



**REVIEW ON THE TAXONOMY, BIOLOGY, ECOLOGY, AND THE STATUS,
TREND AND POPULATION STRUCTURE AND DYNAMICS OF *DALBERGIA
COCHINCHINENSIS* IN VIETNAM**

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Ha Noi, December 2019

Project title: Strengthening the management and conservation of *Dalbergia cochinchinensis* and *Dalbergia oliveri* in Vietnam.

Programme: CITES Tree Species Programme

Project funding: European Union support to CITES Secretariat

Implementing partner: Center for Nature Conservation and Development

Cover illustration: *Dalbergia cochinchinensis* in Dak Uy Protected Area
Photo: La Quang Trung/CCD – 2019.

Citation: Nguyen Tien Hiep, Nguyen Manh Ha & La Quang Trung (2019). Review on the taxonomy, biology, ecology, and the status, trend and population structure and dynamics of *Dalbergia cochinchinensis* in Vietnam. Center for Nature Conservation and Development, Ha Noi, Vietnam.

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Acknowledgement

The report “Review on the taxonomy, biology, ecology, and the status, trend and population structure and dynamics of *Dalbergia cochinchinensis* in Vietnam” was made based on the requirements of CITES Management Authority of Vietnam and the Center for Nature conservation and Development through the project “Strengthening the management and conservation of *Dalbergia cochinchinensis* and *Dalbergia oliveri* in Vietnam”. This work was funded by the European Union through the CITES Tree Species Programme.

We would like to express our sincere thanks to Ms. Ha Thi Tuyet Nga – Director, Mr. Nguyen Tuan Anh – Expert of CITES Management Authority of Vietnam, Ministry of Agriculture and Rural Development, for their letters of introduction and leading us to provinces to work with the Provincial Forest Protection Departments: Gia Lai, Kon Tum, Dak Lak, Binh Thuan, Binh Phuoc and Dong Nai, the relevant Forest Protection Departments and special-use forests include: Dak Uy, Yok Don, Bu Gia Map and Cat Tien protected areas.

We would like to thank the following individuals and organizations for their time to participate in our meetings and providing information. They are Mr. Hoang Thanh Son – Vietnam Academy of Forest Sciences, Mr. Le Duc Hieu – Kon Tum Forest Protection Department, Mr. Luong Van Phuong and Ho Thanh Vuong – Dak Uy Special-use Forest, Mr. Truong Van Nam and Mr. Nguyen Khac Tam – Gia Lai Forest Protection Department, Mr. Truong Quoc Dung and Nguyen Trong Hieu – Krong Pa Forest Protection Department, Mr. Kieu Thanh Ha, Mr. Tran Van Khoa and Ms. Vu Thi Chi – Dak Lak Forest Protection Department, Mr. Pham Tuan Linh and Mr. Mai Van Hoa – Yok Don National Park, Mr. Truong Dinh Sy and Vo Ngoc Thuan – Binh Thuan Forest Protection Department, Mr. Nguyen Van Minh, Mr. Do Tan Hoa and Ms. Nguyen Thi Ngoc Thin – Cat Tien National Park, Mr. Le Viet Dung and Mr. Nguyen Van Dung – Dong Nai Forest Protection Department, Mr. Vuong Duc Hoa and Mr. Tran Duc Ai – Bu Gia Map National Park.

We also thank the officers of some District Forest Protection Departments and the technical staff of the watershed protection forests and protected areas that led us to visit their sites.

Finally, we would like to express our gratitude to Mr. Hooi Chiew Thang – Regional Coordinator for Asia and Ms. Milena Sosa Schmidt – CITES Tree Species Programme Coordinator and Regional Coordinator for Central and South America and the Caribbean for their huge supports during the implementation of this project.

