



**Project Title: Status and conservation action plan for three globally threatened tree species in Xuan Son National Park,
Phu Tho province, Viet Nam**

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THE DETAILED FINAL REPORT

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STATUS AND CONSERVATION ACTION PLAN FOR THREE THREATENED TREE SPECIES OF DIPTEROCARPACEAE IN XUAN SON NATIONAL PARK, PHU THO PROVINCE, VIETNAM

I. INTRODUCTION

The Dipterocarpaceae is a family of hardwood, with more than 500 species worldwide in 17 genera [8], distributed mainly in the tropical lowland rainforest and can be found at forest's the highest layer. Most of all dipterocarps are upright trees, reaching up to 40-60 metres (m) in height in primary forest, and sometimes an emergent tree cans reach to 80 m of height with the diameter at breast height got more than 1m. The tree trunk is always straight and high and the species of this family are the one of the major importance plants in the timber trade. There are 42 species in six genera of dipterocarps in Vietnam [5].

Six genera of this family occurred in Vietnam (Vietnam flora, 2000) as follow:

Scientific name of genus	Vietnamese name	Number of species in genus
1. Anisoptera Korth. 1841	Vên vèn	2
2. Dipterocarpus Gaertn.f. 1805	Chò nâu	11
3. Hopea Roxb. 1811	Sao đen	11
4. Parashorea Kurz, 1870	Chò chỉ	2
5. Shorea Roxb. ex Geartn.f. 1805	Sén mủ	8
6. Vatica L. 1771	Táu	8
	Total	42

Among of 42 species of Dipterocarpaceae in Vietnam, has only 11 species were recorded in Vietnam Red Data Book (2007) [4], and their status are divided into categories as critically endangered (CR) level: 1 species; endangered level: 5 species and vulnerable (VU) level: 5 species. On the other hand, the report of the IUCN (version 2.3 and version 3.1) also indicated that there were 37 threatened and rare tree species of this family in Vietnam, including CR: 18 species; EN: 12 species; VU: 2 species; least concern (LC): 4 species and data deficient (DD): 1 species.

Nevertheless, according to the IUCN (2004), nearly 100 percent of Dipterocarpaceae species in Vietnam was confirmed in the Red Data Book as endangered species. Hence, the significant issues could be concerned that need attract the attention of the research conservation as soon as possible (see annex 1).

Distribution of dipterecarp species in Vietnam

The dipterocarps belong to the Indo-Malayxia flora; hence they have tendency to adapt in many conditions, particularly under the drought condition, warmly and strongly sunlight intensity. In Vietnam, they mainly distributed in Central of Vietnam (from Da Nang province to the South) and concentrated in large populations in some provinces such as Daklak, Gia Lai, Dong Nai and Tay Ninh, etc. The forest's ecosystem locating in the provinces had known as the name of

dipterocarp forest, because the major components of the forest were belonged to Dipterocarpaceae, such as: *Dipterocarpus alatus*, *D. obtusifolius*, *D. dyeri*, *Hopea odorata* and *Anisoptera cochinchinensis*. However, in Northern part of Vietnam, dipterocarp species are often found in tropical monsoon evergreen broadleaf forest on lowland, whereas mainly dominance of species of the families named: Euphorbiaceae, Fabaceae, Meliaceae, Rubiaceae, Sapindaceae, Lauraceae, Fagaceae, etc. Several dipterocaps were recorded such as *Parashorea chinensis*, *Vatica tonkinensis*, *Vatica chevalieri*, *Dipterocarpus retusus*, and were counted in a small percent of plant components of tropical evergreen broadleaf forest.

Valuable of Dipterocarpaceae in Vietnam

The family of the trees is significant components dominated in forest ecosystem. They are often found as a dominant or an emergent forest component in the forest areas, the reason could take in account that they can grow fast and regenerate shoots well and are deciduous in winter. In spring season, they grow and change their form quicker than the other time of the year. In addition, they could provide food and shelter for many other plants, birds, mammals, fungi and other organisms in the forest.

The family has many valuable timber species which can be prevented from affects of termite and insects, such as: *Anisoptera costata* Korth, *Hopea ferrea* Pierre, *Hopes mollisima* C.Y. Wu, *Shorea falcate* J.E. Vidal and *Vatica subglabra* Merr. Hence, their wood is more important for local subsistence use and highly valuable in national or international markets because almost all the wood of these trees are always used for construction, building houses and making furniture. Beside timber, the other ones can provide much important productivity such as aromatic essential oils, balsam, resins and are sources for plywood as *Dipterocarpus alatus* Roxb. *D. dyeri* Pierre, *D. intricatus* Dyer, *D. tuberculatus* Roxb. and *Hopea ferrea* Pierre (see annex 2).

II. INTRODUCTION TO THREE THREATENED TREE SPECIES OF DIPTEROCARPACEAE NEEDS CONSERVATION IN XUAN SON NATIONAL PARK.

The descriptions of the three species mentioned above are presented below.

1. *Dipterocarpus retusus* Blume, 1823.

Synonym: *D. tonkinensis* A.Chev, 1918

Dipterocarpus trinervis Blume

Vietnamese name: Chò nâu (the other name: Chò đá, Chò đai, Chò nến).

Conservation status: Global: **VU** A1cd+2cd, B1+2c

Proposed national assessment: **VU** A1c,d + 2c,d, B1 + 2b,c



Two *Dipterocarpus retusus* individuals



The flower and fruit of D. retusus



Photos 1. *Dipterocarpus retusus* Blume in Xuan Son National

2. *Parashorea chinensis* H. Wang, 1981

Synonym: *Shorea chinensis* (Wang Hsie) H.Zhu

Shorea wangtianshuea Y.K.Yang & J.K.Wu

Vietnamese name: Chò chỉ (the other name: Mạy kho, Mạy khay)

Conservation status:

Global: EN A1cd, C2a, D

Proposed national assessment: not evaluated



The stem of the bigger tree



The canopy of the bigger tree



The other one



Two tree of *Parashorea chinensis* in Coi community

Photos 2. Two mature individuals of *Parashorea chinensis* in XNP

Parashorea chinensis H.Wang is the one of the tallest tree species in Asia, with the shape like a big umbrella and so has long body and straight trunk, strong and imposing. The tree's body

is generally 60m in height, with some of them reached to 80 m in height; an individual body is as tall as a 20-storey building. It is a big evergreen tree in the Dipterocarpaceae family.

