Chapter 32
Effective Conservation of Asian Rosewoods (*Dalbergias*) and Their Genetic Resources Through Regional Collaboration

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1 Introduction

The genus *Dalbergia* in the Asia–Pacific region comprises approximately 80 species. Among these, 33 are native to India, 44 to Indochina, and eight to the New Guinea floristic region [1]. The list includes several valuable timber species, also known as the Asian Rosewood species, mostly endemics and species with extensive distributions across multiple countries (Table 1). They are highly valued for their beautiful and dense wood, often used in furniture, musical instruments, and decorative items.

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Table 1 Distribution of selected *Dalbergia* (timber) species across the Asia–Pacific

Scientific name	Distribution	Conservation status (as of 2024)
Dalbergia assamica	Vietnam, China, Lao PDR, Cambodia, Thailand, Myanmar, Bhutan, Bangladesh, and India	Least concern (2012)
Dalbergia cochinchinensis	Cambodia, Lao PDR, Thailand, and Vietnam	Critically Endangered (2020)
Dalbergia cultrata	Myanmar, Cambodia, China, Indonesia, Thailand, Lao PDR, Vietnam, and India	Near Threatened (2010)
Dalbergia latifolia	India, Indonesia, Nepal, Myanmar, Sri Lanka, and Vietnam	Vulnerable (2020)
Dalbergia oliveri	Cambodia, Lao People's Democratic Republic, Myanmar, Thailand, and Vietnam	Critically Endangered (2020)
Dalbergia odorifera	China	Vulnerable (1998)
Dalbergia sissoo	Afghanistan, Bangladesh, Bhutan, North India, Iran, Myanmar, Nepal, and Pakistan	Least Concern (2019)
Dalbergia tonkinensis	Vietnam and China	Vulnerable (1998)

Source [5, 6]

Many Asian Rosewood species are under threat due to overexploitation and illegal logging, driven by high demand for their valuable timber. A study to assess the extent of the illegal trade of Dalbergia species in Indonesia showed an annual increasing trend, with almost a fifth of rosewood being extracted from conservation areas rather than plantations, causing more significant damage than individual tree felling [2]. The high demand for rosewood timber, coupled with slow growth and a decline in natural habitat, has led to dwindling populations throughout the species' ranges

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[3]. Although there are scattered reports on the commercial cultivation of these species, slow growth rates and long rotation periods constrain opportunities to meet the demand for rosewood timber from plantations in the near future.

Previously, each country had different regulations for Dalbergia. For example, in Indonesia, *Dalbergia latifolia* and *D. sissoo,* which were successfully introduced and well-adapted in various geographical areas, have long been used in trade and did not evoke the Indonesian laws concerning protected plant and animal species. Since 2017, however, the entire genus except *D. sissoo* has been listed in the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) Appendices, which regulate and restrict species' international trade to prevent overexploitation and ensure sustainable use. The genus *Dalbergia* is included in CITES Appendix II, meaning that it requires export permits, reflecting the need for conservation measures across the genus [4]. While not all species of *Dalbergia* are threatened, the difficulty of distinguishing closely related species means that threatened *Dalbergia* species could be traded as non-threatened species, justifying a blanket decision to protect the genus. As an exception, specific regulations are in place for *D. sissoo* to facilitate trade of the species, which is abundantly found and cultivated in India and is important for small industries producing handicrafts.

Some of the commercially most valuable—and most threatened—species such as *Dalbergia cochinchinensis*, *D. oliveri,* and *D. latifolia* (Table 1) are distributed across several countries in Indochina, and so the effective conservation of the species and their genetic resources require collaboration between countries, not only in trade regulation and enforcement but also in research and conservation action. This chapter discusses the benefits of regional collaboration in conservation and research, delves into challenges in conserving species with cross-border distributions, and explores potential solutions to enhance regional cooperation for the protection and sustainable use of rosewoods.

2 Benefits of Regional Collaboration

Genetic diversity is the foundation for population viability, productivity, and adaptation to a changing climate. Developing strong research abilities in forest genetic resources (FGR) is crucial for protecting biodiversity, improving forest productivity and opportunities for plantation forestry, and ensuring ecosystem resilience. This requires a multidisciplinary approach, substantial investment, and strong collaboration among various stakeholders. Many Asian nations have developed significant capacities in FGR research, leveraging their rich forest biodiversity and advanced scientific infrastructure. The FGR research landscape in Asia is diverse and dynamic, characterised by strong national initiatives, international collaborations, and a growing emphasis on integrating modern genetic techniques with traditional forest management practices. Regional collaboration also creates capacity for research translation by providing guidance in support of conservation programmes.

