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STUDY ON APPLICATION OF SUSTAINABLE NATURAL FOREST MANAGEMENT BASED ON THE FSC STANDARD AT TRUONG SON STATE FORESTRY COMPAY, A BRANCH OF LONG DAI FORESTRY AND INDUSTRIAL ONE MEMBER LIMITED LIABILITY COMPANY

Major: Forest Inventory and Planning
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SUMMARY OF A DOTORAL DISSERTATION ON FORESTRY

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INTRODUCTION

1. The rationale of the study theme

FSC standard based sustainable forest management (SFM) is one of the key objectives in the Viet Nam National Strategy for Forestry Development for the period from 2006-2020, specifically it is targeted that until 2020, there will be 30% of the Viet Nam's area of production forests – equivalent to over 1 million hectares of production forest area of Viet Nam satisfy the SFM standard endorsed by FSC. However, until 10/2015, the forest area granted with FSC certificate in our country was only around 150,000 ha covering both planted and natural forests, in which natural forest area is only 84,697 hectares.

A crucial and pivotal task in forest protection and development based on FSC standard is development of an appropriate forest management plan, which will be implemented and also audited for forest certification. The SFM plan must satisfy the factors as follows: management objective, description of the silviculture system; quota of annual harvesting in certain forest; monitoring of forest development and change; measures for environment protection; plans for identification and protection of endangered, rare and precious species; thematic maps; description and justification about harvesting techniques, equipment to be employed in compliance with 7 principles prescribed in FSC standard FSC-STD-01-001(V4-0). In practice, most of the forest owners, especially those who are managing natural forests are not capable enough for formulating and implementing SFM plan in compliance with FSC standard. Thus far, number of researches and studies that characterize general, comprehensive and systematic regarding scientific and practical basis on natural forest sustainable management based on FSC standard is a modest number, as a result, in practice, approaches in forest management and organization of production are not based on a firm basis.

In that context, the author conduct the study under the theme: A study about application of FSC standard in management of natural forests in Truong Son forestry company, a branch of Long Dai forestry and industrial one member limited liability company*"* with an aim to address issues surfacing in practice during application of SFM based on FSC standard in the Truong Son forestry company as a certain forest based business unit, a branch of Long Dai forestry and industrial one member limited liability company in the province of Quang Binh.

2. The study objective

2.1. General objective

Application of FSC standard in sustainable management of natural forests in the Truong Son forestry company as a certain forest based business unit, a branch of the one member liability company limited Long Dai in the province of Quang Binh.

2.2. Specific objectives

- Assessment of the current status of forest resource, identification of functions and zones set in forest management, identification of forest areas with high conservation value.

- Development of a plan for sustainable of natural forests based on the FSC standard for the Truong Son forestry company, a branch of the one member liability company limited Long Dai in the province of Quang Binh.

3. Scientific and practical significance of the study theme

3.1. In terms of scientific significance

The study theme has contributed to form a scientific foundation for the formulation of the plan for natural forests sustainable management based on the FSC standard in the Truong Son forestry company, a branch of the one member liability company limited Long Dai in the province of Quang Binh.

3.2. In terms of practical significance

This is a study that characterizes systematic and logical which covers findings from assessment of the current status of forest, identification of forest function and zones set for forest management, identification of forests with high conservation value in order to formulate the plan for natural forests sustainable management for the Truong Son forestry company, a branch of the one member liability company limited Long Dai in the province of Quang Binh. This study report will make available a reference document that guides other forest owners in their upscale of sustainable natural forests management based on the FSC standard.

4. Object and scope of the study

4.1 Object of the study

The area of natural forests in the Truong Son forestry company, the province of Quang Binh.

4.2 Scope of the study

The study puts in sharp focus the formulation of the plan for sustainable management of natural forests based on the principle number 7 of the FSC standard for a specific natural forest; the issues of plan implementation and auditing for FSC certification are not included in this study.

5. New contribution of the thematic study

- According to findings from the study, 13 specific functions are identified and the forest targeted in the study is zoned into 3 groups of functions including environmental ecological function, social function, and economic function that form a lesson learnt for setting up functional zones for forest management based on explicit management objectives and regulations, including the functional zones such as: production, limited production and no production for the Truong Son forestry company, in the province of Quang Binh.

- Another formula for calculating the timber output harvested from the natural forest under sustainable management (taking into account the coefficient of damage, which has higher practical soundness and feasibility than the existing formula was identified.

