Technologies.** The Bank project focuses on institutional capacity building to implement the newly introduced sustainable forest management practice and for scaling up. One of the lessons learned from the project is that strong research-extension-demonstration-training links are fundamental to effective

technology transfer and the adoption of best practice. For instance, in the SEAP project, the extension has proved successful in promoting the ecological forestry concept and improving mixed planting. It was able to disseminate 25 technical and management standards and regulations on topics including model design, seedling selection and nursery management, environmental protection guidelines, and plantation and tending quality check and acceptance methods, all of which aim to introduce technologically advanced approaches to ecological afforestation. In addition, over 50 million patented white elm seedlings have been planted on high-salinity land in project areas and in 10 provinces outside the project, which result in increasing the planting survival rate from less than 50 percent to 90 percent. Doing so largely improved the cost-effectiveness and quality of planting on this type of marginal land.

64. **Community Consultation and Participatory Planning.** The projects brought community consultation and participatory planning to the afforestation and forest management practice. Project Participatory Planning Manuals were developed to guide the consultation process. Through extensive consultations on the ground, householders were kept fully informed about what was being proposed and were given the opportunity to influence project design to accommodate local needs. Householder participation in project implementation was strictly voluntary. In particular, the consultation process ensured that decision making was transparent and that the needs of vulnerable, marginalized groups were identified and properly addressed. To reduce the risk of women and poorer households being marginalized, they were invited to participate in village-level consultations.

65. The projects, which promoted a bottom-up decision-making approach, largely changed the traditional top-down government project design. The participative approach adopted led to a win-win situation whereby householder incomes increased through the incorporation of economic tree crops in the planting, and positive ecological impacts were realized from the establishment of more resilient multifunction afforestation models with a variety of species in the planting mix.

66. **Mainstreaming Gender.** Special attention has been paid to the views and needs of women, so as to mainstream gender concerns in project planning and implementation. The Participatory Planning Manuals include specific provisions for involving female representatives in project training, consultation, and decision making, to enable equal access for women in the development opportunities under the project. Women participated actively in the consultation meetings and interviews, and more than 35 percent of the consulted farmers were women. Women would also participate in the reforestation and forest management activities, as well as in training and other programs. For instance, 43 percent of IFDP beneficiaries were women, and they received 56,000 times trainings, from which they benefit not only from project implementation, but from capacity building, which they would be able to apply to further sustainable forest management. Women participated in the HFRDP at higher rates than men in designated impoverished areas and ethnic minority areas. In total, 35 percent of participating farmers were women. Of poor⁷ forest farmers, 51 percent were women, and of minority forest farmers, 72 percent were women. That reflects the gender composition of the communities,

⁷ Poverty status is defined according to the national poverty line, which changes annually. In 2015, the poverty line was US\$360 per year (RMB 2,300).

many of which have a large proportion of men working outside the community. Overall, around 82 percent of surveyed participants believed that the position of women at home had improved to some extent under the project.

67. **Environmental Consideration.** The environmental safeguards measures introduced have also contributed to project success. Environmental assessments were carried out for all the projects, after which Environmental Management Plans were prepared, which included Environmental Protection Guidelines for Plantation Establishment and Management, and pest management plans. Local species were used for planting and these, coupled with strict site selection criteria, ensured that plantations did not impair or pose threats to either forest ecological functions or biodiversity. Mitigation measures were put in place to offset potential environmental risks associated with soil disturbance and erosion during planting, the possible use of herbicides and pesticides, and pest damage. There were no outbreaks of pests in planted areas, but the pest management plan ensured that patrols quickly detected any possible risks, and that physical control measures would be introduced.

B. Sino-German Forestry Projects

Background

68. Sino-German cooperation in the forestry sector began in the 1980s, with technical cooperation through the German Corporation for International Cooperation (GTZ) in 1983, and financial cooperation with the German state-owned development bank (KfW) in 1993. There are a number of Sino-German projects, valued at 400 million euros, that have invested in forestry programs in China, all of which mainly introduced the advanced forest management techniques to improve forest quality and sustainable management. In recent decades, the theory of close-to-nature forest management, in particular, has provided valuable experience for the sustainable forest management system in China.

Case Study 4: Sino-German Financial Cooperation Afforestation Project in Tianshui City

Project overview

69. The Sino-German Financial Cooperation Ecological Afforestation Project in Tianshui city, Gansu Province, was implemented during 2004–2013. The project, managed by individual farmers, introduced advanced international forest management techniques from Germany aiming at promoting sustainable forests by adapting close-to-nature forest management approaches.

70. **Afforestation Model Development.** Based on site conditions, four afforestation models were designed. The key elements considered include:

- (a) **Selection of tree species.** Diversified species were selected, with main tree species and associated species, which vary according to the different topographic features and site conditions in the project area. In the gully region of the Loess Plateau, *Robinia pseudoacacia*, *Pinus tabulaeformis*, *Ailanthus altissima*, and *Ulmus pumila* are the main species; west of the Qinling Mountains, Spruce, *Pinus armandi*, *Larix kaempferi*, *Larix principis-rupprechtii*, and *Quercus liaotungensis* are the main species. Associated tree species include arbor species or shrub species, which improved the growth of major tree species at a certain period, mainly with *Hippophae rhamnoides*, *Prunus Armeniaca*, *Pyrus betulaefolia*, *Caragana korshinskii*, *Amorpha fruticosa*, and *Prunus davidiana*.
- (b) **Forest structure.** The tree species mixed structure was decided based on the growth characteristics and intended project purpose. Based on the principle of site-adapted species selection, tree species were selected to ensure that the tree species selected are adapted to the site conditions, which is important in ensuring a high planting survival rate and good growth. Three mixture models were developed under the project: a mix of intolerant tree species such as Chinese pine and *Platycladus orientalis*, *Larix kaempferi* and birch, and *Ailanthus altissima* and *Ulmus pumila*; a mix of shade-tolerant and intolerant species, such as *Pinus armandi* and Spruce; and a mix of arbor and shrub, such as *Pinus armandi* and Sea-buckthorn, Chinese pine and Sea buckthorn, *Prunus Armeniaca*, Chinese pine and *Amorpha fruticosa*, *Prunus davidiana*, *Ailanthus altissima* and *Pyrus betulaefolia*, and *Caragana microphylla*, *Xanthoceras sorbifolia*.
- (c) **Mixed species proportions.** Mixed species proportions were determined by geographic location and species characteristics. The project requested that the proportion of broadleaved tree species be no less than 30 percent in shade slope, and the proportion of broadleaved trees be no less than 50 percent in sunny slope. There are three mixed proportions: 7:3, 6:4, and 5:5. The proportion of the main tree species is generally 50 percent to 70 percent, and associated tree species are 30 percent to 50 percent. The proportion is relatively small for species that have high competition capacity; the economic value of the species and farmers' preferences were also taken into consideration in deciding the amount of species. The proportion of shrubs is closely related to site conditions; for example, in high-altitude areas above 2,200 meters, the main shrub species is Sea buckthorn; in arid areas of loess region, *Caragana microphylla*, *Prunus davidiana*, *Amorpha fruticosa*, and *Xanthoceras sorbifolia* are in higher proportion. The proportion of general shrub species is 30 percent to 70 percent.
- (d) **Layout of planting.** Line mixture and small mosaic mixture were used for afforestation. Line mixture is inconvenient for afforestation and was therefore mainly used in high-altitude areas, such as in mixed plantation of Sea buckthorn and Spruce, *Pinus armandi* and applicable for arbor and shrub mixing or shade-tolerant species and intolerant species. Such as the mixture of Spruce and *Pinus armandi*; by taking irregular small mosaic mixture, the same tree species are planted in blocks in accordance with the fluctuation of the small terrain in the afforestation area, and plant another tree species in adjacent block. This method not only mixes different species, but also successfully arranges forest planting to match site conditions. Due to the complex terrain and

microclimate conditions of the hilly-gullied loess region, such a mixture model is widely used in practice.

Results Evaluation

71. As a result of the implementation of the project, forest cover increased by 1.58 percent in project counties; the forest canopy increased by 32 percent in project sites; the quality of forest improved; soil loss declined from 36 percent to 6 percent, with soil erosion in the project areas well controlled; and the quality of the ecological environment was improved significantly.

72. Through implementation of the project, the local labor force has been effectively mobilized and the self-development capacity of farmers enhanced. Farmer income has been significantly increased through planting of economic crop and labor inputs. Approximately 15,221 households participated in and benefited from the project, with households receiving RMB 320.1 million for labor inputs, or RMB 2,103 per household, on average. Farmers will also enjoy medium-term and long-term benefits from economic crop production and timber production by thinning and selective regeneration cutting.

73. **The management mode of the Sino-German Cooperation Project.** In addition to the technical innovations introduced in the projects, the adoption of effective project management is also critical to sound forest management. These include:

- (a) **Contract management.** The Sino-German afforestation projects are managed through contracts signed between the project executive agency and the project implementation entities and local farmers, as well as through project monitoring contracts signed between project agencies and an independent third party. Implementation of these contracts effectively constrained any inappropriate behavior on the part of project managers and staff in terms of rights, obligations, and responsibilities, providing clear technical requests and standards of afforestation and forest management and setting payment arrangements to planting entities and farmers, which standardized the project management under the legal framework and protected planting entities and farmers' rights.
- (b) **Participatory planning.** During project preparation, a detailed consultation and participatory design process was carried out in all project villages and with key stakeholders. The consultation process ensured that all the land users would participate in the project on a voluntary and transparent basis and that poor farmers, vulnerable groups, and ethnic minorities would have equal access to participate in and benefit from the project. This process also ensures that participation in the project would be agreed by villagers within those villages where land remains collective and the participatory exercise was continued throughout project implementation. The participatory planning measures developed under the project include detailed community consultation contents, methodologies, and procedures.

Full ownership was achieved through dissemination of detailed information on proposed project activities in all project villages. The initial consultation consisted of an

information campaign with copies of project information leaflets distributed to the communities within the proposed project counties. The leaflets informed the communities and households about the proposed project activities and provided options to the households to participate in the project via:

- i. Establishment of a two-way communication process between households and county project agencies on the selection of plantation models and tree species. The second step of consultation with relevant stakeholders was undertaken in each project village to collect feedback on whether farmers and communities wished to participate in the project. Farmers' preferences on species selection and on operation and contractual arrangements were sought and incorporated into the final planting design.
- ii. A process of formal application and contracting between the participating villages or households and county government agencies for project participation. As a result, approximately 15,220 individual households in 5 counties applied and were approved to participate in the project and to benefit from the project through various management arrangements.

(c) **Technical assistance and training.** Institutional capacity building is crucial to adopting new technical concepts and afforestation and forest management models. During project implementation, more than 4,600 project staff and 114,000 farmers were trained, which greatly enhanced the technical capacity of local people in planting and forest management. In addition, it greatly improved the capacity of local forestry staff, planting entity staff, and farmers to adopt the close-to-nature forest management technical models, and improve planting survival rates, pest management, and new technology applications.

The project's technical assistance was provided by 50 national experts and 32 international experts, and the relevant workshops were held for knowledge sharing and dissemination. International study tours to Germany were arranged the main focus of which was the use of new technologies, pest and disease control, environmental protection, silvicultural design, nursery improvement, forest tending, and forest management. Farmer training focused more on planting, tending, and best environmental practice. The training courses incorporated feedback from participants on the usefulness and relevance of training. The main results of training were (i) decision makers and farmers came to accept mixed planting models; and (ii) farmers have become aware of the importance of tending and weeding after planting, which has led to a dramatic increase in survival rates and an upsurge in community confidence in afforestation.

Case 5: The Sino-German Cooperation Project in Xiaolong Mountain, Gansu Province

74. The GIZ-funded Xiaolong Mountain Project was located in natural forests of the Xiaolong Mountains in western China. The objective of the project was to evaluate the impact of different stand treatments on secondary forests and observe how the structure and ecology of

these developed over eight years compared with largely undisturbed forests in the area. The work was guided by over four decades of close-to-nature forest management in Germany.

75. The Xiaolong Mountain area is an ecologically complex ecotone where the four vegetative zones of northern and central China converge and join with those of the Himalayas and Mongolia. This, together with the different management systems applied in the past, provided a broad range of growing conditions and management interventions for the evaluation.

76. The forests in the area mainly comprise a combination of oak (*Quercus aliena*) and pine, together with other broadleaves such as birch. In the 1960s, some of these 60-to-100-year-old forests were exploited and brought under a variety of management systems. These included clearcutting 60-year-old oak and pine and leaving around 40 cubic meters of small-diameter trees to help the area regenerate naturally; the selective felling of 118-year-old oak and pine with tending thereafter; clearcutting existing forests in 1970 and planting it with either *P. armandii* or *P. tabulaeformis*, which were thinned thereafter; strip clearing of natural shrub in 1981 and planting the area with either *P. armandii* or *P. tabulaeformis*; and clearcutting shrubs in 1971 and replanting with either *P. armandii*, *P. tabulaeformis*, or Larch (*Larix kaempferi*).