Abbreviation

| | |
|-----------|------------------------------------------------------------|
| a.s.l | Above sea level |
| CPC | Center for Plant Conservation |
| CCD | Center for Nature Conservation and Development |
| CITES | Convention on International Trade in Wild Fauna and Flora |
| DBH | Diameter at Breast Height (at 1.3 m from the ground level) |
| <i>D.</i> | <i>Dalbergia</i> |
| EN | Endangered |
| FPD | Forest Protection Department |
| GPS | The Global Positioning System |
| IUCN | International Union for Conservation of Nature |
| MARD | Ministry of Agriculture and Rural Development |
| MOST | Ministry of Science and Technology |
| ND-CP | Decree of the government |
| VAST | Vietnam Academy of Science and Technology |
| VUSTA | Vietnam Union of Science and Technology Associations |

1. Introduction

Dalbergia cochinchinensis Pierre was announced in 1898, originating from Vietnam, and widely distributed in Vietnam, Thailand, Laos and Cambodia (Pierre, 1898). This is a hard, beautiful, durable rosewood species, and free from termites. Therefore, *Dalbergia cochinchinensis* has high economic value and is threatened if it is not strictly managed, exploited and used for commercial purposes. *Dalbergia cochinchinensis* is listed in the Appendix II of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) and Group IIA of the Vietnamese government's Decree 06/2019/ND-CP on management of endangered, precious, and rare wild plants and animals and the implementation of the CITES.

There are very few studies on taxonomy, biology, and ecology of this species. Recently, a general study on the biological characteristics, ecology and biological activity of some species of *Dalbergia* genus, including *Dalbergia cochinchinensis* was conducted in Vietnam (T. L. Pham et al., 2011).

This report will provide scientific data and information to assess the taxonomy, biology, ecology, and conservation status of *Dalbergia cochinchinensis* in Vietnam.

2. Assessment of taxonomy, distribution, biology and conservation status

2.1. Nomenclature

The followings are nomenclatures of *Dalbergia cochinchinensis*:

- *Dalbergia cochinchinensis* Pierre, Fl. For. Cochinchinensis 5(24). Tab.382B (1898); Gagnep., Fl. Gen. Indochine 2:482 (1916); Craib, Fl. Siam. Enum.1: 475 (1928); Pham Hoang Ho, Fl.III. Viet Nam 1(2): 1113. Fig. 3159 (1991); Pham Hoang Ho, CCVN. Volume 1: 885. Fig 3546 (1999); C Niyomdham, P. H. Hô, P. Dy Phon, J. E Vidal In Ph. Morat, Flore Camb. Laos et Vietnam. 29: 21. Pl.3: fig. 5,6 (1997).
- *Dalbergia cambodiana* Pierre, Fl. For. Cochinchinensis 5(24). Tab.383A (1898); Gagnep., Fl. Gen. Indochine 2:496 (1916). –Typus. *Pierre 1709 (April, 1874)* (*synonym*) (**Figure 2**) (Global Plants, 2014).

2.2. Common names

- Vietnamese: Trắc, Cẩm lai nam bộ, Trắc bông, Trắc đen, Trắc trắng, Sâr (Gia Rai), Ka Rắc (Ba Na).
- English: Vietnamese rosewood, Siamese rosewood, Thailand rosewood, Tracwood.
- Thai: Phayung.
- Cambodian: Kanhung, Kranhung.
- Laos: Khanhung.
- Chinese: Suan zhī mù.

2.3. Biological characteristics

a) Description

A large tree, 6 – 30 m in height, 60 – 120 cm in diameter. Outer bark is brownish-yellow, longitudinally fissured or peeled off into fragments. Tree is profusely branched. Wood is dark red and then becomes black later. Young leaves appear in March. Leaves are

pinnately compound from 15 – 20 cm in length, 7 – 9 leaflets growing almost opposite. Petiole is 2.5 – 5 cm long and rachis is 6.5 – 15 cm long and glabrous. Stipule is caducous. Leaflet is coriaceous, oval to ovoid, white mold on lower surface, 3.5 – 8(–10) cm long, 2 – 4(–5) cm wide, with acute apex, obtuse or rounded at base. Lateral veins are 7 – 9 pairs and prominent on both sides. Secondary venules are clearly reticulate on the lower surface. petiolule is 2 – 5 mm long.