- A plan for natural forest sustainable management with a rotation cycle of 25 years in equivalent to the rotation cycle of selective harvesting in natural forests, which closely follow the criteria, principle number 7 of the FSC standard was formulated which include an initial forecast about forest growth, forest conditions after harvesting and estimation of economic effectiveness once the forest management plan is put into practice.

Chapter 1
OVERVIEW OF THE STUDY ISSUES

1.1 The situation in the world

There are a number of important studies about sustainable forest management, to name a few: Meyer, H.A và D.D Stevenson (1943), Schumacher, F.X và Coil, T.X (1960), Alder (1980), Clutter J. L; Allion B.J (1973) with studies about the growth of forest tree and forest stance (1943); Oettlt, G. Baur, Borggreve, Breymann, H. Cotta, Draudt, M. Hartig, E. Weise, H. Thomasius, Brasnett N.V (1953); Davis K.P (1966) with studies about science of forest output; Pinard and Putz (1997), CIFOR (2000) in Indonesia; Perera G.A.D (2001), the Malaysia Institute of biological and environmental science with studies about Reduction Impact logging; Shen Guofang (2001) with studies about maintenance thinning.

The FSC standard was developed and introduced in the year 1993, since then, this standard has been applied by a number of countries in the world in their forest management and certification. The standard is most popular in Europe and South America, the forest areas granted with FSC certificate there account for 83.4% of the total FSC certified area in other continents in the world. Additionally, there are other sustainable forest management standards that have been being applied by other countries in the world such as: the international one- PFFC (Europe), the national one- MTCC (Malaysia), the regional one-SFI (America and Canada):

Over the past decades, application of techniques, technologies in sustainable forest management has been thriving in most of the regions in the world. Those achievements have been applied by different countries in forest management in order to ensure better the balance between 3 factors including economy, society, and environment in any sustainable forest management plan. In Europe, South America where forests are under large scale management and mostly are planted ones, the auditing for forest certification is uncomplicated and less costly than that for tropical natural forests. With an annual output of dozens million of cubic meters of timbers, the demand for entering markets that require timber certificates is huge, given this, the momentum for actualization of forest certification is very clear. On the other hand, in other countries in the world, forests are mainly belong to private ownership, meaning forest owners can be more autonomous, independent in all activities concerning management, re-investment, finance use in management of forest business, this is a key condition for maintenance and development of forest certification activities as required by different standards.

1.2. Situation in Viet Nam

In recent years, there have been studies about sustainable forest management such as: Hung Tuan Nguyen (2014), a study about scientific and practical basis in sustainable forest management in the Dakto forestry company and in the Central Highland region; De Van Dinh, (2012), a study about scientific basis of regulation of natural forests in the forestry company Con Cuong, in Nghe An province; Tuyen Dinh Vo (2012), a study about measures for improvement of effectiveness in management of community forests in Viet Nam; The Consultative Institute for Socio-Economic Development of Rural and Mountainous Areas (CISDOMA), 2009 had a study report on implementation of sustainable forest management in Viet Nam; Thanh Tien Nguyen (2007), planning for forest business based on sustainable forest management in the Yen Son Forestry Company; Vien Huu Tran (2005), a study about scientific basis of sustainable forest management on karst mountain; Nham Vu (2005) implemented a study and formulated a "guidelines for organization of auditing forests based on the national sustainable forest management standard "in order to support

10 forestry companies under the management of the Ministry of Agriculture and Rural Development to sign a commitment of implementing the plan of sustainable forest management; Hung Van Le (2004), a study on basis and practice to inform the proposal on measures in planning sustainable forest management in Ba Ren Forestry company, Long Dai Forestry company…

However, those studies just focus on specific aspects individually, meanwhile there has not yet any comprehensive study about sustainable forest management that can be used as a guiding tool in production in practice. In this context, a study about the application of FSC standard in timber production in practice that cover from formulation of a SFM plan, to plan implementation, auditing for certification in order to draw upon a process or formulate a handbook guiding FSC standard based sustainable forest management is of utmost necessity.

Needless to say, thus far, laws, policies, commitments of the State have formed a quite firm basis for putting sustainable forest management and forest certification in practice. However, in order to facilitate the implementation of SFM, more in-depth studies, technical guidelines are still needed such as environment impact assessment of forestry production activities, reduced impact logging (RIL), identification of forests with high conservation value…On the other hand, it is necessary to develop a national FSC matching sustainable forest management standard that will be recognized by international for actualization of SFM and forest certification in a uniformed manner in the whole country.