3. *Vatica subglabra* Merr., 1942

Vietnamese name: Táu nước (the other name: Táu xanh)

Conservation status: Global: not evaluated

Proposed national assessment: **EN** A1c, d



Vatica subglabra individuals in XNP



The black bark and the stem in where is more crack along and covered by lichen (one of characteristics to identify this species)



Flower of *Vatica subglabra*



Two stems of *Vatica subglabra* in the plot

Photos 3. *Vatica subglabra* Merr. in Xuan Son National Park

III. INTRODUCTION TO XUAN SON NATIONAL PARK.

Xuan Son National Park (XNP) is located in Southwest of Tan Son district, Phu Tho province, inside the boundary intersection of three provinces Phu Tho, Hoa Binh and Son La. The geographic location is between 104°51'E to 105°01' E longitude and from 21°03'N to 21°12'N latitude. The total natural areas are 15,048ha and most of the areas located on the hills and lowland mountains, average elevation of 200-800m, the peaks of the mountain were reached to more than 1,000m, it was called Mountain Elephant with 1,386m in height and mountain Ten with the height of 1,244m. Whereas it could consider not only the green lung for the whole region but also with high value for the biodiversity and conservation, the forest areas are also

filled with many globally threatened and rare plants and animals. Thus, XNP is the one of the most preserved priority areas in Vietnam.

Moreover, the forest of Xuan Son National Park is a specific ecosystem of vegetations in North of Vietnam and was divided by 9 types of forest ecosystems and vegetations, including:

- i) At elevation of 200-800m, the tropical monsoon broadleaf evergreen forest was covered in 12% of areas total of XNP. In spite of exploiting but it is still like as primary forest.
- ii) Tropical broadleaf evergreen forest on limestone mixed soil mount (11%) is located mainly on mount Can.
- iii) Subtropical evergreen forest on rocky limestone mount (6%) is distributed on scattered in XNP whereas the plant components mix broadleaf and conifer trees.
- iv) Subtropical monsoon broadleaf evergreen forest on lowland mountains (15%). The typical has the biggest of tree components.
- v) The secondary forest recovered after shifting cultivation (11.5%) is located scattered in XNP.
- vi) The secondary forest of Bamboo (2.2%)
- vii) Grassland, scrub and scattered trees (30.8%)
- viii) Plantation (0.1%).
- ix) Cultivation ecosystem (10%) is distributed scattered in XNP where has local people living.

The flora in the forest were diverse, richness and abundant, including 1,217 species belonging to 680 genera and 180 families. There were assessed 40 endangered species belong to 29 families (2007). In the narrow areas distributing in Xuan Son National Park, five dipterocarps were found, namely *Dipterocarpus retusus* Blume, *Parashorea chinensis* H. Wang, *Vatica diospyroides* Sym., *V. odorata* (Griff.) Symingt, *Vatica subglabra* Merr., the *Dipterocarpus retusus* is in the rank of vulnerable species (VU), *Parashorea chinensis* as endangered species (EN) and typically *Vatica subglabra* was assessed no value on global, but it was rank as EN level in the Vietnam Red Data Book (2007) (category EN, VU of the IUCN classification). They were distributed mainly in two forest types, tropical monsoon evergreen forest and subtropical monsoon broadleaf evergreen forest on lowland, at elevation 200-800m. The species are not only a valuable and rare genetic resource, but also commercially valuable. In fact, they only may be remained in some national parks and distribute scattered throughout or concentrated in small populations. Rarely has seen the tree body with diameter is larger than 50 cm at outside of Parks area. Besides, the number of local people like as Dao, Muong have lived in the core site of the park for many years and the main income of them was came from the products in forest, especially timber. The last but not least important reason is detailed information of the species is still gap in currently. Therefore, the species are needed to meet of the highest priority conservation and protection levels.

IV. PROJECT AIMS AND OBJECTIVES

1. Status and distribution of tree species.

+ Evaluating the number of mature individuals of each species, the average age of parents in the population, the size of remaining plant communities, compiling a database on ecological

parameters and the profiles of each threatened tree and making distributions of the species on original map of the XNP.

2. In situ conservation.

- + Assessing the current threats that affect the growth of the species.
- + Collecting information and database of the trees from field trips and obtaining results to update information on the location of the remaining population.

3. Ex situ conservation.

- + Estimating the regeneration rate in the field.
- + Finding the seed and build a living gene bank of the tree species in the sites.
- + Studying the sprout rate of seeds in the field and laboratory.
- + Consulting the propagation experiments in nursery garden.

4. Conservation education activities.

- + Providing the information about status and managing policy for managers in the park.
- + Preventing the loss caused by unsustainable harvesting of timber.
- + Making the discussion with local authorities and Vietnamese experts to synthesize the advices and recommendations for conserving strategy in future.

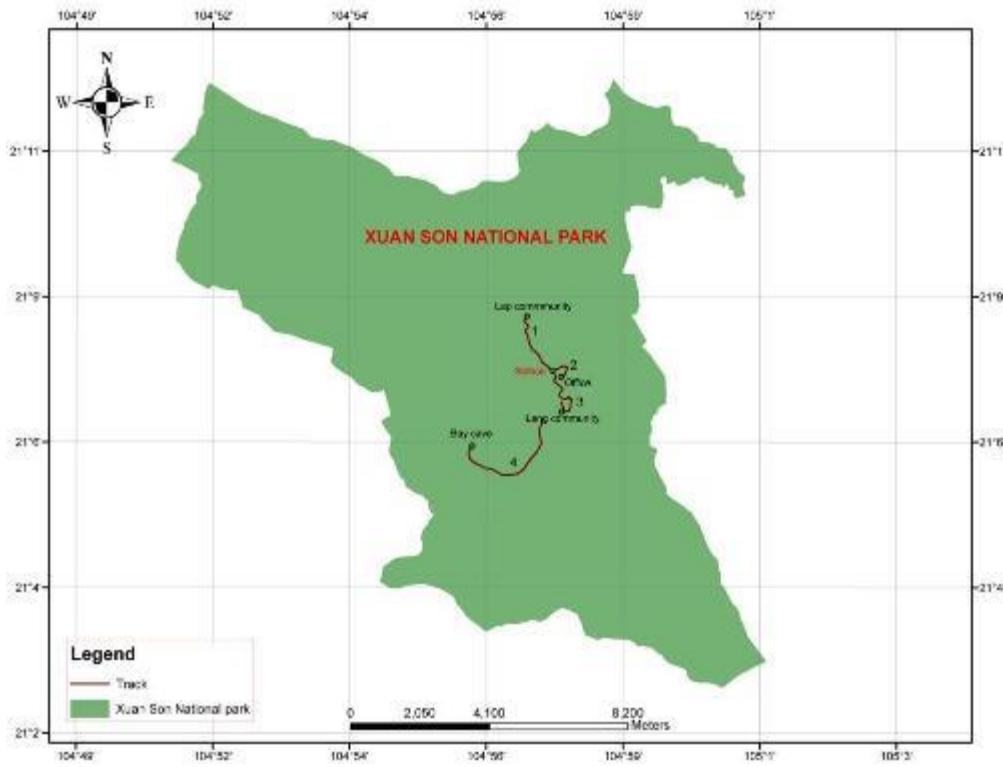
V. METHODOLOGY

1. Field survey.

i) Using the both track and random survey to investigate the status and size of population. By synthesising of the ecological characteristics of each species and forest status as well as experiences of staff of XNP and ethnic people, four tracks were implemented to find out the position of each mature individual and its population.

- + The survey track 1: starting from forest protected Station and ending of Lap community (T1).
- + The survey track 2: from Station to XNP Office (T2).
- + The survey track 3: from Station to Lang community (T 3).
- + The survey track 4: from Lang community to Bay cave (T 4).