Inflorescence is corymbose-paniculate at or nearly terminal, 7 – 15(–20) cm long. Bracts are caducous. Peduncle is 1 mm long. Flowers are white to milky white, 5.5 – 6 mm long, aromatic. Calyx tube is 5 mm, glabrous; calyx lobes are oval to obtuse; inner calyx lobes are slightly longer than lateral calyx lobes but as long as calyx tube; calyx is stiff. Stamens are 9 – 10; filaments stick together; ovary is 2 – 4 ovules, glabrous to villose at base. Fruit is oblong, 4.5 – 7.5(–8) cm long, 0.8 – 1.2 cm wide, thin, glabrescent with compartments containing 1 – 2 seeds. Seeds are reniform, have a size of 4 x 6 mm, reddish brown. Flowering is from June to July. Fruiting is from September to November (**Figure 3**, **Figure 4**).

b) Holotype: (Typus). L. Pierre 1710b (Dec. 1866). Viet Nam, Song Bé, Bến Cát (**Figure 1**) (Muséum National d'Histoire Naturelle, 2014).

2.4. Distribution

In Vietnam, Siamese rosewood has scattered distribution in Da Nang, Quang Nam (Hien and Phuoc Son districts), Kon Tum (Dak To, Dak Uy and Sa Thay districts), Gia Lai (Krong Pa district and Cheo Reo commune of Ayun Pa district), Dak Lak, Lam Dong (Blaio/Bao Loc district), Binh Thuan (Ham Thuan Bac district), Binh Duong (Ben Cat), Dong Nai (Nam Cat Tien), Binh Phuoc, Ba Ria-Vung Tau (Dinh mountain), Ho Chi Minh city, Tay Ninh, Kien Giang (Phu Quoc district).

In the world, Siamese rosewood distributed in Thailand, Laos and Cambodia.

2.5. Ecology

Dalbergia cochinchinensis found in moist evergreen broad-leaved forests mixed with lowland Dipterocarpaceae deciduous forests with altitude from 50 – 60 m to 500 m above sea level (**Figure 5**) or moist tropical monsoon evergreen broad-leaved forests on lowland, preferably sandy clay and limestone soil. Growth rate is quite slow. Strong regeneration in crop fields. At Song Ba village, Chu Rcam commune, Krong Pa district, Gia Lai province, many small trees of *Dalbergia cochinchinensis* under 10 cm in diameter were regenerated from remaining base and roots in the edge of streams and brooks, and along the cashew field fences of local people. In the ecosystem of the lowland tropical monsoon evergreen forests, sometimes *Dalbergia cochinchinensis* is scattered regeneration and sometimes is in dense population and domination like in Dak Uy protected area (**Figure 6**). In forest structure, *Dalbergia cochinchinensis* plays important role in covering the surface soil layer, preventing soil erosion, keeping soil humidity, and creating beautiful landscape (**Figure 7**).

2.6. Studied specimens

To identify exact scientific name of the species, we have referred to highly valuable original scientific documents of plant taxonomy and studied the following specimens: photos of holotypes of *Pierre 1710b* (Dec., 1866), *Pierre 1709* (April, 1874) stored at Paris natural historical museum (P) and newly collected specimens in Vietnam stored at CPC. These specimens came from:

- **Gia Lai** province: Krong Pa district, Song Ba/Quynh Ba Village, GPS coordinate at 13°18'15.0"N; 108°37'13.0"E , 170 m a.s.l. , 11/11/2019, CPC 8557.
- **Dak Lak** province: Yok Don National Park, 13/11/2019, CPC 8558.
- **Kon Tum** province: Dak Ha, Dak Uy protected area, 10/11/2019, CPC s.n.

2.7. Assessment of taxonomy

The official scientific name of the Siamese rosewood is recognized as *Dalbergia cochinchinensis* Pierre of the family – Fabaceae (Leguminosae)¹. This species was published by a French botanist namely Louis Pierre in 1898 in the book “Flore forestière de la Cochinchine” based on the holotype *Pierre 1710b (Dec. 1886)* collected from the location “Song Bé, Ben Cát” of Vietnam in December 1886. Later in the 20th century, this name was still accepted for the rosewood species, *Dalbergia cochinchinensis*, distributed in Vietnam, Laos, Cambodia and Thailand (Craib & Kerr, 1928; Gagnepain, 1916; Niyomdham et al., 1997; Pham, 1999). At the same year of 1898, in the book “Flore forestière de la Cochinchine”, Pierre announced Siamese rosewood (*Dalbergia cambodiana* Pierre, Fl. For. Cochinchinensis 5(24). Tab.383A, 1898), based on the holotype *Pierre 1709 (April, 1874)* collected from Cam Chay, Cambodge (Campuchia) and kept at the Paris Museum of Natural History (Pierre, 1898).