The formulation of forest management plan or forest management scheme has yet to meet international SFM standard, specifically: the forest management scheme does not include comprehensive surveys about the current status of forest resources such as forest resources, growth rate, biodiversity values, identification of forests with high conservation value, management zones that will be integrated in the management plan. The planning process has just focused on economic aspect. Sivilcultural, environmental, and social factors are not paid due attention.

Moreover, targets in production and business are set subjectively, without basing on the practical production capacity of forest capital for example, thus far, the annual output of natural forests is what set by the State as a target. So to make SFM and forest certification possible, planning and implementation of SFM plan must satisfy regulations prescribed in the principle number 7 of the FSC standard, specifically the forest management plan must be inline with the scale and intensity of the forestry activities, and be formulated, implemented, updated on a regular basis. Long-term management objectives, measures set for achieving such objectives must be identified clearly. The forest management plan is integrated in the overall land use planning process and based on the regular forest inventory result.

Regarding natural forests in our country at the moment, the areas under SFM and gained FSC FM/CoC certificate covers 64,952.0 hectares, in which, 2 companies are entitled to harvest from natural forests are Truong Son forestry company whose is operating on an area of 32.149 hectares and DakTo forestry company on an area of 16,318 hectares, the remaining area gained certificate for planted forests is intermingled with some areas of natural forests on which there is no products suitable for certification. Given this, the support, guiding and expanding of the areas granted with SFM certificate for natural forests in the whole country is very necessary and completely inline with the Viet Nam National Strategy for Forestry Development in the period from 2006 – 2020.

The capacity in forest management in Viet Nam is at a low level against what required in the international SFM standard. Improvement of forest management requires the availability of resources and long time. The knowledgeability on SFM and forest certification remains very limited at both central and local levels, most of the forest owners do not have a thorough understanding about SFM, objective and benefit of forest certification, therefore, studies, training

courses and capacity development measures for staff at central and local level especially forest owners are needed.

Chapter 2
CONTENT AND METHODOLOGY OF THE STUDY

2.1. Content of the study

2.1.1. Assessment of the current forest resources status

2.1.2. Identification of forest functions and zones for management

2.1.3. Identification of forest with high conservation value

2.1.4. Formulation of SFM plan based on FSC standard

2.2. Study method

2.2.1. Inheritance method

- Assessment upon the natural, socio-economic conditions: selective inheritance of data, available documents in the Truong Son Forestry company.

- Data regarding land, terrain maps, forest status: make use of the existing data of forest owners, with update upon changes regarding area, boundary.

- Biodiversity inventory: selectively inherit available data, documents, relevant study results which have been conducted before in the study area including: inventory the forest floral system of the authors Cu Van Ho, Tai Anh Vu; inventory resources of bird, animals, reptile of the author Thuy Dinh Le, Tuoc Do.

- Forest growth: inherit the calculation result, analyse the growth of natural forests conducted by Mr. Schindele, the international expert in the forest area managed by the Truong Son Forestry company.

- Identify forest with high conservation value: selectively inherit result from the report on identification of forest with high conservation value by the author Dung Quoc Nguyen using the method guided by the tool kit for identification of forest with high conservation value of the World Wild Fund, Viet Nam Programme.

2.2.2. Method for data collection in the field

- Method for setting up standard compartments

  Of the 99 standard compartment s in total, number of standard compartment s inherited is 78 (in 2013) and number of additional standard compartments is 21 (in 2014). Standard compartments are set up in square shape at a size of 100m x 100m, the measured area in each standard compartment is 2,000 m2, which is divided equally in 4 standard sub-compartments (each standard sub- compartment cover an area of 500 m2) arranged at 4 angles of the square. In each standard sub- compartment, there are 4 compartments to be measured (3 cells in circle shapes and 01 cell in rectangle shape) in order to make necessary measurements and collect other data.

- Data collection method

On each measured compartment, all tree with D>8cm, will be counted and measured, identified with names, measured growth regarding diameter $D_{1.3}$, height (H_{dc}), identified with regenerated tree, all data is recorded in the survey form.

2.2.3. Data processing and calculation method

a) Assessment of the current status of forest resources

- *Under branch volume*

$$V_{dc} = G_{1.3} * f_{1.3} * h_{dc} = \frac{D_{1.3}^2 * \pi}{4} * f_{1.3} * h_{dc}$$

In which:

V_{dc}: is the volume of a tree calculating from its stump to the point of the 1st branch including the tree bark (m^3/ha).