Main locations in XNP	Co-ordinate
The forest protection Station	E 104° 57' 27.58'' N 21° 7' 29.154''
Lap community	E 104° 57' 1.874'' N 21° 8' 21.88''
Lang community	E 104° 57' 36.708'' N 21° 6' 49.24''
Bay cave	E 104° 56' 5.269'' N 21° 6' 16.341''



The mapping of survey tracks in Xuan Son National Park

The plots were set up at the study sites and carry out of identification of candidate populations' location. The size of each plot was designed dependence on the population areas (three size types of plot: $50\text{m} \times 50\text{m} = 0.25\text{ha}/\text{plot}$; $50\text{m} \times 20\text{m} = 0.1\text{ ha}/\text{plot}$; $20\text{m} \times 20\text{m} = 0.4\text{ha}/\text{plot}$; $40\text{m} \times 40\text{m} = 0.16\text{ha}/\text{plot}$). At first, the research measure all juvenile and adult trees (diameter at breast height, DBH $> 5\text{cm}$) of tree in the plots and then tagging up and measurement the number of individuals for each species on the height and the DBH of tree as well as the other are parameter necessary issues. Within the plot subplots ($20\text{m} \times 20\text{m}$; $5\text{m} \times 5\text{m}$), the research could take randomly establishment to study seedlings and saplings ($< 5\text{cm}$ DBH). All parameters such as DBH, height were applied for each individual studied.

Identifying growth stage of tree was based on dimension of stem diameter and monitored phenology of individuals to divide into three groups

Mature individual: DBH > 30

Juvenile: 5cm & DBH $< 30\text{cm}$

Sapling: DBH $< 5\text{cm}$

ii) Collecting the seeds of the species for studying ex situ collection.

iii) Mapping the species distribution base on the spatial data of GPS system where individuals were found.

2. Interview method:

Interviewing the people communities, the method based on the people are living in the core of the forest and several staffs of XNP in order to get the valuable information on the status of each species in the field interaction with the human activities and the threatened levels for growth plant. Consequently, the surveying plans were exactly proposed to the forest managers, forest rangers and interested members of village communities who are invited to participate in the field work survey throughout the proposed study area and period.

3. Training and workshop.

Making the seminars and meetings with participation of local communities in order to improve their knowledge to conserve these threatened plants, the workshop's results will become the initial values for making the action plans.

VI. RESULTS.

Four transects and many plots were set up in different locations. That information about ecological parameter, regeneration, distribution inside or outside of each species was recorded by the conservation team (including conservationists, scientists and forest rangers of XNP and local people).



The surveying team in field



Making a plot



Measuring DBH of
Dipterocarpus retusus



The site of the natural
regeneration plot



Finding sapling in field



A sapling of *Vatica subglabra*

Photos 4. Typically surveying activities of the conservation team

A/ STATUS OF THREE THREATENED DIPTEROCARP SPECIES IN XNP

Assessment of the threatened status species of any forest ecosystem is a major method and become an important task because the database will provide the basic information to the other conservation, such as in situ or ex situ research activities. The input information is included all of the status of species about the distribution and size of remaining population or mature individuals. The set of parameter of forest ecology was indicated the effectiveness on growth of species, natural generation rate and threatens to their habitats.

1. *Dipterocarpus retusus* Blume.

Dipterocarpus retusus is widespread in both forest types of tropical monsoon broadleaf evergreen forest and subtropical monsoon broadleaf evergreen forest on lowland mount in XNP. The species prefer to grow on the thick clay, fertility and drainage. In each survey track, the number of mature individuals was identified separately and the data was given below:

Table 1. The parameters of *Dipterocarpus retusus* in XNP

Population	Surveying track	Number of maturity	Percentage (%)	DBH _M (cm)	H _M (m)
1	Track 1	19	46.34	72.76	35.12
2	Track 2	11	26.82	40.04	23.9
3	Track 3	6	14.65	49.36	26.67
4	Track 4	2	4.88	80.41	47.5
5	Track 4	3	7.31	57.92	35.18
Total		41		60.1	33.67

Note: M: medium data of maturity

The table 1 shows that, on four survey tracks had established for the research, the conservation team found out five locations where *Dipterocarpus retusus* is living. There were only two isolated populations of this species. The size of the remaining populations was not so large area, the biggest area of population on track 1 was covered about 0.8ha, and rest of population located on track 2 was covered 0.5ha. The other maturities distributed scattered on the different tracks and did not develop individual in population. The total number of maturity has been counted for 41 individuals; the average height of individuals was around 33.67m and the average DBH approximately 60.1 cm.

Most of all the maturities located in tracking survey 1 (T1) and 2 (T2), are represented 73.17% of the total maturities. Typically, in surveying track 1 had found 19 mature individuals (covered 46.34% compared with those of the other populations). Of which, 6 trees were identified to species with DBH over 100 cm and the biggest diameter individual was 130.6 cm, the highest individual plant was measured up 63m. The small maturity number was estimated for 2 which located closely to cave Bay (track 4- T4), but the average diameter was measured over 80.4 cm.

Hence, the parameters could present that *Dipterocarpus retusus* is being highest protected level in natural habitats of park.

The population structure was provided the relationship information between *Dipterocarpus retusus* and the other species and the regeneration status of the species. After had assessed the mature tree density, candidate plot was set up in the population 1 (T1) and a seldom plot was took place in track 3 (T3), with had: 50mx20m (0.1ha) around the mother trees to inventor and gather all information of the ecological elements, silvicultural structure and the natural regeneration rate.

The location of the survey plots of population 1 was located on N 21°08'187'' and E 104°57'081''. In the plot had counted for 124 tree individuals belong to 24 species and 18 families. In this case, the *Dipterocarpus retusus* was dominant species in the area and had consisted of 11.6% total of tree individuals in compare with another species in the plot. It could indicated that: 14.74% of *Aglaia spectabilis* (Meliaceae), 6.5% of *Gironniera subaequalis* (Ulmaceae), 8.1% of *Camelia sp.* (Theaceae), 6.5% of *Hyprocarpus kurzii* (Flacourtiaceae), 12.9% of *Machilus thunbergii* (Lauraceae), 4.8% of *Helicia grandifolia* (Proteaceae) and the rest of 35% was belong to the others. In fact, all maturities of *Dipterocarpus retusus* could be seen in the highest forest layer. Finding out ability of its natural regeneration, it was seemed that 25 regenerative individuals, among them 8 juveniles (with the height of the body from 1.8m up to 5.9m) and 17 saplings from 40 up to 150cm in height.