Yet, research capacities across the region are unevenly distributed, especially considering the extremely high species diversity and the lower middle-income status of many countries within the distribution ranges of *Dalbergia* species. Further, many national initiatives are project-driven with a short time frame.

Through regional collaboration, it is possible to achieve synergies between national efforts, some of which are described below.

2.1 Developing Novel Research Methods and Approaches

Using 95 samples of 31 Southeast Asian *Dalbergia* species spanning 14 countries, DNA barcoding to support species conservation was successfully applied [7]. The study allowed identifying *D. cochinchinensis*, the first CITES-listed *Dalbergia* species from Asia, supporting efforts to curb the illegal trading of the species. Building on the same network of national partners a few years later, a regional research initiative led by the University of Oxford developed reference transcriptomes for six *Dalbergia* species, using samples from multiple Southeast Asian countries across the species distributions [8]. The study demonstrated more diverged disease resistance proteins in widely distributed species, implying higher genetic diversity and higher adaptive potential in species with wider ecological niches. The reference transcriptomes are expected to foster further studies on population genomics and gene-environment associations in Dalbergia. Later, a comparative greenhouse experiment characterised the different strategies of *D. cochinchinensis* and *D. oliveri* towards drought [9], where *D. cochinchinensis* tends to maximise photosynthetic assimilation by maintaining stomatal conductance during drought, but at the risk of hydraulic failure. *D. oliveri*, on the other hand, is more conservative in terms of water use. Their strategies are well-related to their ecological niche, as *D. cochinchinensis* is a pioneering species that prioritises growth. In a follow-up, a range-wide genomic study of both these species showed that the two species are adapted to different temperature and rainfall patterns and detected particularly strong local adaptation in the coastal ranges of the species, indicating that populations in those areas are of high genetic conservation priority [10]. Plant species, especially threatened species, are currently underrepresented in genomic databases, highlighting the importance of such studies.

2.2 Developing Range-Wide Conservation Assessments

Using species occurrence data contributed by 60 national research institutions and experts across Southeast Asian countries, species distribution models and vulnerability assessments for *D. cochinchinensis*, *D. cultrata,* and *D. oliveri* for current and future climate conditions and other threats such as overexploitation and habitat loss were developed [3]. The results were validated by the experts and helped to update

the conservation status of *D. cochinchinensis* and *D. oliveri* on the IUCN Red List to Critically Endangered [10, 11], and are expected to help mobilise more resources for species conservation. Out of the 166,000 species on the IUCN Red List, only a handful of others are evaluated using quantitative conservation assessment methods.

2.3 Designing Effective Genetic Conservation and Restoration Strategies

Different conservation approaches are required based on the conservation status of and threats to each species. Knowledge of genetic differentiation between *D. cochinchinensis* populations across the species range was used to identify genetic management units to help ensure that local adaptations are effectively conserved through in situ and ex situ conservation units [12]. Building on range-wide, expert-validated distribution and threat maps, spatially explicit conservation priorities for *D. cochinchinensis*, *D. cultrata,* and *D. oliveri* by ecoregion, as a proxy for genetic differentiation, were identified [3]. Some ecoregions where the species are predicted to be the most threatened are transboundary, highlighting the need for practical collaboration between countries to conserve the species' unique genetic resources. In some cases, the species populations were predicted to have practically disappeared in one country while ample suitable habitats still remained on the other side of the border. In such cases, germplasm exchange can importantly support the restoration of viable, genetically diverse, and resilient populations [3]. Yet currently, regulations commonly prevent such exchange. In Indonesia, a genetic analysis of *D. latifolia* using 95 samples from eight populations across the country showed relatively low to medium levels of genetic diversity and complex/mixed origins [13]. The results imply the need to clarify the origin of the species, which would require analysing samples from countries of known natural distribution of the species, such as India.

Countries can also collaborate in exchanging experiences of working models of conservation and management. In Indonesia, the Indonesian State Forestry Company (Perum Perhutani) has since long implemented a management plan for *D. latifolia*, with planned rotation cycles and replanting to ensure the species' persistence. Since then, the practice has also been informally adopted on community-owned lands [14]. To our knowledge, similar detailed species management plans are not widely applied in other Asian countries within the *Dalbergia* spp. distributions, yet there is growing interest for sustainable plantation management in some countries. In Cambodia, *D. cochinchinensis* is the second most planted tree species nationwide (Institute of Forest and Wildlife Research and Development, Cambodia, unpublished report), and forestry department collaborates with smallholder farmers to supply seeds and seedlings from farmland seed sources for planting needs, an excellent model of decentralised tree seed supply chain.