After thorough studied and compared with the holotype *Dalbergia cochinchinensis: Pierre 1710b (Dec. 1886)* collected from “Song Bé, Ben Cát”, Vietnam and 28 different samples collected from Laos, Cambodia and Vietnam during 1886 and 1950, Niyomdham et al., (1997) changed the name of *Dalbergia cambodiana* to a synonym *Dalbergia cochinchinensis* Pierre and confirmed that the name *Dalbergia cochinchinensis* Pierre (1898) is official and legal nomenclature of this rosewood species.

In terms of the relationship amongst the taxa, the *Dalbergia* genus has about 100 species, distributed mainly in the tropics and subtropics in the world. In Vietnam, there are about 47 species (Pham, 1999) with some high valuable species such as *Dalbergia oliveri*, *Dalbergia cochinchinensis* and *Dalbergia tonkinensis*.

At the higher taxonomic level, the *Dalbergia* genus belongs to the tribe Dalbergieae Bronn ex De Candolle (1825), which was published by a Swiss botanist – Augustin Pyramus de Candolle and German geologist and paleontologist – Heinrich Georg Bronn in 1825. This tribe has 22 genera and distributes in the tropical regions of the two hemispheres. There are only two genera of *Dalbergia* and *Pterocarpus* in Vietnam, Laos and Cambodia.

2.8. Conservation status

In Vietnam, *Dalbergia cochinchinensis* listed as Endangered (EN A1a,c,d) in the Red Data Book of Vietnam (MOST & VAST, 2007). The basis of category is that *Dalbergia cochinchinensis* is a precious rosewood species and therefore is target for exploitation; the number of mature individuals has been significantly decreased; and deforestation has caused serious damage to its habitat.

In IUCN Red List of Threaten Species, *Dalbergia cochinchinensis* is classified as Vulnerable – VU (Asian Regional Workshop (Conservation & Sustainable Management of Trees, Viet Nam, August 1996), 1998).

¹ <http://www.theplantlist.org/tpl1.1/record/ild-46412>

2.9. Use and scientific values

Dalbergia cochinchinensis is a hard, durable, fine texture, termite resistant rosewood. Timber has high economic value and therefore is used for construction, ornament and furniture. In terms of science, *Dalbergia cochinchinensis* is a rare genetic resource and high threat of extinction; therefore, it is taken in consideration for distribution and genetic research by the International Plant Genetic Resources Institute.

3. Current status, trend and population dynamics of *Dalbergia cochinchinensis* in Vietnam

According to published documents during 19th and 20th centuries and information collected from recent field visits, *Dalbergia cochinchinensis* widely distributed in 13 provinces of Vietnam, namely Da Nang, Quang Nam, Kon Tum, Gia Lai, Dak Lak, Lam Dong, Binh Thuan, Binh Duong, Dong Nai, Binh Phuoc, Ba Ria- Vung Tau, Tay Ninh and Kien Giang.

The Siamese rosewood population trend is decreasing in both Vietnam and in the world. The number of mature individuals has been significantly declined. Moreover, deforestation has seriously compromised to the occupation of the species. In the past distribution locations such as Ben Cat of Binh Duong province, Trang Bom district of Dong Nai province and Thu Duc district of Ho Chi Minh city, where six of 30 specimens of *Dalbergia cochinchinensis* were collected in the period 1880 – 1890 and are being kept at the French National Museum of Natural History, wild populations of *Dalbergia cochinchinensis* maybe now exterminated due to the urbanization.

Results of field visits on Siamese rosewood in the provinces of Kon Tum, Gia Lai and Dak Lak from 9 – 14 September 2019 and Binh Thuan, Dong Nai and Binh Phuoc from 7 – 12 October 2019 indicated that *Dalbergia cochinchinensis* is still naturally distributed in all sites above. However, the occupancy area, populations, and the number of mature individuals have been drastically reduced due to over-exploitation and destructed habitats.