The surveying plot in track 3 located on N 21°06' and E 104°57'750'', it had counted for 104 tree individuals belong to 23 species in 16 families, *Dipterocarpus retusus* counted the proportion of 3.26% of total number of trees, the forest was mainly composed by others broadleaf species, namely 12.05% of *Antidesma fordii* (Euphorbiaceae), 8.94% of *Caryodaphnopsis tonkinensis* (Lauraceae), 7.58% *Cinnamomum balanceae* (Lauraceae), 5.19% of *Garcinia oblongifolia* (Clusiaceae) and rest of the others species were: *Knema globularia* (Myristicaceae), *Pometia pinnata* (Sapindaceae), *Xylopia sp.*, ect. Especially, only two saplings were identified in plot with the height from 0.7-1.2m. Extending of survey areas, the study team has discovered the population of natural regeneration (in the area of 600m²); *Dipterocarpus retusus* was dominated and located outside of the plot at a distance of over 300m and the direction east. The total regenerative was accounted for 37 individuals, with 14 juveniles (H: 2.5 – 11m; DBH: 5 -16.9 cm) and 23 saplings (DHB <5cm; H: 1.0m-2.6m). The state of the research could explain that, the mother tree of this species always distribute in emergent layer of forest and its fruit is characterized with two large wings so that the ripe fruit could be dispersed to another site by wind and then a new regenerative population could be established. Besides of the story, the forest land was used to shift cultivation then fallowed about 10 years. Although sapling grew well in shading condition, it could development in open light canopy.

During the field survey in track 1, 6 mature individuals were dead with unknown reason, all of the interactions were not related by observation, and the question could be marked in this case for further research: *once they got the height around 35-45m and diameter of 75-90 cm or more was the maximum limitation for their develop?*



Photos 5. The six deadly big trees of *Dipterocarpus retusus* in XNP

2. *Parashorea chinensis* H. Wang.

Parashorea chienensis species in XNP had only trees lived in vegetation type of tropical monsoon broadleaf evergreen forest on lowland. These trees are strongly grew up on red-brown feralit and soil-depth was thick, soft, rich humus content and high acidity (pH scale range from 4 to 5). There were found two big trees and three natural regeneration populations.

Two mature individuals were found in Coi community with location of E 104°56' 57.087'' and N 21°9'18.368''. One of these individuals had the height of 60m and the trunk diameter around 170 cm and the individual is the one of giant trees in the areas, the tree had the long trunk and straight height. Comes up with the field survey experiences, this individual had been seen the biggest one and could compare with another in North of VN at the moment. The another ones could a big tree with H: 53m and DBH: 120cm. Based on the phenology was indicated that, the *Parashorea chinensis* species was not flowering in annually but the blossom cycle within 2-3 years, 2 mature individuals are also obligated follow the cycle. But, at the gathering fruit and seed of them time in 2011, the survey team had gained a considerable amount of seeds to provide for propagation. Extending of inventory areas surrounding these big tree at the aim of finding natural regeneration population, but could not found of any sapling around this area. According to managers information provided, the trees was existing in the area such a very long time and was reserved by managers in XNP and local people.

Three natural regenerative populations of *Parashorea chinensis* had discovered in the survey tracks T3 and T4. The remaining regeneration populations were almost composed by species and differential age and the density of the species in the area.

The first regenerative population was located closed to Lang community T3 in 0.2 ha area. Including 42 individuals with the average height of 14.7m and the diameter is around to 21.3 cm, the smallest was got 11cm diameter and the largest was measured at 42cm diameter. However, there was no other tree species grew up together but grass is an exceptional sample. According to the local people, the population of the plants had been developed in 15-16 years and was not yet flowered through while the individuals had gotten up 30 cm in diameter.

The second natural regenerative population was distributed closely to Bay cave (R4) with N $21^{\circ}06'33''$ and E $104^{\circ}56'71''$ and the area covering 0.3ha. Within 0.2 ha of plot area, the number of species are accounted on 169 individuals with the average height and diameter of tree 7.2 m and 5.5cm, respectively, of which 43.8% juveniles of the species and the others of saplings with height from 0.8m to 2m. The population grew up in 10-11 years and the largest diameter was 19.8cm. The forest component was dominated by *Parashorea chinensis*, the proportion of 95% compared with the others tree species. The percentage of other species was estimated but not so many, namely 1.1% of *Duabanga grandifolia* (Sonneratiaceae), 1.7% of *Prunus arborea* (Rosaceae), 1.1% of *Trema orientalis* (Ulmaceae) and 1.1% of *Canarium trandenum* (Burseraceae).

Similarly, the third population located on E $104^{\circ}55'41.925''$ & N $21^{\circ}6'4.215''$, likely as the secondary population about age, geomorphology, but the area of this population was three times bigger than secondary one and space between two populations was measured approximately 800m in direction of West. The number of mature plant was counted for 192 individual in the plot 0.2ha area and the average height of the trees counted for 3.9m and the average diameter 15.5cm. As the surveying result, the dimensions of the trees in population 3 were obtained higher and bigger than those of population 2.

Following the oral information from people living in core of XNP, the big trees of *Parashorea chinensis* grew near those regeneration populations, but it was no longer exist, it had fallen down about 9 years ago.



Population 1: 15-16 years



Population 2: 10-11 years



Population 3: 10-11 years

Photos 6. The natural regeneration populations of *Parashorea chinensis*

3. *Vatica subglabra* Merr.

The field inventory had found about two isolated populations of *Vatica subglabra* distributed on tropical monsoon broadleaf evergreen forest. One population located near the forest protected station (T2) and another distributed on track 3.

Table 2. The parameters of *Vatica subglabra* in XNP

Population	Surveying track	Number of maturity	Percentage (%)	DBH _{M(*)} (cm)	H _{M(*)} (m)
1	Track 2	8	26.67	80.4	26.4
2	Track 3	22	73.33	57.5	19.2
	Total	30	100	68.9	45.6