77. With training provided by GIZ, the target tree management system/model was introduced in 2007 in 124-year-old broadleaf and pine stands with bamboo. This involved identifying the final crop oak trees and eliminating tree vegetation competing with them (around 30 percent of stems)—the so called close-to-nature system. In 2008, the structure-based forest management was applied in another area where the tending and thinning of 124-year-old mixed broadleaf with pines was used to favor the high-value, rare, and threatened species in the stand, with the aim of creating a healthy stand by maximizing its diversity and improving its structure.

78. An area of 110-year-old oak provided the baseline against which the other interventions were evaluated. These treatments constituted the 10 different forest management regimes, the performance of which was compared with that of the control.

79. Data from the models were used to determine which model produced the healthiest (sustainable or nearest to the natural state) and productive forest stands, and which models were most cost-effective at achieving this objective. Data collected from the models included the spatial distribution of trees in the stand, spatial utilization/coverage, stand growth rates, species composition, species competition, and labor inputs. Using biometric formulas, the ecological value of each model was judged on the basis of how close the ecology of each model was to that of the control. Model costs were also used to identify the cost-effectiveness of models at producing ecologically stable and healthy forest stands.

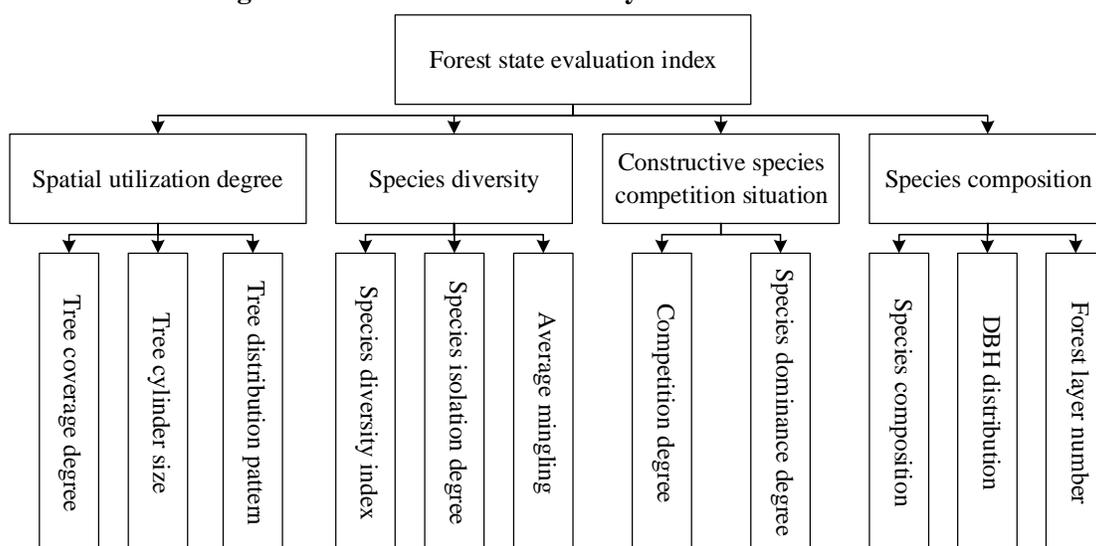
80. GIZ was largely responsible for implementing the study in collaboration with the NFGA and the Chinese Academy of Forestry. Operational activities were managed in accordance with a Project Implementation Plan.

Results Evaluation

81. The project evaluation assessed the impact of different stand treatments on secondary forest and observed how their structures and ecology developed over a 10-year period compared with the structures and ecology in largely undisturbed pine-oak forests.

82. Based on stand characteristics, growth, and cost input and output values, the viability of the different management models was assessed. To do this, fixed sample plots were used to gather data, including slope gradient, slope direction, and canopy density, with these procedures being carried out in accordance with the Investigation Technical Specification of National Forest Resources Planning and Design (GB/T 26424-2010), NGFA and MOF . On the basis that sound management should always seek to protect forest health, the characteristics shown in figure 4 were assessed, as were inputs and outputs.

Figure 4. The Evaluation Index System of Forest Status



Note: DBH = diameter at breast height.

83. The evaluation showed that among the 11 forest management models, (10 + the control) the management models in natural forest were more sustainable than conifer monocultures. In the treatment of natural forest management models, the structure-based forest management⁸ was the optimal model, followed by the close-to-nature model. The selective thinning model was ranked third, and the least sustainable model was clearcutting with natural regeneration. In the plantation models, the reconstruction model of natural shrub in strips with planting was better than the clearcutting with replanting. The *Larix kaempferi* monoculture plantation model appeared to be the least sustainable.

84. A comparison was also made between the structure-based forest management model and the close-to-nature forest management model in natural forests. The results showed that both models can improve forest quality and productivity. Compared with the control, the structure-based management model increased productivity in native forests by 1.0 cubic meter per hectare

⁸ The structure-based forest management model is an advanced close-to-nature forest management model with additional interventions on adjusting the forest structure combining species composition, spacing, and layout.

per year, or 17.2 percent of the control, and the close-to-nature management model improved productivity by 0.1 cubic meters per hectare per year, or a 4.1 percent increase over the control.

85. A comparison was conducted of the inputs among the 11 models that created a stable forest system. The monitoring results indicated that the structure-based forest management model and the close-to-nature forest management model have less inputs than other models, which are around 13.4 percent to 48.7 percent and 15.9 to 57.6 percent compared with traditional forest management practices, respectively.

86. Work done in the Xiaolong Mountains confirms that the judicious thinning of native forests can improve productivity and forest resiliency. However, a possible impediment to the large-scale application of the close-to-nature and structure-based forest management is the existence of the logging ban and harvesting quota in natural forests. These controls apply to 56.4 million hectares of natural forest, or 53 percent of total forest area, and either forbid harvesting completely or limit it to levels below those required in close-to-nature and structure-based forest management. As a result, carbon sequestration potential is being lost and over-mature forest stands are being created.

87. The findings reflect those obtained in Germany with the close-to-nature system over the last 20 years. As a result, forest policy in Germany is now firmly anchored in the “structure-based” and “close-to-nature” principles. However, researchers conclude that most forests in Germany have been disturbed in one way or another in the past (98 percent in Germany’s case) and that converting these forests back to a near-natural condition is a long-term process. They also concluded that an accurate system of site classification is an essential prerequisite for ecologically focused forestry, something well worth bearing in mind in China, where poor species-site matching has adversely affected plantation productivity in some areas.

Recommendations on the implementation of proposals for near-natural forest management (Case 4 and Case 5)

88. Near-natural forest management means that the forest management should be transferred from the traditional monoculture, to the multiple purpose forest management with balance economic benefits and ecological functions, which coincides with the requirements of ecological civilization construction in China’s forestry development strategy. It is also the sustainable way of forest management, with the use of natural capacity of forest regeneration to improve the cost-effectiveness in forest management and promote a stable and resilient forest ecosystem.

89. One of the goals of near-natural forest management is to harvest a certain amount of timber for sustainable use through individual cultivation and selective logging. Over years, China’s forestry sector has generally adopted the management system of a cutting quota, which causes certain obstacles to the development of some German aid projects. Especially in western China, where most forest functions focus on ecological protection, under the current forest-cutting quota management system, there are limited forest-cutting quotas allocated, especially for natural forests. In large-scale implementation of near-natural forest management, it is

difficult to obtain the required cutting quota. There is an urgent need to adjust forestry policy in this regard to scale-up near-natural forestry management in China.

90. **Close-to-Nature Forest Management.** The theory of close-to-nature forest management developed from the concept that the management of forest should be based on the features of natural forest. Natural forest is characterized by a complex spatial structure and a mixture of multispecies and multiage trees. Thus, the close-to-nature forest management model should promote the development of forest structure similar to natural forest, which is healthier and more stable, and a core concept of sustainable forest management.

91. The principles of close-to-nature forest management are characterized by:

- (a) **Respecting the natural process and protecting the potential of the site.** The potential of the site means the natural growth potential of forestland. Close-to-nature forest management is based on the natural succession and the natural regeneration of forests with necessary human intervention.
- (b) **Promoting the use of diversified tree species mixtures in forest management.** Studies of natural forest formations show that tree species comprise a complex web of elements and forest ecosystem functions, with the physiology of different tree species performing different functions in the forest ecosystem. The aim of multifunction forest management is to support these functions so that the target trees would be able to fulfill their natural roles in the forest ecosystem more efficiently. To date, China has made limited use of this concept, with most planting comprising a single species.
- (c) **Promoting improvements to forest structure and stability.** A multistory forest structure with mixed species, large-diameter trees and vigorous growth is synonymous with a healthy and ecologically rich forest; these are also the essential characteristics of multifunctional forest management.
- (d) **Promoting improvements to forest ecosystem vitality.** The vitality of a forest ecosystem can be assessed by its growth and stand health. The productivity of a healthy mixed species stand is superior to that of a degraded monoculture stand under stress. A healthy mixed species stand also has greater capacity to adjust and adapt to stress, natural disasters, and human interventions and, as a result, can provide more stable economic and ecological functions. By contrast, the productivity of degraded monocultures is low due to physiological stress.
- (e) **Multiuse forestry.** Woodland and forest owners are more likely to protect their woodlands if they benefit from its management. Multiuse management seeks to achieve this by strengthening the sense of ownership among farmers by allowing them to harvest limited quantities of produce from their areas.

C. China Government-Financed Forestry Programs

Case 6: The Grain for Green Program

92. In 1998, catastrophic floods affected 29 provinces in China. Around 223 million people were affected, over 3,000 people died, and the economic losses were estimated to be RMB 166 billion. The flooding was partly due to deforestation and environmental degradation in hilly areas. In 1999, the GoC resolved to address the problem by returning large areas of farmland in critical areas to forest. Initially, trials were launched in Gansu, Shaanxi, and Sichuan Provinces, and in 2002, the State Council promulgated “Regulations on Returning Farmland to Forest,” which expanded the farmland-to-forest program nationwide.

93. To begin with, the government provided grain to farmers in returning farmland to forests as compensation. The annual subsidy for grain per ha of cultivated land was 2,250 kg in the Yangtze River Basin and the southern region, and 1,500 kg in the Yellow River Basin and the northern region. In addition, the annual cash subsidy of RMB 300 per ha of farmland was provided, and the seedlings and afforestation fees at RMB 750 per ha were subsidized to the farmers. Subsidies for ecological forests were set for 8 years, while subsidies for economic forests and grassland were for 5 and 2 years respectively. Subsequently the subsidy policies have undergone several major adjustments with changes in social and economic conditions, including (i) the grain subsidy adjusted to a cash subsidy of RMB 0.7 per kg; and (ii) the subsidies(reduced by 50%) were continued after the end of the first phase of the project to improve on- farm works for the converted forest land; and (iii) subsidy standard was raised to RMB22,500 per ha (including RMB 18,200 in cash and RMB 4,500 for seedlings).

94. Under the program, farmers who convert their sloping or eroded land from crop production to ecological forests could receive the government compensation and the cost of tree planting. However, the subsidy on offer is much shorter than the actual cost.

95. Many planting models have been adopted to fit different geographic conditions, but they are largely traditional planting practices. The review of this program focuses on its social, economic, and financial impacts on participating farmers, and the effectiveness of the subsidy program. The study was carried out by an expert team in collaboration with provincial and county authorities, and a comparison was made of inputs and outputs in a “with-project scenario” (conversion of crops to ecological forests) with a “without-project scenario” (farming). Extensive farmer consultation in the field confirmed that farmer participation in the program was strictly voluntary.

Results Evaluation

96. Physical progress under the program was found to be good, with 29.8 million hectares of farmland converted to ecological forests by the end of 2017 at a cost of around RMB 450 billion. This represented an increase in forest cover in the program area of more than 3 percent. Some 124 million farmers in 2,279 counties have benefited from the program, with each participating household receiving a subsidy of around RMB 7,000. Further, returning farmland to forest program has diversified farmers’ income sources, allowing more of them to seek urban employment opportunities.

97. Since the second phase of the project of returning farmland to forests in 2014, the country has completed 2 million hectares of returning farmland to forests. It is estimated that by 2020, more than 5.33 million hectares of returning farmland to forests will be completed.

98. Data from NFGA show that among the second-phase returning farmland to forest areas, 62.35% were steep slope farmland above 25 degrees, with ecological forest (including ecological and economic forest) accounting for 62.53%. As such, the ecological priority goal is large realized. The average preservation rate of afforestation trees in the cultivated land is about 70%. Compared with 1998 before the implementation of the project, the forest coverage rate of the sample counties increased by 11 percent, and the ecological environment of the project area gradually improved. However, it should be noted that in the 14 clusters of poverty areas under the first phase of the project, about 60% of the farmers, who have developed ecological forests, could not maintain cash inflows without the subsidies. As a result, 7% of forest land has been reconverted into farm land.

99. A financial and economic evaluation of returning typical farmland to ecological forest over 20 years was undertaken and revealed divergent financial returns for farmers and the broader economic benefits (including environmental benefits) for society as a whole. Three sample sites were selected for the evaluation, covering Yuexi County in Anhui Province for tea plantation, Guangyuan City in Sichuan Province for tree crop (walnut), and Hongya County in Sichuan Province for ecological trees.