$G_{1.3}$: cross section measured at the point of 1.3 m from the tree stump (cm) ($G_{1.3} = \frac{\pi}{4} * D_{1.3}^2$)

H_{dc}: Under branch height (m)

$f_{1.3}$: Calculation made for each sample tree is based on its diameter and under branch height, using the following mathematic formula: $f_{1.3} = a + b * h_{dc}^2 + c * D_{1.3}^2$

a, b and c is: the specific coefficient of each species, already include the reduction coefficient – of the stump volume.

- *Volume of the standing tree*

$$V_{cd} = V_{dc} / Cf$$

Of which: V_{dc} is the volume of a tree calculated from its stump to the point of the first branch including the tree bark (m^3/ha); Cf is the coefficient for converting the under branch volume to the standing tree volume of each specific species used in the calculation for the area in the study.

- Calculation the result on each standard cell

$$X_{unit} / ha = \sum_{i=1}^{n} X_i * fr_i$$

Of which:

X: is for calculation of targets: Density of high layer tree, regenerated trees (N/ha); Area of the cross-section (Ga/ha); Volume of the standing tree (Vcđ/ha); Under branch volume (Vdc/ha).

fri: the coefficient representing to the size of the measured cell.

- *Calculations that demonstrate forest status*

$$X_{stratum}/ha = \frac{\sum_{i=1}^{N} X_{unit}/ha}{N}$$

Of which:

X: is for calculation of targets: Density of high layer, regenerated trees, (N/ha); Ara of the cross-section (Ga/ha); volume of standing tree (Vcd/ha); under branch volume (Vdc/ha).

N: is the standard cells in total for each forest status

- *The value of species composition rate*

$$N\% = \frac{Ni}{\sum_{i=1}^{m} Ni} * 100$$

If: Ni ≥5% that species is included in the species composition formula; if Ni < 5% that species is not included in the species composition formula.

- *Species composition coefficient*

$$Ki = \frac{Ni}{m} * 10$$

(Of which: Ki is the species composition coefficient of the ith species ; Ni is the number of individuals in the ith species; m is the total individuals under the survey.)

- *Classification of the current forest resources:*

Based on the average reserve of standing tree calculated for each forest status, forest classification will be conducted in accordance with provisions in Circular 34/2009/TT - BNNPTNT dated 10/6/2009.

b) Identification of forest functions and zones for management

Based on the survey result on the current status of the forest, result of planning for 3 types of forest, analysis of sloppy degree, survey on socio-economic status in the study area in order to identify specifically different forest functions. On the basis of forest functions identified, the functions are grouped so that the whole forest area is divided in 3 zones for management (1) no production zone; (2) Limited production zone; (3) Production zone, specifically forest functions are grouped so that zones for management are divided as follows:

- No production zone, including the functions as follows: Soil protection, protection of riparian areas, protection of water resources, protection of wildlife, protection of ecosystems, buffer zone at the country border, buffer zone at the travelling routes.

- Limited production zone, including the functions as follows: conservation of soil, conservation of water basins, conservation of habitats for wildlife, the production is for use by local habitants or for commercial purpose.

- Production zone: for production

c) Identification of forest with high conservation value

Based on the result from the forest function identification process, some forest functions will be converted into forest with high conservation value, specifically the following functions are

converted: conservation of habitats for wildlife is converted to HCVF3, HCVF1; the function of protection of ecosystem is converted to HCVF3; The function of water resource protection, water basins, protection of soil, protection of riparian area is converted to HCVF4; The function production for use at site or for commercial purposes is converted to HCVF5, HCVF6.

* *Calculation, identification of technical factors*

- Identification of annual output to be harvested:

$$L \ (m^3/\text{year}) = M_t \cdot P_{tb} \cdot R \cdot K$$

Of which: L is the annual output (m^3); M_t is the total reserve of the forest to be harvested (m^3); P_{tb} is the average growth rate of the forest (%); R is the rate of timber salvage (%); K is the approach coefficient (%)

- Identification of harvesting intensity:

Based on the data about average intensity of harvesting in the 5 most recent years in the study area, to collate it with the previous study result of Schindele regarding harvesting intensity for analysis, argument and identification of the annual harvesting intensity in the forest management plan.