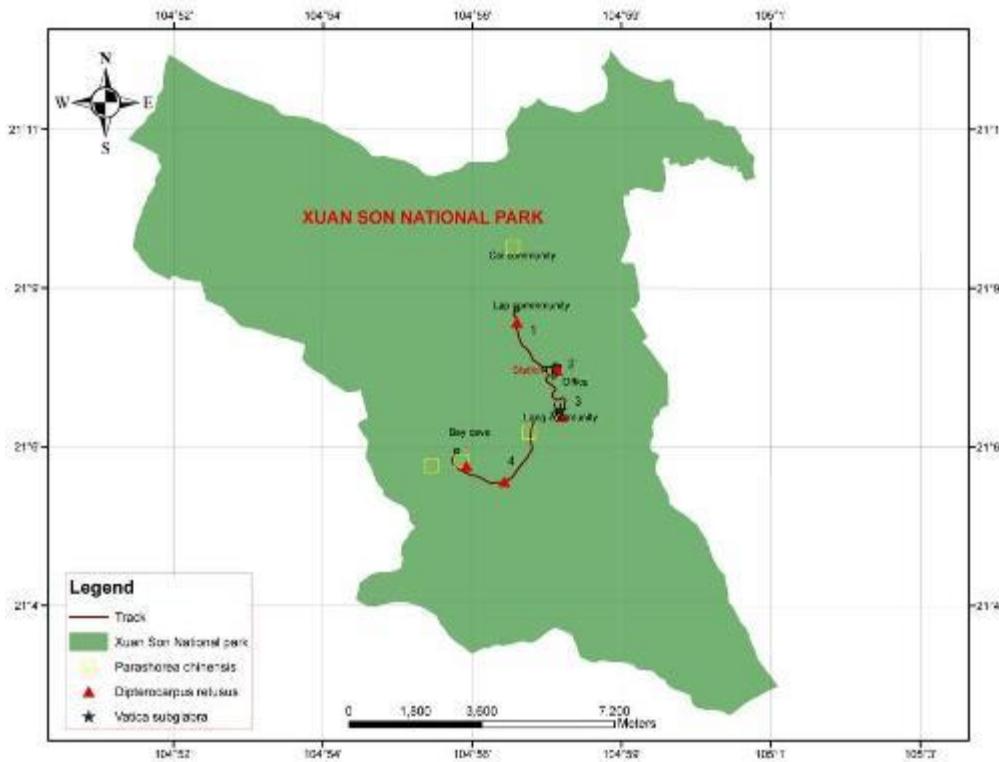
Note: M: medium data of maturity

On the survey track 2, eight mother tree individuals (26.67% of total number of maturities) were found with the average height of 26.4 m; the average diameter of 80.4 cm. Of which, there are two individuals got the diameter over 100cm. At the site, one plot was set up randomly to gather regeneration data within 0.2 ha area, there were only 25 individuals and of which 16 juveniles were range from the height of 1.5-7m and were 9 saplings with less than 1,5m in height.

The randomly inventoried method was established for surveying in track 3, whereas 22 (73.33%) maturities with the average height of 19.2m and the average diameter of 57.5 cm. in small are less than 0.04ha in the plot, *Vatica subglabra* population had covered 24% of individuals plants found in the plot: 27.2% of *Aglaia polystachya* (Meliaceae); 16.8 % of *Diospyros eriortha* (Ebenaceae), 10.2% of *Dipterocarpus retusus* (Dipterocarpacear), 9.5% of *Vatica odorata* (Dipterocarpaceae), 8% of *Syzygium formosum* (Myrtaceae), 7.4% of *Knema globularia* (Myristicaceae). Three species of Dipterocarpaceae were identified, and are typically appeared in a new species as *Vatica odorata* with big size of the tree. Regeneration study had been found 18 sapling individuals, in this case 16 individual were measured less than 1.5m high and 2 individuals got over 1.5m high. This refers the variable development rates from seedling to maturity. The study observed that the low of regeneration rate of *Vatica subglabra* under field conditions.

4. Map the status and distribution of three threatened dipterocarp species in XNP.

As the spatial resolution of data on the geographic distributions of threatened species increases, so does the utility of these data for conservation (Collar 1993–4, 1996). Using GPS equipment and mapping technology built the map of the status and the distribution of remaining populations and typical maturities.



**Table 3. Geographical location of remaining populations of these trees in XNP
(reading from GPS)**

Species	Survey track	No. of population	Co-ordinate	Characteristic of population
<i>Dipterocarpus retusus</i>	Track 1	1	E 104° 57' 1.269'' N 21° 8' 10.156''	Appearance of maturities and saplings
	Track 2	1	E 104° 57' 39.248'' N 21° 7' 29.275''	Appearance of maturities and saplings
	Track 3	1	E 104° 57' 43.884'' N 21° 6' 46.942''	Appearance of maturities and saplings
	Track 4	2	E 104° 56' 14.34'' N 21° 6' 3.641'' E 104° 56' 50.38'' N 21° 5' 49.58''	Appearance of maturities Appearance of maturities
<i>Parashorea</i>	Track 3	1	E 104° 57' 13.907'' N 21° 6' 32.465''	Natural regeneration population
	Track 4	2	E 104° 55' 41.925'' N 21° 6' 4.215''	Natural regeneration population

<i>chinensis</i>			E 104° 56' 9.744'' N 21° 6' 8.237''	Natural regeneration population
	Coi community	1	E 104° 56' 57.087'' N 21° 9' 18.368''	Two big trees
<i>Vatica subglabra</i>	Track 2	1	E 104° 57' 37.918'' N 21° 7' 31.356''	Appearance of maturities and saplings
	Track 3	1	E 104° 57' 41.358'' N 21° 6' 53.513''	Appearance of maturities and saplings

3. Estimation on natural regeneration of three conservation trees.

Natural regeneration of plants is the process of the woodlands are restocked by trees that development from seeds or sprouts. On the other hand, ability of natural regeneration of each species was estimated based on targets of density, quality, seed sources and number of prospective tree individuals and explains favorable conditions of habitat for scatter and sprout of seeds as well as growth of saplings. The parameters of natural regeneration were show in the table:

Table 4. The parameters of natural regeneration of three dipterocarp species in XNP

Species	Density (n/ha)	Source of generation		Quality of regeneration (percentage)			Prospective individual (n/ha)
		Seed	Sprout	Good	Medium	Bad	
<i>Dipterocarpus retusus</i>	67	94.6	5.4	77.1	17.5	5.4	60
<i>Parashorea chinensis</i>	32	99.5	0.5	69.5	29.3	1.2	25
<i>Vatica subglabra</i>	90	93.2	6.8	70.2	24.8	5.0	79

In order to accurate assess ability of natural regeneration of three dipterocarps, survey areas was extended, namely 5 plots for each species were set up seldom throughout in two forest types where these species found, with size of plot was 20mx20m, to inventory and gather the natural regeneration data of these trees. The following values in the table, it could indicate that the regeneration density of dipterocarps was so different from the others, namely the number of saplings of *Diptercarpus retusus* 67 individuals/ha, the highest number was accounted for 90 individuals/ha of *Vatica subglabra* and the lowest sapling of *Parashorea chinensis* counted for 32 individuals/ha. In many cases, each growing step of diptercarps needs the intensity of light differently, because most of species are shading plants. During young tree stage, saplings like to grow in dark condition. Due to strong influence of plant density and light intensity in natural forest, the regenerative ability of sapling and competition between the other species are low. Specially, the sapling of *Parashorea chinensis* grows better in high moisture condition and low canopy density, it will be die when develops under the dark shadow of the thick canopy.

Actually, all of three regenerative populations of *Parashorea chinensis* were identified in locations in the originated locations from shifting cultivation. Hence, the process depends mainly on the factors of climate, edaphic and biotical in an area.

There were regeneration mode's two types of the species that the tree body was established from sprout of residual parts and from newly dispersed seeds. In fact, the most of Dipterocarps germinated from seed, approximately 99.5% of saplings of *Parashorea chinensis* grew from seed.

Based on the data of both quality of regeneration and prospective individual, it could explain the sustainable growth of the any species in forest in recently or future. Generally, almost of all saplings of these three trees in survey location were suitable to meet the quality to well develop in the forest, but percentage of three tree regeneration in natural forest was not high. Therefore, their conservation efforts in this park must utilize and apply for all criteria considering on above during the course of the propagation study period each species treated individually in nursery.