100. Sample Site 1: Yuexi County, Anhui Province: Yuexi County, Anhui Province is located in the hinterland of the Dabie Mountains, which covers both the Yangtze River and the Huaihe River valleys. The County has implemented the project of returning farmland to forests since 2002. Up to now, it has converted 8,600 hectares of land to forests, including 7,267 hectares for afforestation and forest restoration, and 1,333 hectares for assisted natural generation. The forest species are mostly ecological forests including chestnut, tea, mulberry and peach. The research site is located in Nanhe Village, Hetu Town, Yuexi County. The area of returning farmland is 50 mu (about 3.33 hectares), and the afforestation tree species is tea.

101. Sample Site 2. Chaotian District, Guangyuan City, Sichuan Province. Guangyuan City is located in the northern part of Sichuan Province. The Pujia Township in Chaotian District, which was selected for the case study, began to implement the project of returning farmland to forests in 2002, with 16.67 hectares of land converted to walnut trees. The walnut trees have fully developed with an average fruit weight of 10 kg per plant and an average output value of about RMB150,000 per ha.

102. Sample Site 3. Hongya County, Sichuan Province. Hongya County is located in the southwest of the Sichuan Basin, covering an area of 1896 square kilometers and administers 11 towns and 4 townships. It has 138 administrative villages and 21 communities with a total population of 350,000. The forest coverage rate is 70.5%. Since 2003, the county has implemented the project of returning farmland to forests. The case study on returning farmland to forest is 12.5 hectares. The main species of cultivated ecological trees are Chinese fir, cedar and bamboo.

103. As mentioned, the evaluation is based on a comparison between the with and without program scenarios. The financial analysis covers all cash outflow for the farmers involved, while economic analysis takes into account the environmental benefits.

104. Financial analysis was conducted to evaluate the incentives for farmers to participate in the program. Financial benefits were estimated from cash flow by tree plantation models, which use quantities of inputs (seedlings, fertilizer, labor, etc.) valued at prevailing market prices. Similarly, outputs such as timber, fruits and non-timber products are estimated and valued at market prices. For plantations and forest products which are not harvested, the market value of the standing volume is estimated at the end of production cycle. It is assumed that such value would represent a conservative approximation of its future value. Further, the government subsidies, both in cash and in kind, are treated as farmers' income.

105. The following key quantifiable benefits were taken into consideration on the economic analysis: (i) Direct production benefits as stated in the financial analysis, exclusive of government subsidies; (ii) carbon sequestration; and (iii) the retention of water, soil and nutrients. The project costs cover all incremental expenses under each and every component, including the O&M costs after the project completion.

106. Carbon sequestration: Vegetation and soils are widely recognized as carbon storage sinks. Sequestration of carbon in terrestrial ecosystems offers a low-cost means of reducing carbon emissions. The 'Kyoto Protocol' makes provisions for direct human-induced land use change and vegetation recovering activities to be considered in relation to each country's greenhouse gases reduction target. Various tree species would generate different incremental carbon sequestration over the production cycle. The increased biomass has used to estimate carbon sequestration. Based on latest Bank guidelines, a lowest shadow price of 40 USD/Ton is used in the analysis.

107. The retention of water, soil and nutrients: one of the key environmental benefits of the forest is the retention of water, soil and nutrients. In addition, reducing the sediment inflow into Rivers their tributaries have several benefits. Firstly, irrigation systems suffer less from large inflows of sediment that choke the canals and often make it necessary to stop diversions when sediment loads are high. Secondly, river channels become stable and maintenance costs for river draining works are reduced. Thirdly, sediment build up in downstream reservoirs is slowed. Fourthly, the rise of the riverbed in the rivers will be slowed and the cost of raising the flood embankments can be deferred. As such, based on the established practices in China, the economic value of water and soil retained is included in the analysis.

108. Based on the above, the analyses show that the returns for farmers planting walnut and tea are attractive with financial internal rate of returns(FIRR) of 12 percent and 16 percent respectively, while the economic internal rate of returns(EIRRs) are somewhat lower at 8 percent and 10 percent, respectively. Conversely, if farmers plant ecological trees for ecological protection, the financial return is low, at 6 percent, while the EIRR is high, at 16 percent. However, in the latter case, it is unlikely that the farmer would profit from the benefits attributable to the extra 10 percentage points of return from improving the ecosystem. As a result, the trees planted under this program are mainly economic crops such as tea and walnut

instead of ecological trees, thus discounting the environmental benefits the program intended to achieve.

109. Clearly, there is a divergence of interest between the environmental benefits enjoyed by society and the financial benefits/profits required by farmers, with farmers preferring to plant tree crops such as tea and walnut that offer the best returns. This has important policy implications because it suggests that subsidies paid to farmers for ecological forests should be raised if ecological forests are required to plant.

110. As such, to make forestry subsidy policy more effective and fairer, the current flat-rate model needs to be reformed to adequately compensate the substantially greater ecological and environmental contribution made by the ecological forest. In this regard, the government should make effort to establish and operationalize the mechanism for “payment for ecological service” (PES).

Case 7: The National Forest Reserve Program

111. In 2013, the SFA issued the National Timber Strategic Reserve Plan (2013–2020). To launch the plan, a pilot operation was established under which key state-owned forest farms in seven provinces were charged with planting 583,000 hectares of plantation—the national strategic reserve or national reserve forests. The objective of the national reserve forest program was to create a high-quality wood reserve for economic and social development. To realize the goals of the program, large areas of intensively managed plantation, including multifunction plantation with native and valuable species and long rotations, were established.

112. In 2014, the SFA expanded the program to 15 provinces, and in April 2018, the SFA launched the National Reserve Forest Program (2018–2035). Under the program, 7 and 20 million hectares of national reserve forest are to be established by 2020 and 2035, respectively. It is estimated that the program would increase average annual standing volume by 200 million cubic meters and improve the representation of rare, valuable, and large-dimension trees in forest stands.

113. To achieve these goals, a combination of new planting and improvement of existing forest will be undertaken. Three rotations are used for the forest management, which include the establishment and management of short-term (10 years), medium-term (11 to 30 years), and long-term (more than 30 years) forest stands. Site conditions permitting, around 20 tree species will be planted in mixtures to enhance sustainability. By the end of 2016, around 2.55 million ha of plantations have been established.

114. To evaluate the performance of the program, a case study was undertaken in Qipo State-owned Forest Farm in Nanning City, Guangxi Zhuang Autonomous Region. A comparison was drawn between two types of plantations—a mixture of eucalyptus with native tree species over a long-term management rotation, and a plantation of eucalyptus monocultures. Parameters measured under the different management regimes included growth rates, inputs/costs, and benefits.

Results Evaluation

115. A financial and economic evaluation of the National Forest Reserve Program was conducted in two plots in Qibo Forest Farm. The study areas covered 13.7 hectares of mixed plantation of Red Cone, Gemu, *Phoebe bournei*, Fragrant Nan, Flamingo, Ash, and Taiwan eucalyptus. The target stand is designed as a 40-year rotation, uneven ages, multifunction forest, balancing economic and ecological benefits. The forest multifunction will be developed by combining the planting of ecologically beneficial, long-rotation, valuable native tree species, which have low financial returns due to the longer investment period, and fast-growing and large-diameter eucalyptus (over 40 centimeters), which has higher financial returns but lower ecological benefits. More specifically:

- **Plot 1** covered a 13.7-hectare plantation, which comprised eucalyptus planted in December 2014 at a density of 1,470 plants per hectare, and seedlings of native tree species planted in 2015 at a density of 1,245 plants per hectare. The stand was developed under the close-to-nature concept. To achieve this, the eucalyptus would be partially selectively harvested after each four years, while leaving the complementary planting of more native broadleaf tree species with 150 plants of eucalyptus per hectare to form a stable mixed, uneven-aged stand. The design aims to combine long-term income and short-term income and balance economic benefits and long-term environmental benefits.
- **Plot 2** also covered 13.7 hectares, but was planted with only eucalyptus at a density of 1,470 plants per hectare in 2014. During 2015–17, weeding, fertilizing, and pruning were conducted once a year. The pruning focused on shaping the trees for higher-quality timber production.

116. A financial and economic analysis of the two plots showed that, without taking account of ecological benefits, the net income from eucalyptus and native tree species mixed plantation over 20 years was negative at RMB -7.5 million, far less than the RMB 268 million from eucalyptus monoculture plantation for timber production. However, including the value of ecological benefits, net income from the mixed-plantation forest models was RMB 11.26 million, and from monoculture eucalyptus plantation was around RMB 294 million. These results do not include data on carbon sequestration, but they do show that multifunction forests with multiple income streams are the most viable and sustainable approach to forest management. They also show that government preferential financing may be needed to support the forests that are managed for multiple uses, including generating environmental benefits.

D. Research Program

117. A paper in *Science* titled “Tree diversity improves forest productivity” (Sugden 2018) summarizes the trial results of mixed-species planting compared to monoculture planting in diverse subtropical forests in southeast China. In the trial, 150,000 trees of 40 different species were planted in plots of between 1 and 16 species mixtures at two sites of 40 hectares each. After eight years, it was found that species richness strongly increased stand productivity and that the 16-species mixture had accumulated twice as much above-ground carbon as in average monocultures. Even though a shrub layer reduced tree productivity slightly, this effect declined

with an increase in shrub species diversity. This trial provides additional evidence of the positive effects of tree species diversity on tree growth at the stand level in subtropical ecosystems and highlights the higher carbon sequestration potential of rich diversified mixed-species stands. To complement these gains, additional benefits would be obtained from improving biodiversity and strengthening forest resilience.

118. More specifically, at the end of the observation period, mixed stands with 16 species had accumulated about 1.7 times the amount of carbon found in the average monoculture. This effect is, on a relative scale, similar to the 1.8-fold average increase in above-ground stand biomass from monocultures to 16-species mixtures in a multisite grassland biodiversity experience. It is assumed this is because mixtures of a shade-tolerant evergreen and a shade-intolerant deciduous broadleaved species captured lighter than did species pairs with uniform leaf duration.

119. Given that plant biomass is higher in forests, and that the largest fraction of tree carbon is bound in relatively persistent woody biomass, these effects translate into large diversity-mediated rates of carbon accumulation. The first-order extrapolation based on this experiment is that the global scale indicated that a 10 percent decrease in tree species richness would lead to a 2.7 percent decrease in forest productivity on average.

IV. Contribution of Sustainable Forest Management to NDC

120. Forests can reduce the accumulation of greenhouse gases, thereby reducing the concentration of the gases in the atmosphere. As an important part of the terrestrial ecosystem, forest has huge biomass and is an important sink and reservoir of the Earth's carbon cycle, which is directly related to climate change. The data show that the forest absorbed 1.83 tons of CO₂ on average for every 1 cubic meter of biomass growth, which had a strong carbon sink function. Forest soil also has a strong carbon sink function. Afforestation and reforestation to increase the carbon sink of forests are recognized as the most economical and effective solutions to the rise of CO₂ in the world.

121. The four ways forestry mitigates climate change are by increasing forest carbon sequestration, reducing forest carbon emissions, increasing forest product carbon storage, and promoting forest product carbon replacement. Specific measures are to increase forest carbon sequestration through afforestation, vegetation restoration, and sustainable forest management; reduce carbon emissions from forests by controlling logging, reducing deforestation, preventing and controlling forest fires, diseases and insect pest outbreaks; increase the use of wood forest products to store carbon; and use wood forest products to partially replace other fossil energy and products to reduce carbon emissions caused by the use of fossil energy. As this review focuses on forest management, it will concentrate on how sustainable forest management could contribute to carbon sequestration and carbon emissions reduction, to achieve China's NDC. It can do so by:

- (a) **Expanding forest area and increasing carbon sink through afforestation.** This is the most direct and effective way to expand forest carbon sink. China's forest coverage rate is low, and afforestation increases forest cover, which will increase carbon

sequestration. China still has 57 million hectares of barren mountains and wasteland suitable for forest, and 174 million hectares of decertified land, which will be used for afforestation. By 2050, China's forest coverage rate will increase from 23 percent to more than 26 percent. According to the 2017 GoC report, "China Forest Actions for Addressing Climate Change," (published by State Forestry Administration in 2008) even if the current practice of forest management continues, the annual total amount of fixed CO₂ absorbed by forests in China will probably increase by 500 million tons by 2050.