- The area of harvesting annually:

$$S_{KT}(\text{ha}) = L/M_{KT}$$

(Of which: S_{KT} is the annual harvesting area (ha); L is the annual harvesting output (m^3); M_{KT} is the harvesting reserve (m^3/ha))

- Identification of harvesting cycle:

$$T \ (\text{year}) = M_{KT}/\Delta_M$$

(Of which: T is the harvesting cycle (year); M_{KT} is the total harvesting reserve (m^3/ha); Δ_M is the average growth capacity of the reserve $(m^3/\text{ha/year})$)

* *Proposed activities in the forest management plan*

Based on Circular 38/2014/TT - BNNPTNT dated 03/11/2014 of the Ministry of Agriculture and Rural Development guiding the formulation of SFM plan;

Based on the results of forest resource inventory, forest functional zoning, identification of forest with high conservation value; socio-economic and cultural conditions in the locality.

Based on the conditions of production and business, capacity of production and finance of the forestry company and demand for consumption of products of market.

* *Arrange the location and proposed technical measures*

Arrange annual production plan, phases and the whole rotation cycle is identified based on the current status of the forest resources, result of functional zoning for management, identification of forest with high conservation value. How location for production is arranged is decided based on actual data in terms of location, area and the map of forest business plan is digitalized for the 1st 5 beginning year phase and generalized for the ensuing phases.

Propose measures for harvesting in natural forests, zoned forest regeneration, forest cultivation, forest enrichment, following the current procedure, norms as guided.

* *Calculation of capital resource and forecast of economic effectiveness*

Application of price, cost for different items in production and business carried by the forestry activities in the period from 2014 - 2015.

- Propose the organization for implementation of the forest management plan

Aggregate, analyse requirements prescribed in the FSC standard and practical conditions in the study area and consult on it with the forestry company.

Chapter 3

MAIN CHARACTERISTICS OF THE STUDY AREA

Assessment of the characteristics regarding natural and socio-economic conditions in the study area that can influence to the forest management activities:

a) Positive influence

- In general, the nature of the natural forest such as fertility and suitability for forest plantation especially plantation for timber and paper material is still retained as seen in the soil and climate.

- Infrastructure such as transportation means, system, communication, health care, …in the area is progressively being completed.

- Labour force in the area is quite abundant, including manual labourers who are familiar to forest works, making available a favourable condition for the forestry company in attracting labourers to its production as set forth in the plan.

b) Negative influence

- Conditions on the highly divided terrain with multiple system of spring, streams in which the climate is divided in 2 clear seasons the rainy one and the sunny one and influence largely to the production and business activities. Especially in the rainy season, big storms happen so often, and long lasting draught. Given this, in the production plan, it is necessary to select appropriate species of tree as well as rotation cycle, planting location in order to refrain natural negative influence.

- It is a mountainous area where people's education level is low, with poor living condition and where many backward customs, habits remain in practice. Infrastructure although has been invested by the State more than before but in comparison with the common level in the society still remains low, especially in some far and remote hamlets.

- The local community do not have enough land for agricultural production, so food for daily living is still insufficient, which cause pressure on natural forests.

- The idle labour force in the local community is quite abundant, part of them tend to rely on forest but not have any production related job, this has created pressure on forest management and protection in the study area.

Chapter 4
RESULT OF THE STUDY AND DISCUSSION

4.1. Assessment of the current status of forest resource

4.1.1. Current status of the forest resources

From the data collected from the standard cells, calculation and analysis has helped to identify average reserve of different forest status, specifically: very rich forest 340.0 m^3/ha; rich forest 248.3 m^3/ha; medium forest 132.0 m^3/ha, the table below shows the forest status classification and respective area and status:

Table 4.1: A summary of findings on forest status and area

T	Type of land, forests	Total (ha)	Of which	
			Protection forest	Production forest
	Total natural area	**32,122.54**	**6,935.80**	**25,186.74**
I	**The area with forest**	**31,092.18**	**6,890.61**	**24,201.57**
1	**Natural forest**	**28,884.28**	**6,788.31**	**22,095.97**
-	Very rich forest	9,849.01	2,475.50	7,373.51
-	Rich forest	14,577.91	2,940.94	11,636.97
-	Medium forest	2,656.33	696.61	1,959.72
-	No reserve forest	1,801.03	675.26	1,125.77
2	**Planted forest**	**2,207.90**	**102.30**	**2,105.60**
-	Timber forest (acacia, melaleuca)	1,672.00	-	1,672.00
-	Indigenous species planted forest	535.90	102.30	433.60
III	**Barren**	**986.27**	**9.10**	**977.17**
-	Barren without regenerated trees	986.27	9.10	977.17
IV	**Other land**	44.09	**36.09**	**8.00**
-	Land for offices	8.00	-	8.00
-	Other land	36.09	36.09	-

Based on the data about the area of all forest status, the software Mapinfo was used to digitalize, edit and display the map on current status of forest resources at a scale of 1/25.000 for forest management and protection.