2.4 Mobilising Funding

In recognition of the importance of regional collaboration for conserving threatened Dalbergias, regional research and development initiatives have received support from countries both within and beyond South and Southeast Asia. Notable donors include UK Darwin Initiative, DANIDA, and the National Science Foundation of China. Through the National Institute of Forest Sciences of the Republic of Korea, Korea Forest Service has supported regional exchanges and workshops to help refine regional research and conservation priorities and strategies. With its vast and diverse forest ecosystems, India has supported regional collaborations through Institutions such as the Indian Council of Forestry Research and Education (ICFRE) and various state forest research institutes. Research related to conservation, sustainability uses, and provision of superior seeds through tree breeding programmes has been carried out by research institutions and universities in Indonesia with funding from within the country and abroad, such as the CITES Tree Species Programme (CTSP). Many of the research initiatives and exchanges have been facilitated by the Asia Pacific Forest Genetic Resources Programme (APFORGEN), a regional network of 15 countries (Box 1).

Asia Pacific Forest Genetic Resources Programme (APFORGEN) APFORGEN works to enhance the conservation and sustainable use of forest genetic resources in the Asia-Pacific region. It aims to support and link national forest programmes, research institutions, non-government organizations, and individuals interested in forest genetic resources in the region [15]. The network was established in 2003 by the FAO, the Alliance of Bioversity International and the International Center for Tropical Agriculture (CIAT) (then International Plant Genetic Resources Institute, IPGRI), and the Asia -Pacific Association of Forestry Research Institutions (APAFRI). Network members are from 15 countries in the Asia-Pacific region: Bangladesh, Cambodia, China, India, Indonesia, Lao PDR, Malaysia, Myanmar, Nepal, Pakistan, the Philippines, Republic of Korea, Sri Lanka, Thailand, and Vietnam.

Since 2014, APFORGEN has had three regional strategy development and review workshops (2014, 2017, and 2023) where the National Coordinators of member countries identified and prioritized regional objectives and targets for joint research and capacity development [15]. These were developed into regional strategy documents (2014, 2017, and 2023), where the objectives and targets are explicitly linked to global conservation goals of the Global Plan of Action on Forest Genetic Resources, and the Kunming-Montreal Global Biodiversity Framework, to demonstrate how the network activities contribute to achieving these in the Asia-Pacific Region.

The Asia-Pacific Forestry Commission, FAO's highest forest decision- making body in the region, endorsed the APFORGEN's regional research and capacity development strategies in 2017 [3, 16–18]. Since then, Chairpersons of APFORGEN, elected from among the National Coordinators, attend the biennial Commission meetings to provide updates about the network's activities and achievements to the Commission members [19].

The recently completed Strategy 2018–2022: Implementing the Global Plan of Action on Forest Genetic Resources in Asia and the Pacific [3] helped the network attract funding for implementing four strategic objectives and genetic conservation assessments for over 60 species, restoration plans in 3 countries, and training workshops with over 150 participants [10, 11, 16]. It has significantly bolstered collaborative efforts between countries in forest genetic resource management in Asia and the Pacific region.

Challenges in Collaboration in Asia for Rosewoods

Collaboration in the conservation and sustainable use of *Dalbergia* spp. across Asia presents numerous challenges. Rosewoods face significant pressure from both legal and illegal logging. The exchange of germplasm, managing high species diversity, and dealing with the trafficking and regulatory landscape are critical factors that impact collaborative efforts.

Varying distributions of different species across multiple countries pose unique challenges for collaboration. Each species of rosewood may have distinct ecological requirements and threats, necessitating tailored conservation strategies. Coordinating these efforts across borders can be complex, as conservation measures effective in one country may not be transferable to other contexts. Despite recent research efforts, comprehensive and collaborative data collection efforts are still urgently needed on the distribution, population status, and ecological needs of many rosewood species. This lack of information hampers the development of effective regional conservation strategies and complicates collaborative efforts. Rosewoods are often found in fragmented habitats due to deforestation and land-use changes. Cross-border collaboration is essential to managing these fragmented landscapes effectively, but it requires coordination and resource-sharing between countries [20].

Illegal logging and trafficking of rosewoods pose severe threats to their conservation and sustainable use. High market demand drives these activities, resulting in significant ecological and economic losses. Effective monitoring and enforcement of environmental laws and regulations require substantial resources and coordination between countries. Weak enforcement mechanisms and corruption can exacerbate the problem, allowing illegal activities to flourish. Illegal logging and trafficking are often facilitated by well-organised transnational criminal networks in collusion with government authorities [21]. These networks exploit regulatory loopholes and differences in enforcement capabilities between countries, making it difficult to curb illegal activities.

The significant economic value of rosewood fuels powerful incentives for illegal logging. Tackling organised crime, corruption, and the underlying economic drivers is essential for successfully conserving *Dalbergia* species. Despite numerous communities reporting illegal logging activities to authorities, their concerns often go unaddressed. Those who push for enforcement frequently face threats, false accusations, or even fatal repercussions. A recent case in Cambodia highlights this alarming trend, where prominent environmental defenders documenting illegal logging were unjustly

arrested, underscoring the dangers faced by those advocating for forest protection [22].