- (b) **Increasing carbon sinks by improving the quality of existing forest resources.** The average storage volume of China's existing forest resources is about 84 cubic meters per hectare, and the average annual growth rate per hectare is about 3.55 cubic meters, less than one-fourth to one-third of developed countries. The carbon storage capacity of China's existing forest vegetation is only 44.3 percent of its potential carbon storage capacity. According to "China Forest Actions for Addressing Climate Change" , through improved forest management practices, increased forest photosynthetic leaf area, and other measures to strengthen forest management, growth can potentially be doubled (GoC 2017).
- (c) **Expanding the potential of forests to mitigate climate change by strengthening forest protection and resilience to reduce carbon emissions from forests.** By adopting low-impact logging operation measures, such as selective cutting, to protect forest vegetation and soil, carbon emission caused by destruction of groundcover and soil can be reduced, and controlling forest fires and pest outbreaks will reduce the carbon released into the atmosphere. Therefore, through improved cutting practices, effective monitoring, control of pest outbreaks, and establishment of a diversified, resilient forest ecosystem, the frequency of forest fire, pest and disease, and natural disasters will be better controlled, leading to reduced carbon emissions from forests.
- (d) **Protecting the organic carbon stored in forest soil by controlling soil erosion in forestland.** Forest soil stores a large amount of organic carbon, accounting for more than 60 percent of total forest ecosystem carbon reserves. At the same time, the study also showed that organic matter in forest soil can capture and oxidize methane in the atmosphere, which helps absorb and fix methane in the atmosphere and plays a positive role in mitigating climate change. However, soil erosion will lead to the decomposition and emission of organic carbon in the soil, reducing the soil's ability to capture methane. Thus, the conversion of non-forest soil to forest soil will be facilitated by increasing and retaining forestland vegetation. Experts estimate that controlling soil erosion could increase soil organic carbon by more than 50 percent a year. The area of soil and water loss in China has reached 356 million hectares. By implementing biological measures to control soil and water loss and reduce the degree of soil exposure, carbon emissions caused by soil and water loss will be greatly reduced, and organic carbon in soil will be increased.

122. According to national forestry inventory report (2014-2018), China's forests absorbed around 434 million tons of CO₂ each year, equivalent to 8 percent of total greenhouse gas

emissions for the entire country over the same period. Based on the Bank-financed forestry project monitoring results that the adaptation of the mixed species and multifunction forest models, combining with the used of improved genetic seedlings, well site and species matching, natural regeneration promotion and underground vegetation protection and long-term forest management will increase around 20-30 percent of forest growth in average, then increase same portions of carbon sequestration capacity of the forests, compared with the existing monocultural forests, which are more than 70% percent of total plantations in China. Research has shown similar results. Therefore, it is estimated that by adapting sustainable forest management practice to afforestation and forest management, annual CO₂ sequestration in China's forests will be increased by more than 20% or more than 200 million tons, which will contribute significantly to the achievement of China's NDC. Sugden (2018) even shows that mixed stands have accumulated around 1.7 times the amount of CO₂ as monoculture, on average.

V. Forestry Financing Review

A. Government Financing Policies on Forest Management

123. The GoC's investment in forestry has expanded considerably since 2015, with most finance coming from the state budget, domestic loans, foreign loans, private capital (companies and individual farmers) and donations. Between 2015 and 2017, funding increased from RMB 429.16 billion to RMB 480.206 billion, with an average annual growth of 5.78 percent. In 2017, funding from the national forestry budget reached RMB 480.026 billion, an increase of 6.45 percent over 2016.

124. State budgetary allocations account for 47 percent of total funding, or RMB 225.923 billion; the remainder comprises private capital (RMB 135.404 billion, or 28.21 percent), foreign contributions (RMB 2.13 billion, or 0.44 percent), and other sources (RMB 69.891 billion, or 14.56 percent). Most funding for forestry has gone into commercial plantations and ecological forests. The forestry programs that are directly financed by the central government are intended to meet the costs of forest management and tending, ecological protection, reform of state forest farms, and forestry development. Subnational sources of funding are also available at the provincial and county levels and are intended to help finance local forestry initiatives supportive of central government policies.

125. Assured sources of financing are crucial to ecological forests, especially with the shift in emphasis in China from self-financing timber production to environmental services and carbon sequestration. Recognizing that incentives would be needed to compensate forest owners for engaging in ecological forest management, a forest eco-compensation mechanism was launched in the early 20th century, with different compensation rates applicable for establishing and tending ecological forests. To expand planting, the Central Government Financial Compensation Fund was created in 2004, an instrument that has become the most important source of financing for ecological forestry.

126. Currently, government incentives are delivered through the following channels:

- (a) **Financial transfer payments.** These take the form of fiscal transfers such as central-to-local government and provincial-to-county transfers. During the 13th Five-Year Plan period, the central government plans to have eco-compensation or ecological payment transfer systems in all key national-level ecological function zones, though it still needs to assign values to ecological services and establish a viable operational system for its delivery.
- (b) **Ecological programs with eco-compensation characteristics and functions.** These include the Conversion of Cropland to Forest and Grassland Program (the Grain for Green Program), the Beijing-Tianjin Sandstorm Control Program, and the Natural Forest Protection Program.
- (c) **Natural resources environmental taxes and fees.** At present, China has 14 environment-related taxes and fees, and the National Development and Reform Commission intends to incorporate an eco-compensation component into these to create a stable and sustainable source of revenue for public sector eco-compensation.

127. Since 2004, the central government of China has gradually launched pilots in support of forest tending, afforestation, tree species improvement, and forest insurance subsidies, and this pilot has since been expanded upon slightly. The “Methods for Forestry Reform and Development Funds Management” (Document Cai Nong No. [2016] 196), issued by Ministry of Finance and State Forestry Administration stipulates the criteria for eligible expenditure in forestry, such as forest resources protection and management, natural forest protection and management, compensation payments for the provision of forest ecological services, tree species improvement (tree breeding), afforestation, and forest tending. Subsidies for forest tree improvement aim at improving seedling quality and cultivation; forest tending subsidies target tending operations in young and middle-aged stands in ecological forests owned by the state, collectives, or individuals; grants for wetland protection and national-level forest reserves may be used for ecological protection systems; and subsidies for state forest farm reforms comprise a one-time payment in support of payments made by state forest farms for staff pensions and medical insurance, and for start-up costs of schools and hospitals, and the forestry development subsidy is designed to provide support to forestry scientific and technical extension and demonstration. The subsidized interest rate for forestry policy loans is at present a 3-percentage-point discount. The values of the various subsidies available to forestry programs are shown in table 6.

Table 3. Subsidies for the Forestry Reform and Development Programs

Category of Subsidy	Specific Purposes	Criteria
Forest Resources Protection and Management	Natural Forest Protection and Management	RMB 90/ha/year
	Compensation for Forest Ecological Services	RMB 150/ha/year
Forest Resources Development	Quality Varieties Breeding and Seedling Cultivation	RMB 7,500/ha/year
	Afforestation	RMB 1,500–3,000/ha/year
	Forest Tending	RMB 1,800/ha/year
	Wetland Protection	Actual costs

Ecological System Protection	National Forest Natural Reserves	
State Forest Farms' Reform	Staff Insurance	RMB 20,000 per staff member
	State Forest Farms' Costs for the Establishment of schools, hospitals, etc under the State Forest Farm system.	RMB 1.15/ha
Forestry Industry Development	Forestry Sci-tech Extension and Demonstration	Actual costs
	Interest Discounting for Forestry Loans	3 percent off current rate

128. Table 3 shows that several forestry-related eco-compensation mechanisms are already in use in China. In addition, the National Plan for the Development of Priority Zones came into force in 2009, the aim of which was to identify and designate priority ecological zones in need of protection, and promote or expand the use of eco-compensation payments for their sustainable management and protection. Over the last 10 years, government expenditure under these programs has steadily increased. In 2017, RMB 225.9 billion in financial compensation and subsidy payments was spent on forestry-related ecological restoration programs, including afforestation, forest tending, and quality improvement, of which around RMB 110.8 billion came from the central government and RMB 115.1 billion from provincial and county governments. Payments under these programs resemble payments for environmental services, the main difference being that they are not market based and bear no relation to the value or the costs of services being provided.

129. At present, expenditure on ecological forests is heavily dependent on funding from the Central Financial Compensation Fund, and the demand for such funding far outstrips supply in that the amount of funding available is insufficient to treat areas in need of rehabilitation and protection, such as low-quality forest stands in ecologically sensitive areas. The overdependence of ecological forestry programs on state funding sources has its drawbacks in that they are highly vulnerable to cuts in times of budgetary restraint. To improve the sustainability of such operations, additional sources of funding must be explored to ensure the continuity of forest management over the long term. These might include local financial compensation funds, taxes on nonrenewable resources and energy, tourism, individual donations, and contributions from the private sector. Ideally, a market-based mechanism is required whereby fees paid by the beneficiaries of ecological services such as clean water users; the same principle can be applied to forest operations that sequester carbon. It is also important to develop broader investment instruments to attract the private sector's engagement in forest management, such as credit and public-private financing.

B. Evaluation of Forest Carbon Financing

130. The evolution of and early experience with forest carbon trading highlights its potential to grow as a financing source in support of forest resources management in China. The experience of forest carbon projects implemented with support of the Clean Development Mechanism (CDM), and voluntary domestic action through piloting emission trading systems, highlight the scope of forest carbon trading as a key source of financing for sustainable forest management, and for supporting the target of increasing the national forest stock by 4.5 billion cubic meters by 2030, as China committed to in its Nationally Determined Contributions (NDCs) to combat climate change.

131. **Forest Carbon Trading as a Financial Mechanism.** Reducing CO₂ emissions and increasing CO₂ absorption are the priorities in combating climate change. The UNFCCC required countries to implement measures to limit greenhouse gas emissions and provide financial and technical assistance to developing countries to respond to climate change risk. Under the convention, China as a developing country does not undertake legally binding emission reduction obligations.

132. The Third Conference of Parties (COP3) to the UNFCCC, held in Kyoto, Japan, in 1997, adopted the Kyoto Protocol, which facilitated developed countries achieving emission reduction targets at lower cost through market-based mechanisms such as the CDM, joint implementation, and emissions trading. The CDM allowed credits issued for CO₂ absorbed by afforestation or reforestation projects implemented in developing countries to offset developed country’s emissions, and enabled the initiation of forest carbon trading in China.

133. **Present Status of International Forest Carbon Financing.** Under the Kyoto Protocol mechanisms that enabled international carbon trading to support compliance and voluntary carbon market initiatives, the forest carbon trading evolved and reached a market volume of 35.3 million tons of carbon dioxide equivalent traded, valued at US\$2.789 billion dollars (see table 4).

Table 4. Summary of Types of Forest Carbon Transactions, 2009–2016*

Finance Type	Financing Sources	2016	All Years**
Market	Voluntary forest carbon offset transactions	US\$74.2 million	US\$996.6 million
	Compliance forest carbon offset transactions***	US\$551.4 million	US\$1,573.9 million
Non-Market	Payments for REDD+ program	US\$36.5 million	US\$218.0 million
Total		US\$662.1 million	US\$2,788.5 million

Source: Hamrick and Gallant. 2017.

Note: *Ecosystem Marketplace has been tracking forest carbon finance annually since 2009, but the data go back as far as the early 2000s, when payments for forest-based emissions reductions were just beginning. **All years refer to the total reported financing associated with the forest carbon trading since the early 2000’s. ***This compliance market value includes Australia’s Emissions Reduction Fund’s payments for land-use offsets, worth an estimated US\$1.2 billion across all years, and US\$509.5 million in 2016, which awarded contracts through a competitive auction, with government as the buyer. Without the Australia value, compliance market payments in 2016 were US\$41.9 million.

134. At the early stage of the carbon market, carbon offsets from forests and land-use were traded on the voluntary market. Gradually, national or regional carbon trading systems have been established led by the growth of compliance carbon markets.

135. **Voluntary Market for Forestry Carbon Credit Transactions.** The voluntary market for forest carbon trading allows transactions involving buyers and sellers that are not subject to the mandatory emission reduction policies of national governments. As a result, it is flexible in terms of types of carbon credits produced and transacted. The value of forest carbon offsets

traded on the voluntary carbon market was about US\$1 billion in 2016 from the transactions of 14.3 million tons of carbon dioxide equivalent (tCO₂e).

136. Even though the GoC supports the development of a voluntary carbon market, most voluntary carbon trading are not regulated by the government. This makes the global unregulated voluntary carbon market more flexible than the regulated market because it does not limit what types of carbon credits buyers may purchase and where they may offset them.

137. Buyers in the voluntary market buy offset carbon credits for many different purposes, from branding to employee engagement, to meet their own greenhouse gas reduction targets. In many cases, they pay more attention to the comprehensive benefits of the project, such as public health improvement, biodiversity conservation and clean water supply. As a result, voluntary markets are diverse, with varying prices and broader offset quality than compliance markets. However, because of this, they also tend to be more innovative than those in the regulated market; quite often, innovations born and tested in the voluntary market are subsequently modified to allow them to qualify for inclusion in the regulated market.

138. **Forestry Carbon Trading in Compliance Market.** The CDM under the Kyoto Protocol enabled developed countries to support developing countries to implement afforestation/reforestation projects to achieve mutual benefits of cost-effective emission reduction in developed countries and to improve forest resources and livelihoods of rural communities in developing countries. The number of afforestation/reforestation projects registered was significantly lower than those registered in other sectors eligible under the CDM.

139. By 2018, the CDM Executive Board registered 66 afforestation/reforestation projects, of which 18 were registered in India, 8 in Colombia, 11 in Uganda, and 5 in China. The annual emission reduction of all afforestation/reforestation projects is approximately 2,202,232 tCO₂e. The unit price of carbon credit varies across projects. In addition to the CDM, other forms of compliance markets include a cap-and-trade system that allows regulated entities to purchase and trade emission allowances to meet their compliance requirements. Examples of cap-and-trade systems that allow forest carbon offsets include Tokyo-Saitama Cap-and-Trade, the Emissions Trading System (K-ETS) of Korea, Québec's cap-and-trade program, the Alberta offset credit system, the British Columbia Climate Action Plan, and the California cap-and-trade program.