4.1.2. Characteristic of the high layer tree structure and forest regeneration

4.1.2.1. Structure, reserve of the high layer tree

a) Intensity of the high layer tree

The average density of high layer tree (tree/ha) of the very rich forest is 1,027 trees, of the rich forest is 823 trees and of the medium forest is 606 trees. There is no big difference in the density of high layer tree between the very rich and rich forests and the density is lowest in the medium forest, because in the medium forest there is invasion, large impact from external factors which made number of timber trees in the high lever decreased.

b) Species composition of the high layer tree

* In total 175 species have identified. Number of species changes depending on forests and their quality. The diversity of species observed highest in rich forests (141 species), the next is very rich forest (107 species) and the lowest diversity is observed in the medium forests (46 species).

* The appearance of tree species composition mainly happens in the following forest statuses:

- Very rich forest

+ Dominant tree species: Tau trang (*Vatica odorata*), SP3 (*Unknown-poor quality*), Nang (*Alangium ridleyi* King), Sao hon gai *(Hopea chinensis)*, Gao vang *(Adina pilulifra)*, Ngat *(Gironniera subaequalis),* Truong mat *(Paviesia annamensis),* Tram trang *(Canarium album),* Goi trang *(Aia elaeagnoidea),* Nhoc den *(Polyalthia thorelii).*

+ Species composition formula: 1.14 TT + 0.67SP + 8.19LK.

- Rich species

+ Dominant species: Tau trang *(Vatica odorata),* SP3 (*Unknown-poor quality*), Ngat (*Gironniera subaequalis*), Chua *(Garuga pierrei),* Tram trang *(Syzygium wightianum),* Mit *(Sugerada multiflora),* Nang *(Alangium ridleyi* King*),* Mau cho la lon *(Knema pierrei),* Den ba la *(Vitex trifolia),* Vang tung *(Endosperrmun sinensis).*

+ Species composition formula: 1.54TT + 0.68SP + 7.78LK.

- Medium forest

+ Dominan species: Nang *(Alangium ridleyi King).* Ngat *(Gironniera subaequalis).* Xoan dao *(Prunus arborea).* Nhoc den *(Polyalthia thorelii).* Vang trung *(Endosperrmun sinensis).* Truong mat *(Paviesia annamensis).* Chua luy *(Bursera tonkinensis).* Mau cho la lon *(Knema pierrei).* Chua *(Garuga pierrei).* De ke *(Quercus kerrii).*

+ Composition species formula: 1.31Na + 1.02Ng + 0.93XĐ + 0.76NĐ + 0.69 VT + 0.56TM +4.73LK

Of which: TT – Tau trang *(Vatica odorata)*; SP – SP3; Na – Nang *(Alangium ridleyi* King*)*; Ng – Ngat (*Gironniera subaequalis*); NĐ – Xoan dao *(Prunus arborea)*; VT – Vang trung *(Endosperrmun sinensis)*; TM – Truong mat *(Paviesia annamensis)*; LK – other species.

c) Allocation of high layer tree by diameter, group of timber

The highest number of trees is at the diameter from 8 -15 and this number decreases to the lowest number at the diameter of above 60cm. However, with the density of 823 tree at the high layer tree in the rich forest and 606 tree/ha at the high layer tree in the medium forest is comparatively low.

The status of very rich forest with number of tree is 1,027, with a quite even allocation among different groups of timber, of which, the timber group takes the majority is the high value groups such as group 2 and group 5, 6,7,8; the group that takes the minority is group 1, 3, 4.

The situation is contradictory in the rich and medium forests where the number of tree is low and poor in terms of species, species of value such as group 1, 2, 3, 4 accounting for the minority and the group of no value timber account for a big proportion such as group 6, 7, 8.

Table 4.2: Allocation of high layer tree according to diameters and in different forest status

Diameter	8-15 cm	16-30 cm	31-45 cm	46-60 cm	D> 60 cm	Total (tree/ha)
Very rich forest	647	246	89	25	21	1027
Rich forest	496	227	69	19	13	823
Medium forest	427	128	38	9	3	606

d) Allocation of cross-section

The average cross-section of the very rich forest is $39.1 m^2$/ha, of rich forest is 30.2 m^2/ha and of the medium forest is $18.1 m^2$/ha. The allocation of cross-section is one indicator showing the abundance of a species or group of species. Comparing this allocation based on group of timber showing the difference between different forest statuses. As for the very rich forest, the proportion of high quality timber species especially group 2, is much higher than in comparison with that of the rich and medium forests, on the contrary, timber groups from group 5 to group 8 allocate a lot in the medium forest.