Dipterocarpus retusus



Parashorea chinensis



Vatica subglabra

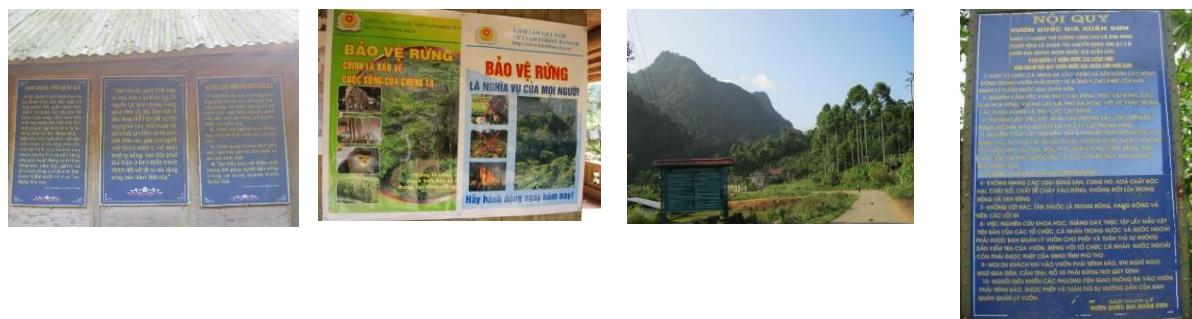
Photos 7. Saplings of three dipterocarp species in field

In another word, some information were obtained could express the status of three threatened tree species of Dipterocarpaceae in Xuan Son National Park. Generally, they distributed mainly on lowland forest in the core of XNP, at elevation 200-800m above sea level. The remaining populations of these species were found a few and size of the population is counted far more small than that of XNP. Besides, although there are not so many mature individuals, they are still remain strongly and had highly quality of the production as well as easy find them in the highest forest layer in which indicator of exceeding 30-50m in height and 40-100cm in diameter. Some *Parashorea chinensis* individuals had more than 100cm in diameter. In addition, the naturally regenerative rate of them was also low, however, some isolated regeneration populations of *Parashorea chinensis* dominated and *Dipterocarpus retusus* was addressed, of which almost germinated from seed and are growing in suitable conditions of natural habitats. A lot of juveniles of the species participated in structure of forest. Therefore, the activities in biodiversity and ecosystem conservation, environmental protection and reserve of tree genetic bank of XNP were regarded for the plant conservation and protection. Hence, any conservation method and protection the plants are necessary to apply and improve. For more understanding about the species, the spatial distribution and structure characteristics of population could help in the generation of threat quantitative and the harmful for the plant incase of non- proper conservation steps are not initiated.

5. Threats to growth of tree species conserving.

Xuan Son National Park is one of northern national parks in Vietnam, had highly carry out good conservation activities, many plans are being managed and monitored by management authorities and foresters as conservation legislation have enacted for long time in the aim protection national property. Therefore, there are not only dipterocarp species but also the other creatures are reserving stringent. The threats from human through logging or firing were reduced in those areas, the number of mature individuals as well as their habitat loss could not occur in the place. By the way, it was still some threats could impact on their growth, such as climate change, harm of insects or animals, the competition between plant species for natural habitat, ect.

In summary, the currently legislation should appear as the key factor sufficiently enough to protect three threatened tree species of Dipterocarpaceae and laws seem to be adequately enforced.



Photos 8. Notice-boards and posters contain rules of XNP and responsibility of local people in forest protection.

B/ IN SITU CONSERVATION STUDY.

1. Phenology study.

The mature individuals of each species were observed their phenology in order to gather information about the steps of plant growth by collecting seed of these species and supplying material for studying in propagation. Most of dipterocarp species tend to flower and fruit irregular (*Parashorea chinensis*), such behavior limits the supply of reproductive materials, especially seeds. However, almost all of dipterocarp species flower annually, but a few mother trees in the population beared fruit. In order to gathering seeds, inventories in the field were set up and closed monitored during flowering and fruiting stages. Almost of flowering and fruiting trees of three species were observed in diameter classes from 30 cm DBH, it turned out that proportion of fertile trees was maximum and stable only above 40cm DBH, which could be considered as limitation of maturity for dipterocarps. Some research were indicated that only the trees had over 40cm DBH, the proportion of fruiting individuals was achieved 90% of *Dipterocarpus retusus* and 76% of *Vatica subglabra*.

Therefore, it is important to monitor the flowering seasons and to optimize the timing of seed collection. After monitoring mother trees, the timing of flowering and fruiting of them was different as the following data

Table 5. The time of seeds harvest of each dipterocarp species

Species	Flowering stage	Fruiting stage	Fruit/seed harvest
<i>Dipterocarpus retusus</i>	January - February	July - August	November – December
<i>Parashorea chinensis</i>	May- June	July- September	September - October The species flowers not yearly
<i>Vatica subglabra</i>	April - May	May - July	September - October

2. Seed collection

The project was granted the finance from The Rufford Small Grants Foundation in September 2010, the research team carried out surveying and collected seeds of these species on time, however it was also late due to the harvest time in 2010 for the plant seeds, it was only could collect them in the time of 2011.

The process of fruit and seed harvest was carried out after falling time. Dipterocarp fruits normally have wings, but their seeds were wingless. Seed of *Dipterocarpus retusus* is heavier than those of *Vatica subglabra* and *Parashorea chinensis*, so the majority could be found under the canopy of the mother tree and the highest number of seedlings was found within 5- 20m of the stem and seed dispersal was not extended beyond 50m from mother tree. In contrast, seed of the *Parashorea chinensis* is smaller than shape those of the other species, but it can be dispersed much longer than distance from mother trees that of *Dipterocarpus retusus*, extension recorded 100- 150m from the source plant. One difficult issue while gathering seed of *Parashorea chinensis* was that the seed of the species fell down snowing immediately so that the monitor process was carefully. However, seed of *Vatica subglabra* could be collected many around mother tree within 2-10m distance from mother tree.

After finishing the project, the conservation team collected and counted the volume of the seeds, typically the highest valued seed of *Parashorea chinensis* was achieved because the maturities distributed in XNP was not so population, only two big trees. In addition, the fruit weight of each species was also accounted different, namely *Parashorea chinensis* 145 fruits/kg; *Dipterocarpus retusus* 57 fruits/kg and *Vatica subglabra* 118 fruits/kg. Generally, they are a genetic bank to provide material for ex situ conservation action plan.

3. Seed storage.

Collecting the seed in a good condition and suitable method for reserving seeds is a necessarily to store for living genetic bank of rare plant but it is also slow down germination and growth of seedlings. A low temperature and low moisture content are obligatory requirement conditions for long-term seed storage of most plants. Dipterocarp seeds lose viability at moisture content

less than 20%, and all dipterocarp seeds must be stored within controlled air humidity in temperature. There are substantial differences in response to temperature among genera and species, such as *Parashorea chinensis*'s seed may be tolerant at low temperatures at 10°C, it could survive for more than 4 months at 5°C, while both seeds of Dipterocarpus and Vatica can be survived at 6°C within near 2 months. The important work before storing seeds is that they need to treat with a fungicide dressing by Chlorothalonil 0.4% concentration. Before storage, the seeds could guarantee to survive when the moisture content reducing by half of the standard limits (at 22.6% from an initial 52.8%). Fungicide treatment followed by partial exsiccation and storage at low temperature has also yielded good results for mid-term storage of these seeds.