140. **Forest Carbon Market Development in China.** Forest carbon market development in China was initiated with support of the CDM, and advanced with support of domestic voluntary action.

(a) **Forest carbon trading with support of the CDM**

141. Forestry carbon trading in China began in 2006 with the Bank-financed Guangxi Integrated Forestry Development and Conservation Project. This project included the pilot carbon trading operations (aimed at exploring the market potential of forests). The Facilitating Reforestation for Guangxi Watershed Management in Pearl River Basin Project, designed in

accordance with CDM rules, was the first registered CDM afforestation/reforestation project worldwide and served as a milestone in promoting afforestation and reforestation efforts to combat climate change. The second Guangxi project implemented with support of the CDM, called Reforestation on Degraded Lands in Northwest Guangxi, also complied with the Climate, Community and Biodiversity (CCB) Standards and won a gold medal as a CCB standards project. Both pilots successfully demonstrated the technical and institutional partnerships of forest farms, households, and communities in implementing afforestation and reforestation activities on degraded lands.

142. The two Guangxi CDM pilots also sought to demonstrate the financial viability of tree planting to sequester carbon through the reforestation of degraded barren lands with the support of payments to the carbon sequestered through the projects. The pilots served as a pre-financing mechanism to make early payments to householders for carbon sequestered in plantations with payments from the BioCarbon Fund. Communities benefited from the sale of the carbon credits to the BioCarbon Fund and from the sale of products such as resin collected from forest stands. The pilot projects also succeeded in demonstrating the promising ways of involving small farmers in tree planting for carbon sequestration and trading under the CDM. In addition to the two Guangxi projects, two afforestation/reforestation projects in Sichuan Province and one in Inner Mongolia are implemented with support of the CDM.

(b) Forest carbon trading with support of domestic voluntary action

143. The carbon market advanced in China with the support of domestic voluntary action through the National Development and Reform Commission, which approved seven pilot emissions trading systems, in Beijing, Chongqing, Guangdong, Hubei, Shanghai, Shenzhen, and Tianjin Provinces. Under the pilots, carbon emission quotas were traded under the cap-and-trade scheme in the electricity, chemical, petrochemical, and steel sectors. The trade of 135 million tons of carbon emission quotas was valued at RMB 2.764 billion by December 2017 at an average price RMB20.47 per ton, ranged from RMB 3.90 and RMB 50.43 per ton.

144. Although pilot emission trading systems were successful in trading significant volumes of allowances, forestry's participation in the domestic voluntary carbon market has been insignificant. A few forestry project carbon offsets were developed with the support of the China Green Carbon Foundation, and a few forest carbon projects have been traded in the Beijing or Fujian carbon markets as CCERs. However, the forest carbon projects are not yet operational under the national Emissions Trading System.

(c) Realizing the potential of forest carbon trading in China

145. The potential for forest carbon trading in China is significant. The total carbon stored by forests in China is about 8.427 billion tons, with an annual forest carbon sequestration of about 500 million tons of CO₂ per year. During the last three decades, the government has implemented several major forestry projects such as the Grain for Green Project, the Three North Shelterbelt Project, the Yangzi River Basin Shelterbelt Project, and the Beijing-Tianjin Sandstorm Source Control Project. A large proportion of forests created under these projects have high capacity for carbon sequestration, and about 90 million hectares of land are available

for tree planting for sequestering carbon. China's forest resources play a major role in advancing the national climate change agenda. With fast-growing forest biomass and the largest area of planted forests in the world, forest resources are expected to play a significant role in the country's commitment to address climate change risk and to achieve its NDC targets of an increase of 4.5 billion cubic meters of forest carbon stock by 2030 over 2005 levels.

146. The experience with forest carbon trading under the CDM, domestic voluntary action supported by the CCERs scheme, and other voluntary standards indicate that time and costs associated with the design, implementation, validation, and verification of forest carbon projects can be significant. Attention is needed to improve the contribution of forest carbon trading, the slow uptake of forest carbon projects, financing of start-up costs, and the low market price for carbon.

147. The recent Action Plan for Establishment of Market-based and Ecological Conservation Compensation Mechanisms (January 2019) communicated by the central government to the provincial governments calls for the establishment of market-based ecological compensation mechanisms to stimulate large-scale participation of public and private sector enterprises and stakeholders in ecological conservation. The action plan emphasizes voluntary forest carbon sequestration projects to harness ecological, social and economic benefits; attract private sector investment; and enable carbon markets to play a significant role in ecological restoration, with priority given to forest carbon sequestration projects in poverty-stricken areas.

148. Improving and strengthening forest carbon trading through domestic voluntary action to enhance the supply of forest carbon offsets and promote market-based ecological compensation mechanisms will stimulate public and private investment in multiuse forest management, which is expected to increase the flow of funds to forests. Meanwhile, various obstacles must be removed, some of which have been highlighted above.

C. Forestry Credit Policies

149. Forestry credit financing in China takes the form of either a Forest Rights Mortgage Loan or a Forestry Policy Loan. Forest Rights Mortgage Loans were first piloted in 2003, after which they were scaled up nationwide. In 2017, the NFGA, in collaboration with the China Development Bank (CDB) and China Agricultural Development Bank (CADB), introduced Forestry Development and Policy Loans (also called Forestry Policy Loans) to help fill financing gaps in forestry. These have become an important source of credit for forestry and are described in more detail below.

150. **Forest Rights Mortgage Loans (FRMLs).** In 2003, when Fujian Province piloted FRMLs, it also launched the first forest counter-guarantee loan. Thereafter, in 2008, the Central Committee of the Communist Party of China and the State Council issued "Opinions on Comprehensively Advancing Reform of Collective Forest Property Right System" (Document Zhong Fa No. (2008) 10), which expanded the scope of the FRML to include forestland management rights and ownership. Following this, the State Council issued "Opinions on Deepening Reform of Investment and Financing System" (Document Zhong Fa No. (2008) 18) in 2008, which required that efforts also be made to offer loans that could use the usufruct of

forest management and compensation payments received from ecological forests as collateral against the loan, thereby broadening the scope of the FRML. Since then, there has been a rapid increase in the uptake of FRMLs, and by 2010, lending had reached RMB 29.98 billion, and by 2016, RMB 130 billion nationwide, a tenfold increase.

151. **Secured Mortgages and Loans.** Loans that use usufruct and compensation payments from ecological forest as security are a promising and innovative mechanism that could be used to finance ecological forestry operations. Such a “pledge” of usufruct rights together with the income expected from ecological compensation payments can be an effective way of securing loan funds in support of ecological forest development. In March 2016, Lishui County, in Zhejiang Province, was selected by the NFGA to pilot the comprehensive reform of collective forest management during which it explored the use of the “usufruct pledge” to secure a loan for ecological forest development.

152. Under the usufruct pledge model, forestry farmers first go to their local forestry office at the township level to obtain a usufruct certificate or certifying document for their ecological forests. Thereafter, they can apply to a financial institution for a loan using the usufruct as a pledge, or security. Under this system, the farmer may obtain a loan of up to 10 times the value of the annual ecological compensation payments that she or he obtains from the government for their ecological forest. The loan period is a maximum of five years and a discounted interest rate is applied. Loan funds can be used for afforestation, forest management, and farming-related livelihood activities (see box 1 for details).

Box 1. Lishui County Experience and Approaches Promoting Compensation Usufruct Pledge Loans for Ecological Forests

In 2016, Lishui County established a usufruct certification system, which defined the usufruct of individual households for compensation of public welfare forests. Under the system, holders of the compensation usufruct apply to the local forestry bureau for a certificate that records the name of the holder, the size and location of the particular public welfare forest, the amount of compensation to which they are entitled, the pledge (transfer) registration, and other relevant information, as legitimate and valid proof for holding compensation usufruct of the particular public welfare forest. The holders can use the compensation usufruct certificate as a pledge to apply for a loan from the local bank.

Lishui County also established a registration system for compensation of the usufruct pledge of public welfare forests. The registration system is maintained by the forestry bureau in the jurisdiction in which the public forest is located. When a borrower applies to a financial institution for a compensation usufruct pledge loan of public welfare forest, or a farmer transfers her or his compensation usufruct of public welfare forest, they must register the usufruct pledge (or transfer) on the Zhongzheng Unified Registration Platform for Receivables, launched by the Credit Investigation Center of the People’s Bank of China, and file the registration form with the local forestry bureau. The registration requires supporting documents such as a compensation usufruct certificate or a loan contract with the financial institution.

Financial institutions standardized the loan process to more expeditiously process pledge loans. Streamlined procedures and preferential interest rates were adopted. A risk management mechanism was established through the participation of guarantee institutions to provide guarantees for the pledge financing, with risk sharing arrangements between the banking and guarantee institutions to ensure the efficacy of loan risk management.

Lishui Country also established a mechanism to deal with overdue loans. The compensation usufruct pledge loan agreement between a borrower and a financial institution provides that, in case of an overdue loan, the Lishui County forestry bureau and finance bureau shall assist the transfer of annual compensation for public welfare forest

to the financial institution until the principle and interest are repaid. The financial institution can also choose to assign the compensation usufruct to a third party to secure the right of subrogation. Lishui County also launched a collection and reserve platform for public welfare forest compensation usufruct and a risk compensation system as additional approaches to dispose of the pledged usufructs.

153. **Forestry Policy Loans.** The “Notification on Promoting Forest Ecological Construction by Further Advancing Forestry Policy Financing” (Document Fagai Nongjing No. 017 (140), issued by the National Development and Reform Commission, identified priority areas for the use of Forestry Policy Loans. These areas are national reserve forests, forest ecological protection areas, and forestry development and forestry-based ecological poverty alleviation programs. It also gave authority to the CDB and CADB to provide long-term maturity and low-cost loans (a 30-year maturity with an 8-year grace period, base rate, and lowest minimal capital ratio) to support those activities. The document also allowed central government budgetary investments to be treated as capital fund expenditures in qualifying projects, which encouraged forest entities to obtain Forestry Policy Loans. Forestry lending volumes made by the CBD and CADB during 2016–2018 are shown in table 5.

Table 5. Loans Issued by CBD and CADB, 2016–2018
Unit Cost: RMB billion

Source	2016		2017		2018	
	Approved	Disbursed	Approved	Disbursed	Approved	Disbursed
CDB	21.80	6.65	63.06	14.08	81.01	19.37
CADB	33.30	12.08	53.85	26.09	75.64	38.06
Total	55.10	18.73	1,16.91	40.17	1,56.66	57.34

Source: State Forestry Administration in 2018.

154. By the end of 2018, the CDB and CADB had approved loans totaling RMB 1,156.656 billion to 203 major forestry projects, including national timber reserve projects. Compared with 2017, loan amounts approved and disbursed by the CDB and CADB had increased by RMB 17.949 billion and RMB 5.338 billion, respectively, and by RMB 22.699 billion and RMB 13.649 billion, respectively.

155. Forest policy loans are preferential loans with preferential interest rates and longer maturity periods than commercial loans. In 2015, several provinces, including Guangxi, Jiangxi, and Fujian, piloted forestry policy loan operations with considerable success. For instance, the typical model, called the “State-owned forestry company + Forest rights mortgage” model, has been broadly used in China. Under this model, the government designates a state-owned forestry company to be responsible for borrowing and managing the loan, and for repaying the principle and interest of the loan using income from the project. State forest farms and other project implementation agencies are the actual users of the loan, and entrust the state forestry company to mortgage their forest rights (user rights to the forestland and rights of the forests). In addition, government afforestation subsidies are available through discounted loan interest rates available to the forestry projects.

156. Guangxi was one of the first provinces to pilot a national timber reserve forest base development project. The project required the establishment of 1.4 million hectares of timber reserve forest between 2015 and 2020. The first phase of the operation involved planting 0.5 million hectares of plantation, for which the province obtained a loan of RMB 10 billion from the CDB, with a 27-year maturation period (and an 8-year repayment grace), and base rate interest payments. The Guangxi regional government designated the Guangxi Forestry Group as the financing vehicle with overall responsibility for borrowing, managing, and repaying the loan principle plus interest to the CDB. Loan users included forest farms and companies, which were made responsible for carrying out fieldwork and repaying the loan principle and interest to the borrowing entity. The details are presented in table 6.

Table 6. Loan Model Guangxi National Timber Reserve Forest Development Project

Borrower	Guangxi Forestry Group
Loan Users	13 regional-level state-owned forest farms and 2 regional-level state-owned forestry companies
Loan Amount and Term	A medium- and long-term loan of RMB 10 billion, with a maturity term of 27 years, including an 8-year grace period
Fund Source for Repayment	Project cash flow (incl. income from felling), totalling RMB 22.6 billion
Credit Structure	(a) Forest rights mortgage for guarantee: maximum of RMB 17.4 billion (b) Loan loss provision: adequate to cover principle and interest on loan (c) Forestry comprehensive insurance: policy insurance and commercial insurance covering full amount of loan principle and interest

157. To prevent and control risks, Guangxi established a mechanism of “Loan loss provision + Forest rights mortgage + Forestry insurance” to form a multilayer risk prevention security system to enhance project creditworthiness. Through the establishment of a united loan borrowing platform (Guangxi Forestry Group), the difficulties of managing scattered and small-scale forest projects were successfully addressed, which helped attract the support of financing institutions for afforestation and forest management projects.