e) Forest reserve

- Findings regarding reserve of different forest statuses are summarized in the table below:

Table 4.3: the average reserve of different forest statuses

Statuses	Reserve BQ(m^3/ha)
- Very rich forest	340,0
- Rich forest	248,3
- Medium forest	132,0

- Allocation of reserve of standing trees in diameter of 3 forest statuses is showed in the table below:

Table 4.4: Average allocation of standing tree in diameter

Diameter	8-15	16 -30	31- 45	46 - 60	D > 60	Total (m^3/ha)
Very rich forest	32.1	70.0	85.0	50.4	102.5	340.0
Rich forest	26.9	67.6	64.4	39.0	50.4	248.3
Medium forest	24.3	39.2	34.4	16.8	17.2	132.0

- Allocation of forest reserve in minimum diameter to be harvested according to regulation

Table 4.5: Allocation of forest reserve in minimum diameter to be harvested according to regulation

Group of timber	Minimal diameter can be harvested (cm)	Very rich forest				Rich forest				Medium forest			
		Minimum diameter		Diameter above 65 cm		Minimum diameter		Diameter above 65 cm		Minimum diameter		Diameter above 65 cm	
		N/ha	Vcd/ha	N/ha	Vcd/ha	N/ha	Vcd/ha	N/ha	Vcd/ha	N/ha	Vcd/ha	N/ha	Vcd/ha
Timber group 1	45	0.34	2.22	0.1	1.58	0.7	1.35	0.0	0.00	0.38	0.71	0.0	0.00
Timber group 2	45	16.02	39.91	3.3	15.26	9.8	23.96	1.8	8.69	0.38	0.49	0.0	0.00
Timber group 3	40	2.95	12.41	1.0	7.92	0.8	1.83	0.0	0.00	1.15	2.07	0.0	0.00
Timber group 4	40	1.70	3.33	0.1	0.40	2.0	4.12	0.1	0.57	0.38	0.50	0.0	0.00
Timber group 5	40	10.45	31.24	2.3	15.75	11.2	25.59	1.1	6.41	6.92	16.14	0.4	5.34
Timber group 6	40	12.39	32.92	1.6	12.07	7.0	17.27	1.2	5.32	6.92	12.42	1.2	6.51
Timber group 7	40	21.59	54.10	4.4	24.38	18.7	34.53	2.0	10.59	16.15	22.26	0.8	2.40
Timber group 8	35	4.66	7.23	0.3	1.95	5.6	10.07	0.4	3.02	1.54	2.30	0.0	0.00
Total	**35**	**70**	**183.36**	**13**	**79.31**	**56**	**118.71**	**7**	**34.60**	**34**	**56.88**	**2**	**14.24**

4.1.2.2. Naturally regenerated

a) Density of regenerated

About the level of regenerated trees, number of regenerated trees in the very rich forest (3,564cây/ha) is less than that in the rich forest (3,638cây/ha) and of the medium forest (3,600cây/ha). The proportion of light demanding trees in group 8 in the rich and medium forest is higher than that in the rich forest and opposite in group 2. However, the density of regenerated trees is not very different with that in different forest statuses, in the rich and medium forests, the density of regenerated tree is much higher as there are many light demanding and speedy growing tree species in these forest statuses.

b) Species composition of regenerated trees

* In total 88 species in the regenerated tree layer have been identified, the diversity in species is found highest in the very rich forest, the rich forest comes the next with 82 species the medium forest has the least with 21 species.

* The appearance of species composition of main trees in different forest statuses is shown below:

- Very rich forest

+ Dominant species: Tau trang *(Vatica odorata)*, Nhoc den *(Polyalthia thorelii)*, Tram trang *(Canarium album)*, Xoan dao *(Prunus arborea)*, Bua *(Garcinia oblongifolia)*;

Nhoc*(Polyalthia cerasoides)*, Com tang *(Eleocarpus dubius)*, Huynh *(Tarrietia javanica)*, Nho noi *(Diospyros apiculata)*, Bua vang *(Garcinia xanthochymus)*.

+ Species composition formula: 1.89TT + 0.54NĐ + 7.57LK (of which: TT – Tau trang *(Vatica odorata)*; NĐ – Nhoc den *(Polyalthia thorelii)*; LK – other species).