C/ INITIATION OF EX SITU CONSERVATION STUDY *Parashorea chinensis* H Wang.

The first result was obtained from testing on snowing of *Parashorea chinensis*, because the seed of this species can be germinated easily around 71% of total seed snowed with moisture contents of 45-53%. After the seeds had treated fungicide, they were deeply soaked in warm water during five hours and then it was spread on a layer of moist sand. The test was carried out in greenhouse whereas the temperature controlled at 15°C, relative humidity at 75% and the photoperiod at eight hours a day. After two days, most of all seeds germinated and they were taken care about 8-12 days in greenhouse for seedlings reached up 10 cm high, then planted into plastic-bags outside greenhouse. The light effectively from 75% to 30% shade because seedlings can not grow under strong light as they are shade-tolerant species, for 2-3 months accounting 70% seedlings were alive. The next step, saplings will be planted in propagation of Xuan Son National Park where soil is fertile and rich in mineral nutrients.

Based on data on silvicultural technology for germinating and growth of seedlings and saplings of *Parashorea chinensis*, the conservation team began to take the tests snowing on both of the other species in next time. After gaining clearly results in nursery garden, the conservation team will transfer all research results and silvicultural technology as well as seed banks of these tree species to managers in XNP.



Seedlings in greenhouse of IEBR



Seedlings were planted in plastic-bag outside greenhouse



A seedling of *Parashorea chinensis* greenhouse

Photos 9. Seedlings of *Parashorea chinensis* in the nursery garden

D/ PARTICIPATION OF MANAGERS, STAFFS AND LOCAL COMMUNITIES OF XUAN SON NATIONAL PARK IN THE PROJECT

Conservation was the most success duty when it received the highly cooperative relationship between all managers, scientific staff and forest rangers of XNP as well as the local people.

Firstly, the research team exchanged with managers and interviewed with local people, living in core of XNP, building up the plans for inventorying and monitoring of them in order to information about distribution and conservation of these three species and then coordinated with. The project was implemented with participation of three scientists and five forest rangers of XNP as well as many local people.

Secondly, for the best project performance, the conservationists made the cooperated with scientists of XNP to improve the purpose of transfer the technical aspects about identification and modernization survey methods, which are applied recently in Vietnam, as well as general conservation activities. Besides, they could take exact information about distribution of these species conserving in XNP.

Thirdly, about 3.000 people are living in the core of XNP [1]; most of them are belong to Dao and Muong groups. They are living in significantly low standards of living, including high poverty and low education levels as well as have not enough land for food production by cultivation. The livelihood is ability dependent on the forest production. The training course was made in order to rise up the awareness about the conservation threatened plant species and sustainable use of natural resources, most of all conservation and protection method were focused on typically three threatened tree of Dipterocarpaceae. They had also known more clearly about positions of each tree individuals and populations in the forest related with living of the community. They were gotten documents as brochures introduced dipterocarps in XNP and should increase responsibility for reserving them. In addition, under the instruction of conservationists, a major of the team to gather the plant seeds and fruits to supply the conservation team, the job could also increase the income inquiry of the local people. The project was also interested in women who participated mainly in the conservation training programmes and seed collection team, there were two aspect must be concerned, first improve

awareness conservation and second sustainable use natural resources because the women's knowledge related to forest land in many forest-dependant communities is still limited.

Finally, based on database collected about status and threats to above three species were gained from four inventories in forest, the conservationist had built not only capacity of the management and dipterocarps conservation but it also transferring the theoretical knowledge and practical skills for management authorities of XNP.



Photos 10. Training conservation three diptetocarps for local people in Du community
(Note: The training must be implemented at evening cause to the local people had to themselves work all daytime)

VII CONCLUSION AND RECOMMENDATION

The project was covered all aspects of the information about the distribution, ecology, biology, flowering, genetic resources, growth and development, propagation and planting of three threatened tree species of Dipterocarpaceae have been updated in Xuan Son National Park.

There were included five populations and 41 mature individuals of *Dipterocarpus retusus*; two big maturities and three natural regeneration populations of *Parashorea chinensis*, two populations and 30 maturities of *Vatica subglabra* were found in XNP. All these tree species distributed on three forest types of tropical monsoon evergreen forest and subtropical monsoon broadleaf evergreen forest on lowland, at elevation of 200-800m above sea level. They are positively growth on red-brown feralit and thick soil layer, soft structure, rich humus content and acidity (pH scale range from 4 to 5). Areas of populations are currently many smaller than that of XNP and remain not so mother trees, typically *Parashorea chinensis*.

The number of natural regeneration individuals of each species is distributes on populations are found in prospect currently and could remain, develop the population size of these species in the certain natural conditions.

The number of seeds of each species was list on living genetic bank, have gathered to provide material for ex situ conservation effort. Modernization of biotechnology application on storage and germination of seeds has initiatively gained highly positive results. The number of saplings of *Parashorea chinensis* will take an experiment on propagation of Me Linh Station of Biodiversity of IEBR for the next 2 months and seeds of the other species were began test snowing and then the silvicultural technologies will transferred to managers of XNP.

Conservationist and management authorities are role played in the important key for the natural resources use and should build plans as well as the strategies in purpose of conservation and improvement the tree species of Dipterocarpaceae. The forest rangers and managers need to monitor stringent and regular to achieve information about survival and threats of dipterocarp populations found. Besides of the conservation and monitor the species, staff of XNP should regularly be trained technical capacity and biodiversity conservation. Managers and scientists of XNP are often improving awareness raising programmes on the importance of dipterocarp conservation for local people in and out of XNP through appropriate media, such as flyers, posters instead of writing a long text documents or brochures. In addition, the local government could make an activity plan to protect and develop the plant species, including monitoring, create the benefits to local people form the protecting, monitoring and conservation activities.