D. Forestry Public-Private Partnership (PPP) Financing

158. To explore the potential of forestry property rights financing mechanisms, and to mobilize social capital for forestry development, the SFGA, Ministry of Finance, and National Development and Reform Commission jointly issued two documents in 2016, Document LinGuifa No. [2016] 168 titled “Guiding Opinion on Using PPP Models to Promote Forest Ecological Construction, Protection and Utilization,” and Document Fagai Nongjing No. [2016] 2455 titled “Guiding Opinion on Using PPP Models to Promote Forestry Development.” These documents assigned priority to funding forestry ecological protection and restoration, national timber reserve development, infrastructure construction in forest areas, forestry economic reform, forest protection, and wildlife protection. The directives encouraged innovation in the use of alternative financing mechanisms, such as trust funds, project financing, finance/leasing, and green financial bonds. The overall aim of these directives was to identify additional investment and financing platforms for social capital investment in forestry development.

159. The PPP is a new model for promoting social capital in forestry investment. As of May 2019, there were 39 PPP forestry project proposals in the Ministry of Finance's PPP project pool. The main features of forestry PPP projects are that (a) the build-own-transfer model is being used in most projects, and other operational models are few; (b) most program proposals are at an early stage of preparation; (c) the "Payment by User plus Viability Gap Funding" principle is being followed; and (d) the social capital partners of most forestry PPP projects are state-owned enterprises, suggesting that forestry PPPs are unattractive to private investors.

160. Nanping City in Fujian Province took the lead in piloting a PPP financing model for its national timber reserve forest development project. The project's objective was to support the development of national timber reserve forests covering 312,600 hectares, with a total investment of RMB 21.6 billion, including RMB 17.0 billion of loans from the CDB. The activities include afforestation, quality improvement for existing forests, understory planting, and forest protection. The project contract covered a 38-year period, including an 8-year program implementation and 30-year forest management. Social investors will recover their capital and revenue from the "payment for user" and "viability gap funding" principle, of which the former comes from the forest production income earned by investors, and the latter from the local government as a subsidy to meet the income gaps of investors. On expiry of the contract, social investors are obliged to hand over, free of charge, ownership of the forests to local county governments. The handover must also include the right to manage the forests, project technical know-how, intellectual property rights, and other relevant intangible assets (licenses) needed for forest management.

E. Issues Concerning Forestry Financing

161. The successful implementation of ecological forestry projects needs access to reliable, long-term, and stable funding sources. However, even though government financing in China is considerable in absolute terms, it is still insufficient to address countrywide requirements. Mobilizing additional nongovernment funding sources has been explored; however, the private sector is reluctant to invest in ecological forest management. The major constraints on forestry financing are as follows.

(a) Inadequate Government Financing to Ecological Forest Projects

162. The 13th Five-Year Plan for Forestry Development in China states that, by 2020, the main objectives of forestry development will be to increase forest stock volume from 1.51 billion cubic meters to 1.65 billion cubic meters, stabilize wetland areas at 53 million hectares, maintain the ratio of forest natural reserves to land area at 17 percent, and increase the area of rehabilitated decertified land by 10 million hectares. To achieve these goals, huge investments will be needed, and the funding gaps are existed. In addition, under the existing forestry subsidy system, the government subsidies for afforestation and forest management have not reflected the actual costs. Empirical studies and actual investments show that the cost of afforestation is between RMB 12,000 and RMB 22,500 per hectare. However, central government subsidies on protection forest planting are only RMB 3,000 to RMB 7,500 per hectare, which are far below actual afforestation costs. For forest tending, the existing subsidy is RMB 1,500 per hectare, which covers only a fraction of the actual cost of between RMB 4,500 to RMB 7,500 per hectare

in central and western China, and between RMB 12,000 to RMB 15,000 per hectare in eastern China.

163. In conclusion, current government financing suffers three shortcomings: (a) only flat rate payments (the average) are available, which fail to take account of different ecological conditions and management costs; (b) payments do not take account of the costs and values of services being provided in strategically important ecological areas; and (c) payments have not kept pace with rising costs, especially labor.

(b) Lending Institutions Do Not Address the Needs of Small-Scale Forestry Operators and the Long Gestation Period of Forest Crops

164. Forest projects are long-term in nature, their economic benefits are low, and they face risks from disease, fire, and other natural disasters. That is, they are high-risk, low-financial-return products compared with other sectors of the economy. This deters financial institutions from lending for forestry operations such as afforestation. Where loans are available, they tend to be concentrated on large-scale forestry projects and large-scale enterprises, which have strong financial performance. Small-scale forestry entities, communities, and individual householders find it difficult to obtain loans. According to statistics, almost all of the loans from the development banks were made available to large-scale forestry entities in 2018.

165. A further constraint to obtaining loans for forestry is that loans are available over the short term, having maturity periods of 1 to 5 years, whereas most forest rotations run for 20 to 25 years (Chinese fir and Masson pine), or 20 to 35 years in the case of most broadleaf tree species.

(c) Insufficient Enabling Environment for Forest Financing

166. Supporting policies for forest financing are not fully in place, which creates three main obstacles to forestry projects obtaining credit funds. First, the forest harvest quota system is at odds with forest management needs (forests need thinning and selective felling to remain healthy), and this prevents forest owners from earning income to help pay off their loans. Second, the forest resources asset assessment and evaluation are incomplete and, as a result, discrepancies arise between the estimated and actual extent and value of the growing stock and its mortgageable value. Third, the existing system of forest insurance is incomplete and does not provide adequate coverage to mitigate the risks faced in forestry, which also deters potential lenders from offering credit to investors in the forestry sector.

VI. Lessons Learned and Policy Recommendations

A. Adopt Close-to-Nature Forest Management Regimes

167. The experience and evidence reviewed in this study suggest that the contribution of forests to addressing climate change and achieving China's NDCs can be better realized through the adoption of forest policies and management regimes aimed at creating mixed-species, ecologically resilient, high-quality, and multifunction forests. This "close-to-nature" forest

management approach requires that the creation and management of forests be based on the natural growth cycles of the forests, which involve the planting and management of multiple tree species stands, and the maintenance of a biologically stable tree species spatial arrangement and structure, which jointly create resilient and healthy forest ecosystems.

168. The following design principles are recommended to support close-to-nature forest management:

- (a) **Protect the site productivity potential by taking account of natural conditions.** Site productivity potential refers to the natural growth potential under existing forestland site conditions. Close-to-nature forestry is based on a site's natural potential and its natural regeneration potential but uses human interventions to support natural processes. It requires a full understanding of the distribution of natural vegetation and the natural vegetative succession at the site. The Bank-financed forestry projects and Sino-German programs in China demonstrated good practice in this respect by modifying site preparation methods from complete ploughing to planting pits to minimize disturbing the native vegetation and promote low-density forestation to encourage natural regeneration. These practices played a key role in reducing costs, improving the diversity of tree species, and strengthening the stability of the forest ecosystem.

These practices have also proved superior to traditional practices, where heavy investments were used to create high-density monoculture tree plantations without an understory. Such was the case in the 1980s when Chinese fir was planted at a density of 4,000 to 6,000 plants per hectare, which increased costs dramatically and resulted in a need to thin and tend the crop early in the rotation. It also reduced soil fertility, suppressed the natural vegetation, and lowered the forest's ecological function. Both the SEAP and the IFDP avoided this by reducing planting density of Chinese fir to 2,000 to 2,500 plants per hectare, which encouraged the development of thicker groundcover and improved biodiversity, and also lowered costs.

- (b) **Tree species must be matched to site potential, and site potential must provide the basis for species selection and forest management.** The Bank-supported programs followed best practice in this respect by better matching site conditions, species selection, and silvicultural management prescriptions. Native tree species with high ecological adaptability must always be prioritized for close-to-nature forestation, with the aim of taking full advantage of their capacity to improve biodiversity, conserve soil nutrients, and withstand natural disasters. The widespread use of native broadleaf trees in the restoration of degraded forestland under the Bank-supported projects in China has effectively demonstrated the protective capacity, adaptability, and carbon sequestration potential in China.
- (c) **Use a mixture of species for afforestation and promote long-term forest management.** The use of mixed species is fundamental to maintaining the ecological balance of forests. Both the Bank and the German government financed forestry projects are found to improve forest ecosystem restoration with planting of varieties of forest species. Planting mixed species and different age classes should therefore be achieved

by using a mixture of conifers, broadleaves, shrubs, herbs, and so on, thereby creating a highly productive and diverse forest structure, with broadleaf trees serving to build up ground litter, humus, and soil fertility. When mixed-species stands are to be created, those tree species intended to form the main crop should be selected to yield both ecological and economic benefits.

Even though the GoC's policy is to encourage planting mixed forests, there are no technical standards to guide this process. Planting under the HFRDP was carried out based on sub-compartment topography, site conditions, and species compatibility. This had the effect of mimicking natural conditions in the native forests by including at least three to five tree species in a species association at the sub-compartment level, with each associative tree species comprising around 10 percent of the total. Improvements to existing forest stands should take the form of replacement or enrichment planting, which may be conducted in different ways such as with three to five seedlings planted as a group to form a mixed-species cluster, or different tree species planted successively in more than one line to form a line-shaped mixed forest, or irregular enrichment planting can be conducted through random spatial planting. Underplanting existing forest requires the use of shade-tolerant tree species during their early development, with low water and fertilizer needs, but with a rapid upward growth to avoid overtopping.

- (d) **Creating multistory forests.** The formation of a multistory forest can be achieved by maintaining the indigenous natural vegetation, creating a random distribution of tree species, tending, thinning, and selective cutting of final crop trees. To achieve this aim, long-term forest planning and management are promoted. The resulting multistory uneven-aged forests will prove more resistant to extreme weather events and provide better protective and ecological function.
- (e) **Applying forest structure management and selective cutting.** Tending, thinning, and selective felling can support natural processes within the forest stands by assisting the growth of ecologically suitable target trees to provide forest products and services on a sustainable basis. These operations are integral to the creation of multistory, uneven-aged forests for sustainable ecological benefits and forest products. Where the overriding objective is ecological protection, continuous forest cover should be practiced to avoid exposing the soil to erosion and degradation. To achieve continuous forest cover, selective cutting must be used, and large-scale clearcutting should be prohibited to avoid the risk of irreparably disturbing biodiversity and disturbing the delicate nutrient and hydrological cycles that exist in forestland.

B. Improve the System of Forest Classification

169. The Forest Law of 1998 divides forest into two categories according to their ecological and economic needs: (a) ecological forests and (b) commercial forests. Ecological forests are subject to complete protection, while commercial forests comprise intensively managed monocultures for timber production. The United Nations Millennium Ecosystem Assessment Report specifies four dominant functions of forests: forest products supply, ecological protection and regulation, ecocultural services, and ecosystem support. Following international

and domestic best practice, the NFGA promulgated the National Forest Management Plan (2016–2020) in which it proposes the use of three major categories: (a) strictly protected ecological forests, for example, those located in ecologically important and fragile areas needing total protection; (b) multifunction forests, for example, forests with the potential to play an important role in ecological protection, carbon trading, and the production of non-timber forest products and services; and (c) intensively managed commercial forests for industrial use. The plan also clarified the meaning of multifunction forest management strategies.

170. The lessons learned from the review strongly support this forest classification adjustment, provided supporting evidence and practice technical models. It is important that the above system of forest classification be adopted to help prioritize the use of government funding and promote long-term forest management and multiple uses of the forest resources to balance public good services and local community livelihood development. The forest management regimes applicable in each category will depend on the forest's dominant functions, with subsidy payments in each area based on their contributions to the provision of ecological services/public goods and the values of the services provided. It further recommends that the GoC consider legally reclassifying forests and replacing the existing two categories of forests (ecological forests and commercial forest) with the three above-mentioned categories.

C. Amend Harvesting and Quota-Based Prescriptions and Relax the Logging Ban

171. Based on the proposed new system of forest reclassification, changes should be made to harvesting policy. In ecological forests, final harvest/logging is forbidden, though thinning is permitted as a forest management intervention. However, to manage multifunction forests where the primary focus is the provision of ecological services and non-timber forest products, interventions are necessary to improve forest quality and satisfy the basic requirements of local people. The thinning and harvesting, therefore, should be based on the prescriptions of an approved forest management plan for the area. Such interventions are essential for promoting the long-term forest management to form health and vigor of forest stands and balancing environmental and economic benefits. The existing technical regulations governing forest harvesting should also be revised to favor natural regeneration and replace clearcutting with the selective cutting of individual trees. Such revisions would be highly supportive of the multifunction forest management concept; the development of healthy, stable, resilient forest ecosystems; and the move toward creating permanent forest cover for ecological services.