In Kon Tum province, this species is extant in Dak Ha and Dak To districts, and Dak Uy protected area.

In Gia Lai province, Siamese rosewood is still in Chu Pah, Chu Prong and Krong Pa districts, and watershed protection forests of the Ialy Hydro Power Plant. Many resprout seedlings of *Dalbergia cochinchinensis* were observed in the production forests and cashew gardens of local people in these places.

In Dak Lak province, *Dalbergia cochinchinensis* exists in Eaka, Krong Pong, Ea Sup, Yok Don, Easo, and Krong Nang districts.

In Binh Thuan province, *Dalbergia cochinchinensis* distributed in many up-land communes before 1996. The species was vastly exploited from 1998 for the huge market demand. At the present, Siamese rosewood is extant in the adjacent areas to Di Linh district, Lam Dong province and the watershed protection forests of Ham Thuan – Da Mi Hydro Power Plant.

In Dong Nai province, there are many *Dalbergia cochinchinensis* trees, which are well protected in Tan Phu watershed protection forest, and Dong Nai cultural nature reserve (Ma Da commune of Vinh Cuu district and Cat Tien district).

In Binh Phuoc province, there was no record of the existence of the Siamese rosewood.

In general, the rapid assessment of status, trend, population structure and dynamics of Siamese rosewood through desk review, quick interviews, and short field visits to the six provinces, found that the number of individuals, especially large-sized *Dalbergia cochinchinensis* trees and its occupancy areas have been reduced due to over-exploitation or habitat destruction. Nevertheless, there are still large-sized trees existing in Dak Uy protected area and Ham Thuan – Da Mi watershed protection forests, and many regenerated seedlings in Chu Rcam commune, Krong Pa district and Dak Uy protected area (**Figure 8**). This means that the seed source for propagation may meet the conservation purposes.

4. Management and conservation of *Dalbergia cochinchinensis* in Vietnam.

4.1. Protected by laws.

Dalbergia cochinchinensis is listed as Endangered (EN) in the Red Data Book of Vietnam (2007) and Vulnerable (VU) in the IUCN Red List of Threaten Species. In reality, wild populations of this rosewood species have been rapidly decreased due to uncontrolled exploitation, massive trade and destructive habitats. In 2016, Vietnamese plant conservationists predicted that this species would be extinct in the next 10 years if no effective protection measures undertaken. Based on the scientific evidences, the government of Vietnam placed *Dalbergia cochinchinensis* in the group IIA of the Decree 06/2019/ND-CP dated on January 22, 2019 on the management of rare and endangered wildlife and implementation of CITES. According to group IIA of this Decree, wild plants and animals which have not been immediately threatened to be extinct but are at high risk of extinction if the exploitation and trade of these species are not strictly managed.

In places where *Dalbergia cochinchinensis* distributed, MARD and local FPDs have implemented some actions to manage the exploitation, trade, and conservation of *Dalbergia cochinchinensis* in accordance to provisions of laws.

4.2. *In situ* conservation.

The wild populations of *Dalbergia cochinchinensis* in protected areas such as Cat Tien national park, Dong Nai Culture and Nature Reserve, IaLy watershed protection forest, Ham Thuan-Da Mi watershed protection forest and Yok Don national park should be *in situ* conservation.

In Kon Tum province, a management board for Dak Uy protected area was established in 1993 in Dak Mar commune, Dak Ha district. The management board has main duties of protecting and developing forests. Dak Uy protected area has 546.24 ha with average altitude of 620 m a.s.l. The protected area has many rare and precious plants such as *Dalbergia cochinchinensis* and *Pterocarpus macrocarpus*, of those, *Dalbergia cochinchinensis* is abundant with high density. The management board has constructed a 14 km fencing system around the protected area to protect this *Dalbergia cochinchinensis* population and is assigning forest protection forces to be in position for 24 hours/day to guard at key positions where many Siamese rosewood trees distributed. The management board also took inventory and measurement of Siamese rosewood individuals in 2018. As a result, there are 800 trees with average diameter at breast height (DBH) greater than 20 cm and 500 trees with DBH between 15 – 20 cm in Dak Uy protected area. Trees under 15 cm were not measured. All counted trees were determined by GPS coordinates and assessed