The regulatory environment surrounding rosewood conservation and trade is complex and varies significantly between countries. This complexity poses several challenges for collaboration. Differing national regulations on the harvesting, trade, and transport of rosewoods can create barriers to effective collaboration. Efforts to harmonise these regulations are essential but require significant political will and coordination. The Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) regulates the trade of rosewoods to ensure their survival. However, compliance with CITES regulations can be challenging, especially for countries with weak governance and a lack of impartial courts. Ensuring consistent implementation of CITES provisions across countries is critical for effective collaboration. In response to overexploitation, some countries have implemented trade bans on rosewoods. While these bans are intended to protect the species, they can have unintended consequences, such as driving the trade underground and increasing illegal activities. Finding a balance between regulation and sustainable use is essential.

Germplasm exchange, the process of sharing genetic resources between different regions, is essential for the conservation and breeding of rosewoods. However, this process is fraught with challenges in Asia. Different countries have varying regulations regarding the exchange of genetic material. These laws are designed to protect national biodiversity but can inadvertently hinder collaborative conservation efforts. For instance, the Nagoya Protocol on Access and Benefit-sharing requires stringent compliance, which can complicate the process of germplasm exchange between countries. The movement of germplasm across borders carries the risk of spreading pests and diseases. Each country has its own phytosanitary regulations, which can create additional bureaucratic hurdles. Ensuring that exchanged germplasm is free from pests and diseases requires rigorous screening and certification processes. The ownership and use rights of genetic resources can be contentious. Countries and local communities want to ensure that they are fairly compensated for the use of their genetic resources, which can lead to protracted negotiations and delays in germplasm exchange agreements.

3 Way Forward

Addressing the challenges of collaboration in rosewood conservation requires a multi-faceted approach. Establishing regional platforms for dialogue and cooperation can help harmonise regulations, share best practices, and coordinate conservation efforts including environmental compliance assurance. Organisations such as the Association of Southeast Asian Nations (ASEAN) can play a pivotal role in facilitating such cooperation.

Enhancing the capacity of national and local authorities to enforce regulations, monitor rosewood populations, and manage conservation programmes is crucial.

This can be achieved through training, resource allocation, and technical assistance from international organisations. In addition, because not all countries have regulations governing the protection of Dalbergia in their country, reviewing the status of Dalbergia in CITES based on the utilisation, conservation status, benefits, and priorities of each country may facilitate the management of Dalbergia at the regional level.

Engaging local communities in conservation efforts is essential, especially where most Dalbergia wood is obtained from smallholder or community-owned land, such as in Indonesia where an estimated 80% of rosewood is supplied by local communities [14]. Efforts inspired by Indonesia's practices in sustainably managing Dalbergias on community lands focus on planned harvesting to maximise utilisation without harming the environment. These initiatives prioritise maintaining seed availability through stand management designated as seed sources, enhancing propagation, and providing seeds for various purposes, including conservation and reforestation programmes. Community monitoring also plays a pivotal role in the conservation of *Dalbergias*. With their deep ecological knowledge and direct connection to their surrounding environment, local communities become vital stakeholders in conservation efforts. Community-led actions strengthen the monitoring and protection of *Dalbergias* and empower communities, fostering a sense of stewardship and ensuring more sustainable and culturally attuned conservation outcomes. Such approaches ensure the sustainable management of *Dalbergias* along with benefits for local communities who contribute to their conservation. Providing economic incentives for sustainable use and involving communities in decision-making processes can help reduce illegal activities and ensure the success of conservation initiatives.

Investing in research to fill data gaps on rosewood species and promoting the sharing of scientific information between countries can support evidence-based conservation strategies. Collaborative research projects and databases can facilitate this process. Efforts are also directed towards improving tree species for timber, non-timber forest products, and agroforestry systems in India. Developing and promoting certification schemes for sustainably sourced rosewood can help balance conservation goals with economic interests. Encouraging consumers to choose certified products can reduce the demand for illegally sourced wood.

Collaboration in the conservation and sustainable use of rosewoods in Asia is a complex and challenging endeavour. By addressing the barriers to germplasm exchange, managing the high species diversity, combating illegal logging and trafficking, and navigating the regulatory landscape, stakeholders can enhance regional cooperation. Through strengthened regional cooperation, capacity building, community engagement, research, and the promotion of sustainable trade, it is possible to develop effective strategies for the conservation and sustainable use of rosewoods. Such efforts are crucial not only for the survival of these valuable species but also for the preservation of the ecological and economic benefits they provide to the region.

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