D. Draw Social and Environmental Considerations into Forest Management

(a) Institutionalize Public Participation and Raise Public Awareness

172. Participatory forest management planning was introduced in China through forestry projects funded by the Bank and the German government. Consultation and interviews with village collectives and farmers who hold forestland use rights strengthens links between forest management and rural development. In addition, experience has shown that reflecting the wishes and aspirations of communities and farmers in forest planning, design, and implementation can encourage much greater voluntary participation in project activities. This, in turn, enhances the ecological, social, and economic impacts of the projects.

173. Carefully designed and implemented participatory forest management planning and public awareness campaigns will ensure that the projects serve the purpose of improving community understanding of the rationale and objectives of projects, the role that stakeholders can play in the achievement of the objectives, and the types of project benefits that participants are likely to enjoy. A public awareness campaign should therefore start early in the project formulation process and should cover project topics such as project rationale and objectives, project area, species being proposed, silvicultural planting models, tending requirements, safeguard policies, financing arrangements, and employment possibilities. In this way, local people can better understand what is being proposed, their rights and responsibilities, and how the project might benefit marginalized groups such as ethnic minorities and women. Farmer and community opinions should be solicited on project proposals so that they can decide whether to participate, what tree species best suit their needs, and what follow-up assistance will be needed to sustain project impact. Experience has shown that forestry projects with open and transparent management enjoy high levels of voluntary participation. Experience has also shown that, under such circumstances, farmers are willing to contribute their land and labor to such projects and help ensure that project management maintains the required standard.

174. Essential to the task of successfully involving farmers and communities is the formulation of a participatory village-level forest management plan. This will help create a cooperative partnership between government authorities and stakeholders, heighten the sense of ownership of the project participants, and reinforce transparency and confidence in project objectives and management. It will also help ensure the equitable distribution of project benefits and enhance prospects for project sustainability. The proposed Bank-financed Forest Ecosystem Improvement in Uppers Yangtze River Basin Program, which is under preparation, will use the client system to institutionalize the public consultation and participation approach in forestry program design and implementation.

175. During project preparation, the needs of ethnic minorities who might reside in project areas must be reviewed and, if necessary, special measures should be put in place to safeguard their interests through an Ethnic Minorities Participation Plan. Measures will also be needed to ensure that women and poor households are given a voice in the decision-making process and, in all cases, the voluntary nature of stakeholder participation should be clearly understood.

(b) Improving Environmental Awareness and Applying Safeguards

176. Raising public awareness of environmental issues is essential to mitigating environmental risks in forestry projects, and it is important that project agencies recognize this. Forestry professionals in China, as in many other countries, often assume that the impact of afforestation is environmentally positive and not negative. It is also often assumed that environmental assessments are not necessary for afforestation projects. However, large-scale forestry activities can have adverse environmental impacts if the correct technical and managerial regulatory safeguards are not applied and complied with. In Bank-supported forestry projects, strict safeguard measures are applied to minimize their possible negative impacts by having an environmental assessment carried out during project preparation and by having the appropriate environmental protection measures incorporated into project designs with relevant

mitigation measures introduced. This has helped ensure that adequate protection measures are in place to prevent soil erosion, water pollution, biodiversity loss, and pest and fire outbreaks. This approach should be applied to all projects.

177. All World Bank-funded forestry projects in China include Environmental Protection Guidelines and a pest management plan, and the provisions of these must be complied with throughout and checked rigorously during supervision. The Environmental Protection Guidelines articulate which environmental protection requirements are required for afforestation and forest management activities, ensuring that adequate protection measures are in place to prevent soil erosion, water contamination, pest outbreaks, and the spread of fire. Protection measures include protecting natural ecosystems, retaining natural regeneration, belt-shaped and fish-scale-shaped planting holes prepared to reduce erosion, site preparation along the contour on slopes to avoid gulying, the prohibition of mountain burning, retaining site vegetation on mountain tops and along water courses, and the protection of sensitive areas. The burning of cut vegetation is prohibited, instead, such residue should be piled up on site and allowed to compost naturally.

178. During the preparation of the IFDP, Chinese authorities strongly disputed the Bank's requirement to have an environmental assessment for the project's plantation establishment component. However, having worked with the Bank staff on project implementation and having witnessed the benefits of an environmental assessment, assessing the environmental impact of forestry projects has now been mainstreamed into national-wide practice, and all forestry projects are assigned an environmental rating.

E. Diversify Funding Sources and Recalibrate Subsidy Policy

(a) Optimizing the Use of the Government Subsidies and Incentives

179. Inadequate government financing is a possible risk that could constrain the future expansion of sustainable forest management in China. Despite the increasing importance that the GoC has given to the restoration and protection of forestry ecosystems, and the recognition that ecological services and stability play an important role in underpinning sustainable development, investments in ecological forestry fall far short of what is needed.

180. The case studies reviewed in this report show that the unit cost of the various mixed ecological forestry models is much higher than the government subsidies, or less than one-third of costs recorded in the Bank-supported forestry projects. This, combined with the low financial rates of return from ecological forestry, has deterred social participation in ecological forestry. With the end of China's "demographic dividend", rising labor costs are squeezing returns from forestry, especially ecological forestry. Added to this is the long-term nature of forestry investments and the risks that accompany it, a lack of income over the short term, and the irreversibility of the investment decision (once planted it cannot be changed for many years to come), all of which have combined to deter investments in forest management activities with strong ecological benefits. To help address these issues, a forestry incentive policy is needed based on a function-related system of classification.

181. A comparative analysis shows that the value of ecological benefits from ecological forests is between 1.5 and 32.5 times higher than that from economic forests (Wang 2013; State Forestry Administration 2018), and the empirical studies and actual investments show the gaps between the planting and forest management cost and government subsidies. Given the present focus on ecological forests and the limited financial resources available from the central government, it appears logical for the government to focus incentive payments for ecological forest development in key areas. In addition, the existing flat-rate system of government incentive payments should be replaced by a system of payments that reflects the actual costs of ecological afforestation and forest management. For example, in critical areas where the protection and provision of public goods or services are essential, and in areas where the creation and management of multifunction forests can yield both ecological services and economic benefits, the rate of subsidy payments should be calibrated to reflect the value of the ecological services being provided. In the case of fast-growing commercial forests that show good financial returns but have little or no public service value, incentive payments should be phased out and their development left to market forces under the regulatory framework of government agencies.

(b) Promoting Forest Carbon Trading

182. Forest carbon trading is an important potential source of financing to promote afforestation/reforestation and forest management activities in China. The international and domestic carbon markets are experiencing rapid development, and it is imperative to learn from the successful practices of international forest carbon trading to promote forest carbon financing projects in China that enable enterprises to offset their emission credits. There are around 90 million hectares of land in China suitable for multifunction forest management. If only 50 percent of this met the additionality criteria needed for carbon sequestration and they were planted with mixed-species, multifunction stands yielding an additional 2 cubic meters per hectare per year over the baseline value, (a very modest estimate for managed stands), around 165 million tons of carbon could be sequestered each year when the area is fully planted, using a conversion rate of 1.83 tons of carbon per cubic meter of growth. This would enormously increase forestry's contribution to China's NDCs.

183. The lessons learned from forest carbon offsets and trading under the Clean Development Mechanism (CDM) and the China Certified Emission Reductions (CCERs) credit scheme in China highlight that the time and costs needed to design, implement, validate, and verify forest carbon projects are excessive and constrain the potential of forest carbon trading. To enhance the forest carbon trading process, the following actions are suggested:

- Promote forest carbon trading mechanisms to serve as offsets in the domestic voluntary action;
- Prioritize forestry carbon sequestration as an integral part of multifunction forest management and landscape management;
- Simplify technical requirements, methodologies, and procedures for implementation, monitoring, and verification of forest carbon trading projects;
- Develop policies that encourage enterprises to purchase forest carbon offsets associated with forest management;

Strengthen capacity (technical assistance, training) to enable local communities and farmers to participate in forest carbon trading.

(c) Expanding Innovative Financing Models

184. Multifunction forests can produce a wide range of products and services on a sustainable basis. They can also generate incomes for forest owners, however, funding gaps are likely to persist between revenues and expenditure. To help bridge this gap, government support is needed in financing multifunction forest projects to attract social capital. Other instruments can also be used, such as Forestry Policy Loans and public-private partnerships, as well as mobilizing credit financing through the pledging of usufruct and compensation payments for ecological forests. Further details include:

- Forestry Policy Loans are preferential policy loans provided by national development banks, including the CDB and the CADB. These are currently targeted at large-scale forestry projects, such as national park projects, forestry industry projects, commercial afforestation, and forest quality improvement programs. Those banks provide lower interest rates and longer maturity period preferential loans, with the government bearing certain interest, compared with commercial loans. In 2015, several provinces, including Fujian, Guangxi, and Jiangxi, launched projects financed by Forestry Policy Loans. Since the CDB and CADA only provide Forestry Policy Loans to large-scale forestry enterprises, to allow broader forest entities, particularly small-scale forest entities and communities, to access this preferential policy loan for afforestation and forest management, the conditions for applying the loan need to be amended or made more flexible.
- Public-Private Partnership (PPP) Financing Models. Under PPP-financed forestry projects, a special purpose vehicle (SPV) is responsible for financing forestry operations using social capital. The SPV may use its own assets, equity, and earnings under the PPP contract as security/pledge against a mortgage or bank loan, and takes responsibility for project implementation and management. The government provides “viability gap funding” through annual financial budgeting in accordance with government obligations under the PPP contract.
- Loans with usufruct and compensation payments for ecological forests as security/pledge is an innovative loan provided by a financial institution against the pledge of usufruct of compensation payments for ecological forestry services legally owned by the borrower over the long term. The pilot program appears to be successful and can be applied to both large- and small-scale forestry operations.

(d) Putting in Place Support Policies on Forestry Investment

185. Forestry investment differs from most other forms of business investment in that it is for long-term management, the majority of costs are incurred in the first three years, and most benefits are reaped after 20 to 30 years or so. Risks are also higher because of such threats as fire, pest outbreaks and other natural disasters. These factors, combined with the irreversible

nature of the investment, are a deterrent to investors, however, they can be offset somewhat by the development of insurance mechanisms such as the following:

- Forestry credit guarantee schemes. Institutions to provide all kind of credit guarantee services for forestry financing should be developed. It is necessary to use financial leverage of development credit guarantee system to transfer or reduce the relevant financing risks, and to encourage various kinds of guarantee institutions to engage in forestry financing guarantee services, so that financial institutions can be better mobilized to support forestry financing.
- Financial risk management. It is essential to diversify forestry financing risk management approaches and improve contract management, such as encouraging insurance companies to expend the current narrow credit guarantee coverage for forest products to fit the broad needs on forest management and forest products; and developing forest product futures market and using forest product orders to transfer and distribute forestry financing risks to speculators in the futures market, which will result the forestry credit financing risks reduced.
- Quality verification system. The methods for verification of forest resources and asset evaluation institutions should be developed, including forest resources and asset appraiser or evaluation specialist system, so that professional intermediary institutions for forest resources and asset evaluation can be put into operation. It is necessary to reinforce code of practice, and training needs to be provided to the asset appraisers to help improve the credibility of asset valuation work and user confidence in their services.
- Forest harvesting management system. The forest harvesting management system needs to be optimized by deciding felling based on the forest management plans with exercising better control over the quantity and intensity of felling. Relatedly, felling quotas should be made more flexible, with priority given to the management needs of the stand or ecosystem. If a felling application is submitted to help reduce mortgage debt, the local forestry department should judge the application based on the needs of the trees and the forest ecosystem.