Based on the results of the conservation team and on the considerations displayed above, the some recommendations are proposed, as follow:

- i) Cooperating between scientists and local people collecting the seeds of the plant in order to build a living gene bank, it is not only of Dipterocarpaceae but also other rare species distributed in studied area and extending areas of propagation in XNP.
- ii) Studying on genetic diversity and conservation activities for all threatened and rare tree species of Diptercarpaceae located in the North of Vietnam

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Annex 1. Threatened Species List of Dipterocarpaceae in the Vietnam Red Data Book (2007) and The IUCN Red (ver 2.3)

No.	The threatened species of Dipterocarpaceae in the Vietnam Red Data Book (2007)		The threatened species of Dipterocarpaceae in the IUCN Red List (ver. 2.3)	
	Scientific name	Red List Category & Criteria	Scientific name	Red List Category & Criteria
1	<i>Anisoptera costata</i> Korth.	EN A1a,b,c +2b,c	<i>Anisoptera costata</i> Korth.	EN A1cd + 2cd (ver 2.3)
2	<i>Dipterocarpus dyeri</i> Pierre	VU A1c,d + 2b,c	<i>Dipterocarpus alatus</i> Roxb	EN A1cd+2cd, B1+2c
3	<i>Dipterocarpus grandiflorus</i> Blanco	VU A1c,d + 2c,d	<i>Dipterocarpus baudii</i> Korth.	CR A1cd+2cd
4	<i>Dipterocarpus retusus</i> Blume	VU A1c,d + 2c,d, B1 + 2b,c	<i>Dipterocarpus costatus</i> Gaertn.f.	EN A1cd+2cd
5	<i>Hopea ferrea</i> Pierre	EN A1c,d + 2 c,d, B1 + 2c,d,e	<i>Dipterocarpus dyeri</i> Pierre	CR A1cd+2cd, B1+2c
6	<i>Hopea hainanensis</i> Merr et Chun	EN A1c,d, B1 + 2b,c	<i>Dipterocarpus grandiflorus</i> Blanco	CR A1cd+2cd
7	<i>Hopea mollissima</i> C.Y.Wu	VU A1c,d	<i>Dipterocarpus hasseltii</i> Blume	CR A1cd+2cd
8	<i>Hopea pierrei</i> Hance	EN A1c,d	<i>Dipterocarpus intricatus</i> Dyer	LC
9	<i>Parashorea stellata</i> Kurz	VU A1b,c + 2b,c, B1 + 2a,b,c	<i>Dipterocarpus obtusifolius</i> Teijsm. ex Miq.	LC
10	<i>Shorea falcate</i> J.E	CR A1c,d	<i>Dipterocarpus retusus</i> Blume	VU A1cd+2cd, B1+2c
11	<i>Vatica subglabra</i> Merr.	EN A1c,d	<i>Dipterocarpus turbinatus</i> C.F. Gaertn.	CR A1cd+2cd
12			<i>Hopea chinensis</i> (Merr.) Hand.-Mazz.	CR A1cd+2cd, C1, D
13			<i>Hopea cordata</i> J.E. Vidal	CR A1cd+2cd, B1+2c, C1, D
14			<i>Hopea ferrea</i> Laness.	EN A1cd+2cd, B1+2c
15			<i>Hopea hainanensis</i> Merr. & Chun	CR A1cd+2cd, B1+2c
16			<i>Hopea mollissima</i> C.Y.Wu	CR A1cd, B1+2c, C1, D
17			<i>Hopea odorata</i> Roxb.	VU A1cd+2cd
18			<i>Hopea pierre</i> Hance	EN A1c+2c, B1+2c, C1,

				D
19			<i>Hopea recopei</i> Pierre ex Laness.	EN A1cd+2cd, B1+2c
20			<i>Hopea reticulata</i> Tardieu	CR A1cd, B1+2c, C1, D
21			<i>Hopea siamensis</i> Heim	CR A1c, B1+2c
22			<i>Hopea subalata</i> Sym.	CR B1ab(i,ii,iii,v)+2ab(i,ii,iii,v); C2a(i) (ver 3.1)
23			<i>Parashorea chinensis</i> Wang Hsie	EN A1cd, C2a, D
24			<i>Parashorea stellata</i> Kurz	CR A1cd, B1+2c
25			<i>Shorea falcata</i> J.E.Vidal	CR C2b
26			<i>Shorea guiso</i> (Blanco) Blume	CR A1cd
27			<i>Shorea henryana</i> Pierre	EN A1cd
28			<i>Shorea hypochra</i> Hance	CR A1cd
29			<i>Shorea obtusa</i> Wall.	LC
30			<i>Shorea roxburghii</i> G.Don	EN A1cd
31			<i>Shorea siamensis</i> Miq.	LC
32			<i>Shorea thorelii</i> Pierre exx Laness.	CR A1cd
33			<i>Vatica cinerea</i> King	EN A1cd
34			<i>Vatica diospyroides</i> Symington	CR A1cd, C2a
35			<i>Vatica mangachapoi</i> Blanco	EN A1cd
36			<i>Vatica pauciflora</i> (Korth.) Blume	EN A1c
37			<i>Vatica philastrina</i> Pierre	DD

Annex 2. Valued tree species list of Dipterocarpaceae in Vietnam

No.	Threatened species with high economic value	Threatened species with high scientific value	Precious native species for reforestation
1	<i>Dipterocarpus chartaceus</i> Seem	<i>Hopea cordata</i> Vidal	<i>Anisoptera costata</i> Korth
2	<i>Dipterocarpus grandiflorus</i> (Teijsm. Ex Miq.) Craib	<i>Hopea hainanensis</i> Merr et Chun	<i>Dipterocarpus alatus</i> Roxb
3	<i>Hopea ferrea</i> Pierre	<i>Hopea reticulata</i> Tard	<i>Dipterocarpus dyeri</i> Pierre
4	<i>Hopea helferi</i> (Dyer) Brandis	<i>Shorea falcata</i> J.E. Vidal	<i>Hopea odorata</i> Roxb
5	<i>Hopea pierrei</i> Hance		<i>Shorea roxburghii</i> G.Don
6	<i>Parashorea chinensis</i> H. Wang		
7	<i>Parashorea stellata</i> Kurz		

**List of members participated in training to improve awareness for
local communities on conservation three tree species of Dipterocarpaceae
in Xuan Son National Park**

Date: 10th - 15th October, 2011

Place: Protected forest Station in Xuan Son National Park

STT	Participants	Sex	Address
1	Ban Thi Bien	Female	Du community
2	Ban Thi Xuan	Female	Du community
3	Dang Thi Xuan	Female	Du community
4	Ly Thi Nguyen	Female	Du community
5	Dang Thi Van	Female	Du community
6	Ban Thi Thu	Female	Du community
7	Ban Van Hung	Male	Lang community
8	Ban Xuan Dau	Male	Lang community
9	Ha Ngoc Chan	Male	Lang community
10	Ban Van To	Male	Lang community
11	Dang Que Hong	Female	Coi community
12	Kieu Hoa Tham	Female	Coi community
13	Ban Thanh Son	Male	Coi community
14	Ly Thi Ngoc	Female	Coi community
15	Phung Van Manh	Male	Lap community
16	Ly Phuc Nhau	Male	Lap community
17	Ban Van Hung	Male	Lap community
18	Dang Thanh Ha	Male	Head of Administration - Xuan Son National Park (XNP)
19	Nguyen Kim Hiep	Female	Scientist of XNP
20	Tran Quang Thang	Male	Scientist of XNP
21	Nguyen Van Tuat	Male	Staff of XNP
22	Hoang Kim Son	Male	Staff of XNP
23	Phung Van Giang	Male	Staff of XNP
24	Ha Van Da	Male	Staff of XNP
25	Tue Ha Van	Male	Leader of the project -IEBR
26	Tran Huy Thai	Male	IEBR
27	Nguyen Van Sinh	Male	IEBR
28	Dang Thi Thu Huong	Female	IEBR
29	Ha Quy Quynh	Male	IEBR