health condition. This is valuable scientific data for further studies on ecology, growth, development and nursery. If implemented, those studies will support the proposal to establish a national nursery for *Dalbergia cochinchinensis*. In response to the World Environmental Day in 2018, Kon Tum provincial FPD in cooperation with Dak Uy protected area management board and local authorities planted 4.500 seedlings of *Dalbergia cochinchinensis* within the protected area. Additional 6.600 seedlings of *Dalbergia cochinchinensis* were planted in other places of the province. The number of illegal logging cases has significantly decreased from 28 in 2017 to seven in 2018 and no case in 2019. It can be said that Dak Uy forest is the best *in situ* conservation place for *Dalbergia cochinchinensis* in Vietnam and will be able to provide good seed source for plantation in Central highland and other suitable climate condition areas.

In Quynh Ba/Song Ba village of Chu Ream commune, Krong Pa district, Gia Lai province, households are protecting regenerating Siamese rosewood populations along streams and in their cashew plantations. These young populations are in good growing condition with some individuals reaching to the height of 5 – 6 m and DBH about 10 cm (Figure 9).

4.3. Growing *Dalbergia cochinchinensis* in sparse land with protection

In recent years, under the instruction of the provincial FPDs of Kon Tum, Gia Lai, Dak Lak and Binh Phuoc provinces, citizens and local governmental officers planted *Dalbergia cochinchinensis* in the small isolated lands (also called as sparse land) on the streets, cultivation land of households and office on the international environmental day.

4.4. Local nursery system for *Dalbergia cochinchinensis*

Field visits indicated that there are few nurseries having *Dalbergia cochinchinensis* in the region. Some seedling provision facilities such as the Tropical Forest Research Center in Pleiku city of Gia Lai province Yok Don national park and families in Trang Bom district of Dong Nai province produce *Dalbergia cochinchinensis* seedlings for local government programs of scattered afforestation, and planting trees in offices, streets, local households and surrounding areas (Figure 10).

5. Proposed interventions for conservation and sustainable development of this species in Vietnam

Dalbergia cochinchinensis is precious, economically and scientifically valuable, and is subject for logging and international trade. The population trend of the species is sharply declining. At national level, *Dalbergia cochinchinensis* is protected by the governmental decree 06/2019/ND-CP dated on January 22, 2019. To protect this species at provincial level, provinces should take the following actions:

5.1. Develop and implement provincial policies

- Develop operational management plan for protected areas where *Dalbergia cochinchinensis* distributed and ensure that requirements of *in-situ* management and protection of *Dalbergia cochinchinensis* are taken into account.
- Propose species conservation plan and budget to the Vietnam Forest Protection and Development Fund of Vietnam.
- Enforce the relevant laws and regulations to protect *Dalbergia cochinchinensis*.

5.2. Communication and education

- Raise awareness of the public on species conservation by using mass media such as radio, television and newspapers.

5.3. Law enforcement

- Management boards of protected areas and FPD officials should carry out regular inspection and control of unprocessed and processed timber transport of this species at the entrances of the forests where the presence of *Dalbergia cochinchinensis* has been known.

5.4. Community-based interventions

- Provide trainings to local villagers and local forest rangers on population survey and monitoring.
- Recruit local people to establish forest patrolling teams to patrol forests and deliver conservation actions.

5.5. Species-based interventions

a) *In-situ* and *Ex-situ* conservation

- Undertake *in-situ* conservation of wild *Dalbergia cochinchinensis* populations in protected areas.
- Establish nurseries at the protected areas where *Dalbergia cochinchinensis* exists to produce seedlings for *in-situ* and *ex-situ* conservation.

b) Restoration

- Involve local communities in re-planting *Dalbergia cochinchinensis* seedlings in the historical areas where the species might have grown in the past.
- Encourage scattered afforestation program for *Dalbergia cochinchinensis*.