References

- Andres, Luis Alberto, Gnanaraj Chellaraj, Basab Das Gupta, Jonathan Grabinsky, and George Joseph. 2015. "Why Are So Many Water Points in Nigeria Non-Functional: An Empirical Analysis of Contributing Factors." World Bank Policy Research Working Paper 8388, World Bank, Washington, DC. <https://data.worldbank.org/cn/>.
- Angelsen, A., and T. Dokken. 2015. "Environmental Reliance and Climate Vulnerability: A Cross-Section Analysis of Structural and Stochastic Poverty." Policy Research Working Paper, World Bank, Washington, DC.
- Cai, Chongfa, Ding Shuwen, Shi Zhihua, Huang Li, Zhang Guangyuan 2000. "A study of predicting soil-eroded volume in small river basins using USLE model and the geographical information system IDRISI." *Journal of Soil and Water Conservation* 14 (2): 19–24.
- Cao, Yanyun, Peng Yuhua, Liang Yanfang, Huang Zhiling, He Qinfei. 2012. "Soil nutrient analysis of young forest lands of three native broad-leaved tree species in Qipo forest farm of Guangxi Province." *Journal of West China Forestry Science* 41 (6): 68–72.
- Chan, C. C. 1981. "Evaluation of soil loss factors on cultivated slopelands of Taiwan." *Technical Bulletin 55*, Food and Fertilizer Technology Center, Taipei.
- Dong, Deming, Li Shuming, and Li Xiquan. 2005. "Cost and benefit analysis of returning farmland to forest projects." *Hunan Forestry Science and Technology* 32 (3): 43–44.
- FAO (Food and Agriculture Organization). 2015. *State of the World's Forests: Enhancing the Socioeconomic Benefits from Forests*. Rome: Food and Agriculture Organization.
- Fay, M., S. Hallegatte, and M. Bromhead. 2015. *Inclusive Green Growth – the Pathway to Sustainable Development*. Washington, DC: World Bank.
- GoC (Government of the People's Republic of China). 2017. "China's Policies and Actions for Addressing Climate Change." Government of the People's Republic of China, Beijing, October 31.
- Gong, Zhiming. 1999. "Soil fertility status and improved fertility in Guangyuan area." Southwest Agricultural University, Southwest University, Chongqing.
- Hamrick, Kelley, and Melissa Gallant. 2017. *Fertile Ground: State of Forest Carbon Finance 2017*. Washington, DC: Forest Trends' Ecosystem Marketplace. https://www.forest-trends.org/wp-content/uploads/2018/01/doc_5715.pdf.
- Hong, Jusheng, and Hou Yuanzhao. 1990. "Establishing timber cultivation bases is the key measure to reverse the forest resource crisis in China: also discuss about the use of the World Bank USD300 million loan." *World Forestry Research* 1990(0-4): 1-11. .
- Hong, Yanzhen, and Fu Yonghai. 2008. "Research on factors influencing the availability of rural households' forest right mortgage loan – a case study of 'fulindai' product in Sanming City, Fujian Province." *Journal of Forestry Economics* 40 (09): 31–35, 39.
- Hui, Gangying, Zhao Zhonghua, Yuan Shiyun and Hu Yanbo. 2012. "Evaluation method of forest management model." Science Press, Beijing.
- Hui, Gangying, and Klaus Von Gadow. 2001. *Modern forest management technology in Germany*. Beijing: China Science and Technology Press.
- Hui, Gangying, Klaus Von Gadow, Hu Yanbo and Xu Hai. 2007. *Structured forest management*. Beijing: China Forestry Press.
- Hunan Academy of Forestry. 2016. "Research on mixed afforestation model effect of 7

- coniferous and broadleaved tree species including Hunan *Cunninghamia lanceolata*, Fujian *Phoebe zhennan* under Hunan Forest Restoration Development Project (HFRDP).” Hunan Academy of Forestry, Changsha.
- IEG (Independent Evaluation Group). 2013. *Managing Forest Resources for Sustainable Development: An Evaluation of the World Bank Group’s Experience*. Washington, DC: World Bank.
- Kumar, Nalini, Naresh Saxena, Yoginder Alagh, and Kinsak Mitra. 2000. *India Alleviating Poverty through Forest Development: Evaluation Country Case Study Series*. Washington, DC: World Bank. <https://ieg.worldbankgroup.org/sites/default/files/Data/reports/india.pdf>.
- Jiang, Xilin. 2019. “Experience of typical forestry public-private partnership (PPP) projects in foreign countries.” *Journal of China Forestry Industry* (04): 76–80.
- Kaplinsky, Raphael, Anne Terheggen, and Julia Tijaj. 2010. “What Happens When the Market Shifts to China: the Gabon Timber and Thai Cassava Value Chains.” Policy Research Working Paper 5206, World Bank, Washington, DC. <https://data.worldbank.org.cn/>.
- Kostka, Genia. 2014. “Barriers to the Implementation of Environmental Policies at the Local Level in China.” World Bank, Washington, DC. <https://data.worldbank.org.cn/>.
- Lamb, David. 2014. *Large scale forest restoration*. Abingdon, UK: Routledge.
- Li, Chunchang, and Tian Jianfu. 2016. “Reflections on PPP model of national reserve forest construction.” *Forest Products Industry* 43 (10): 3–6.
- Liang, Yin, Liu Xianchun, Cao Longxi, Zheng Fenli, Zhang Pingcan, Shi Mingchang, Cao Quanyi, Yuan Yongqin. 2013. “Calculation and macroscopic distribution of K value of soil erodibility in water eroded areas in China. *Journal of Chinese Soil and Water Conservation* (10): 35–40.
- Liu, Shaojuan. 2015. “Discussion on the application of PPP model in forestry ecological engineering construction projects.” *Journal of Forestry Construction* (06): 54–58.
- Lu, Shaowei, Jin Fang, Yu Xinxiao, Xie Yuanyuan, Li Yanhui. 2005. “Evaluation of soil protection in China’s forest ecosystem.” *Journal of Soil and Water Conservation* 3 (3):16–21.
- Lu, Yuanchang, Lei Xiangdong, and Hong Lingxia. 2010. “Research on technical system of near-to-natural forest manager program.” *Journal of Southwest Forestry University*.
- Matthews, John D. 2006. *Silvicultural Systems*. Oxford: Oxford University Press.
- Megevand, C., A. Mosnier, J. Hourticq, K. Sanders, N. Doetinchem, and C. Streck. 2013. *Deforestation Trends in the Congo Basin: Reconciling Economic Growth and Forest Preservation*. Washington, DC: World Bank.
- Ming, Angang, Liu Shirong, Mo Huihua, Cai Daoxiong, Nong You, Zeng Ji, Li Hua, Tao Yi. 2016. “Comparison of carbon storage in the pure and mixed forests of *Castanopsis hystrix* Miq., and *Cunninghamia lanceolata* in subtropical region of South Asia.” *Acta Ecologica Sinica* 36 (1): 244–251.
- Morgan, R. P. C. 2005. *Soil Erosion and Conservation*. Oxford: Blackwell Publishing.
- O’Hara, Kevin L. 2014. *Multiaged Silviculture: managing for complex forest stand structures*. Oxford: Oxford University Press.
- Pagiola, S., R. Martin-Hurtado, and Priya Shyamsundar. 2002. “Generating Public Sector Resources to Finance Sustainable Development: Revenue and Incentive Effects.” World Bank. <https://data.worldbank.org.cn/>.
- Puettmann, Klaus J., K. David Coates, and Christian Messier. 2008. *A Critique of Silviculture:*

- Managing for Complexity*. Washington, DC: Island Press.
- Pukkala, T. 2016. “Which type of forest management provides most ecosystem services?” *Forest Ecosystems* 3: Article 9.
- Puzio, L. 2015. “Analysis of World Bank Finance and Forests: The Impact of Development Projects on Tropical Forests and Forest Peoples.” World Bank Information Center, World Bank, Washington, DC.
- Qin, Tao. 2009. Research on Chinese forestry financial support system. Beijing Forestry University.
- Qin, Tao, Tian Zhiwei, and Pan Huanxue. 2017. “Implementation effect, existing problems and suggestions of forest insurance premium subsidy policy in China.” *Economic Review* (01): 105–110.
- Qin, Tao, Zhang Yanhong, Wu Jin, and Liu Jiaru. 2008. “Case analysis of national reserve forest base construction supported by development finance – taking Guangxi national reserve forest project as an example.” *Journal of Forestry Economics* 40 (01): 56–60.
- Roose, E. J. 1977. “Application of the Universal Soil Loss Equation of Wischmeier and Smith in West Africa.” In *Soil conservation and management in the humid tropics*, edited by D. J. Greenland and R. Lal. London: Wiley, pp.177–187.
- Song, Pei, Qin Tao, and Jiang Lincheng. 2013. “Typical case analysis and enlightenment of forestry trust financing projects in China.” *Journal of Green Finance and Accounting* (04): 13–17.
- State Forestry Administration. 2008. “Specification for assessment of forest ecosystem services in China [LYT 1721-2008].” State Forestry Administration, Beijing.
- State Forestry Administration. 2014. “Overview of China’s forest resources – the eighth national forest resources inventory.” State Forestry Administration, Beijing.
- State Forestry Administration. 2018. *National report on monitoring ecological benefits of returning farmland to forest projects*. Beijing: China Forestry Press.
- Sugden, Andrew M. 2018. “Tree diversity improves forest productivity.” *Science* 362 (6410) (October 5): 41–43.
- Vogt, K., J. Gordon, J. Wargo, D. Vogt, H. Asbjornsen, P. A. Palmiotto, H. J. Clark, J. L. O’Hara, W. S. Keeton, T. Patel-Weynand, and E. Witten. 1997. *Ecosystems: Balancing Science with Management*. New York: Springer.
- von Gadow, Klaus, and Gangying Hui. 1999: *Modelling Forest Development*. Kluwer Academic Publishers.
- Wan, Pan. 2018. “Impact of structured forest management on stand quality.” PhD dissertation, Chinese Academy of Forestry, Beijing.
- Wang, Chao. 2017. “Spatial and temporal distribution characteristics of rainfall erosion forces in Sichuan Province.” *Journal of Geospatial Information* 15 (2): 111–114.
- Wang, Hong, Wang Guosheng, Wang Zhouxu, Dong Hui, Song Lei. 2016. “Performance evaluation of forestry projects financed by international financial organizations – taking China forestry comprehensive development project financed by the World Bank as an example.” *Forestry Resource Management* 2016 (04): 19-23.
- Wang, Hongxia, Wang Bing, Li Baoyu, Niu Xiang, Wang Xiaoyan, Lu Shaowei, Li Shaoning, Shi Hexiong Chen Bo. 2014. “Ecological benefit evaluation of different forest species in the projects of returning farmland to forest.” *Journal of Forestry Resources Management* (3): 150–155.
- Wang, Xiaoli, Shi Yingwen, and Shi Daojin. 2008. “Discussion on loan securitization of

- compensation right pledge of ecological forests.” *Journal of Forestry Economics* 38 (04): 48–54, 106.
- Wen, Cao, and Chen Jiancheng. 2006. “The orientation of fiscal policy to achieve forestry sustainable development of forestry.” *China Population, Resources and Environment* (06): 194–197.
- Whitmore, T. C., and C. P. Burnham. 1969. “The altitudinal sequence of forests and soils on granite near Kuala Lumpur.” *Malayan Nature Journal* 22: 99–118.
- Wischmeier, W. H. 1975. “Estimating the soil loss equation’s cover and management factor for undisturbed area.” In *Present and prospective technology for predicting sediment yields and sources*. USDA ARS Publication ARS-S-40: 118–24. Washington, DC: United States Department of Agriculture.
- Wischmeier, W. H., and D. D. Smith. 1978. “Predicting rainfall erosion losses.” In *USDA Agricultural Research Service Handbook 537*. Washington, DC: United States Department of Agriculture.
- World Bank. 2001. *CHINA: Air, Land, and Water – environmental priorities for a new millennium*. Washington, DC: World Bank. <http://documents.worldbank.org/curated/en/166121468743733519/pdf/multi0page.pdf>.
- World Bank. 2004. *Sustaining Forest: A Development Strategy*. Washington, DC: World Bank. <http://documents.worldbank.org/curated/en/424531468781760578/pdf/297040v-1.pdf>.
- World Bank. 2016. *Forest action plan FY16–20*. Washington, DC: World Bank Group. <http://documents.worldbank.org/curated/en/240231467291388831/Forest-action-plan-FY16-20>.
- Xu, Qiu, Huang Lingyun, and Liu Fengbo. 2018. “Analysis on the development strategy of inclusive forestry finance in the county area of southern collective forest region – a case study of ‘fulindai’ in Youxi County, Fujian Province.” *Journal of China Forestry Economy* (06): 5–8.
- Yong, Fang, Mu Zongzhao, and Meng Zhenong. 2014. *Classification analysis of forest plant resources in Shandong*. Beijing: China Environment Press.
- Yuan, Shiyun. 2010. “Evaluation of existing forest stand management model in Xiaolongshan, Gansu Province.” Doctoral dissertation, Chinese Academy of Forestry, Beijing.
- Zhai, Mingpu. 2011. *Theory and technology of modern forest cultivation*. Beijing: China Forestry Press.
- Zhang, Daoyang. 2013. “Reflection on development modes of environment protection industry supported by development finance.” *Journal of Economic Review* (10): 71–74.
- Zhang, Haixing, and Zhang Yu. 2015. “PPP model: multidimensional deconstruction, operation mechanism and system innovation.” *Ningxia Social Science* (06): 83–89.
- Zhang, Hongwen. 2007. “Problems and countermeasures of returning farmland to forest projects in China.” *Journal of Forestry Resources Management* (3): 13–17.
- Zhang, Yongtao, Yang Jihua, and Mu Zongzhao. 2016. *Establishing forest site classification system, and research and application of forest management model in degraded mountains in Shandong*. Beijing: Publishing House of Electronic Industry.
- Zhang, Zhijun. 2009. “Cost-effectiveness research on carbon sequestration through forestation and reforestation in Guangxi.” Chinese Academy of Forestry Sciences, Beijing.
- Zheng, Hong. 2011. “Forestry trust guarantee: Reflection on improving the effectiveness of forestry guarantee resources.” *Journal of Finance and Economy* (03): 21–24.
- Zhou, Caixian, Zhi Xin, Zhu Jiangang, Stephan Gamp 2016. *Near-to-nature forest management*

- *exploration and practice of Beijing*. Beijing: China Forestry Press.
- Zhou, Gentu. 2011. *Afforestation and management of main timber species in Anhui*. Beijing: China Forestry Press.
- Zufle, A., Ye Jingzhong, and M. Seebauer. 2000. *Afforestation Projects Training Manual*. Beijing: China Forestry Press