5.6. Research-based interventions

a. Carry on surveys on population and distribution

- Conduct further field surveys on *Dalbergia cochinchinensis* to confirm its distribution areas and identify its wood volume in prioritized areas of Central highland, South Central and Southeast regions.

b. Ecological study

- Conduct further research on ecology such as phenology, germination and seedling formation and growth rate, and regeneration to support both *in-situ* and *ex-situ* conservation.

c. Monitoring

- Establish local common interest groups to attract people who are interested in conservation to monitor threats of this species like the model in Bu Gia Map National Park.
- Draw attention of local people in mapping and recording GPS coordinates, making profile and inventory of each tree that has DBH above 10 cm in the protected area.

d. Conduct socio-economic study with the participation of local communities

- With the participation of local communities, conduct socio-economic research, identify potential human-induced threats, and study utilization of *Dalbergia cochinchinensis* to highlight the problems that relate to population growth, poverty, education, traditional and cultural activities, land use, crop structure, and dependence on forest resources.

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Illustrations



Figure 1. *Dalbergia cochinchinensis* Pierre (1898). **Holotype.** Pierre 1710b (Dec. 1866). Collected in Viet Nam, Song Bé, Ben Cát.

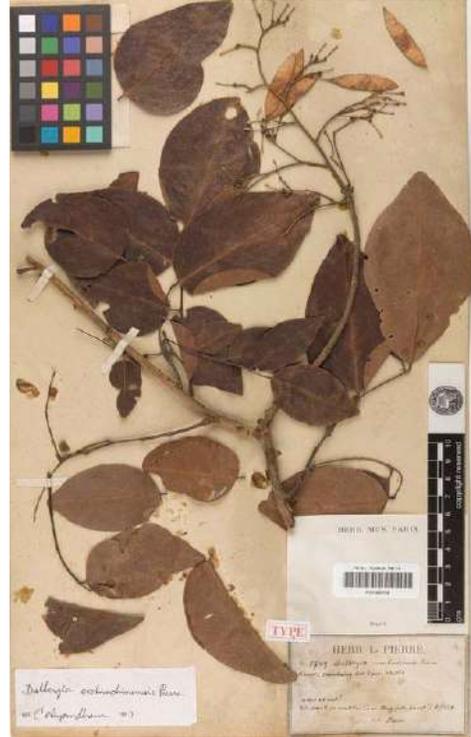


Figure 2. *Dalbergia cambodiana* Pierre (1898). **Holotype.** Pierre 1709 (April, 1874). Collected in Cam Chay, Cambodia (synonym of *Dalbergia cochinchinensis*).



Figure 3. *Dalbergia cochinchinensis* Pierre (1898) with young fruit. Specimen: 13 Sep., 2019 CPC 8558 collected at York Don national park, Dak Lak province. Photo by Nguyen Tien Hiep/CPC – 2019.



Figure 4. *Dalbergia cochinchinensis* Pierre (1898). Specimen: 11 Sep., 2019 CPC 8557 collected in Gia Lai province (Krong Pa district, Song Ba (Quynh Ba) Village), GPS: 13° 18' 15.0 "N, 108° 37' 13.0"E, 170 m a.s.l. Photo by Nguyen Tien Hiep/CPC – 2019.



Figure 5. Lowland mixed tropical evergreen and deciduous forest in Yok Don national park. Photo by Nguyen Tien Hiep/CPC – 2019.



Figure 6. *Dalbergia cochinchinensis* trees are dominated in the lowland evergreen broad-leaf tropical monsoon forest of Dak Uy protected area, Dak Ha district, Kon Tum province. Photo by Nguyen Tien Hiep/CPC – 2019.



Figure 7. *Dalbergia cochinchinensis* trees are densely extant in Dak Uy protected area having functions of covering the land, preventing soil erosion, keeping soil humidity, and creating beautiful landscape. Photo by Nguyen Tien Hiep/CPC – 2019.



Figure 8. Many *Dalbergia cochinchinensis* seedlings are sprouted from the remaining roots in the cashew plantation of a household at Song Ba (Quynh Ba) village, Chu Rcam commune, Krong Pa district, Gia Lai province. Photo by Nguyen Tien Hiep/CPC – 2019.



Figure 9. *Dalbergia cochinchinensis* regenerating in the cashew plantation of a household. Photo by Nguyen Manh Ha/CCD – 2019.



Figure 10. A nursery at the Center for Tropical Forestry in Gia Lai province, where *Dalbergia cochinchinensis* seedlings are produced for scattered afforestation. Photo by La Quang Trung/CCD – 2019.