- Rich forest

+ Dominant species: Tau trang *(Vatica odorata)*, Huynh *(Tarrietia javanica),* Nhoc den *(Polyalthia thorelii),* Chua *(Garuga pierrei)*, Xoan dao *(Prunus arborea)*; Tram trang *(Canarium album)*, Goi den *(Amoora gigantea)*, Truong mat *(Paviesia annamensis)*, Truong Sang *(Amesiodendron chinensis)*, Chua luy *(Bursera tonkinensis).*

+ Species composition formula: 1.36TT + 0.73H + 0.58NĐ + 0.53Ch + 6.80LK (Of which: TT– Tau trang *(Vatica odorata)*; H– Huynh *(Tarrietia javanica)*; NĐ– Nhoc den *(Polyalthia thorelii)*; Ch– Chua *(Garuga pierrei)*; LK–Other species).

- Medium forest

+ Dominant species: Chua *(Garuga pierrei)*, Xoan dao *(Prunus arborea)*, Huynh *(Tarrietia javanica)*, Rang rang mit *(Ormosia balansae)*, Truong mat *(Paviesia annamensis)*; Nhoc *(Polyalthia cerasoides)*, Mau cho la lon *(Knema pierrei)*, Nang *(Alangium ridleyi King)*, Chua Luy *(Bursera tonkinensis)*; Tram trang *(Syzygium wightianum),*

+ Species composition formula: 1.54Ch + 1.28XĐ + 1.11H + 0.68RR + 0.68TM + 0.61NĐ + 0.51MCLL + 0.51N+ 0.51TC + 2.57LK (Of which: Ch- Chua *(Garuga pierrei)*; XĐ– Xoan dao *(Prunus arborea)*; H– Huynh *(Tarrietia javanica)*; RR – Rang rang mit *(Ormosia balansae)*; TM– Trường mật *(Paviesia annamensis)*; NĐ- Nhọc *(Polyalthia cerasoides)*; MCLL– Mau cho la lon *(Knema pierrei)*; N– Nang *(Alangium ridleyi King)*; TC–Truong chom; LK–Other species)

4.1.3. Forest growth

4.1.3.1. Forecast about general forest growth

With the survey data of over 2,770 trees with over 8 cm of diameter in the standard cells in the forest statuses set up, the author Werner Schindele conducted analysis, calculation of the annual growth rate for each forest status, regression analysis was used in calculation the growth of tree volume, accordingly, the timber volume of the first inventory was used as an independent variable and the polynomial regression equation ($IncVt = a + b* Vt + c*Vt^2$). The result of the forecast about the average growth rate of tree volume in production forest in the study area is summarized in the table below:

Table 4.6: Forecast about growth rate in natural forest

Forest status	Forest status	
	(m³/ha)	%
Very rich forest	4,5	2,02
Rich forest	3,5	1,90
Medium forest	2,9	1,81
BQ Natural production forest	**3,4**	**1,90**

4.1.3.2. The result of net growth rate calculated

According to Werner Schindele the actual growth rate or net growth rate means the difference the timber reserve estimated in two surveys deduct the timber lost due tô trees died even of storm. In

one forest stance, the net growth rate can be a negative number, Werner Schindele also calculated and analysed, the annual net growth rate of the harvested forest after deducting the lost timber due to died trees even of storm, collapse … in the Truong Son forestry company which was 1.0%.

4.1.4. Biodiversity

4.1.4.1. The diversity of forest floral species

* Diversity in the system of floral species

It was recorded that there are 663 species, belong to 131 families and 408 genus of 4 phylums of vascular plants, the richest phylum here is the Magnolia one (also called the angiosperm phylum) and the poorest phylum is the Licophyta phylum and is reflected in the following statistics:

* Endangered floral species

It was recorded that there are 27 species in the floral system in the Truong Son forestry company are endangered species according to the regulations in the Red Book of Viet Nam (1996), including: 1 endangered species (EN), 9 to be endangered species (VU), 5 under threat species (NT), 7 rare species (LR) and 5 species without enough information for conclusion (DD). Most of them are species of flowering plants (Magnolia branches), only one species of gymnosperms phylum and other species belonging to the Ferns phylum. There are 17 species listed in the list for protection of ICUN (2000), including: 3 endangered, 8 vulnerable species 8, 4 rare and 2 species without enough information to ascertain the level of being endangered.

* Findings about species with economic value

- Timber group: the most valuable species is the ones of Lim *(Erythrophleum fordii)*, Truong *(Xerosperum noronhianum)*, Tau *(Hopea chinensis)*, Tau mật *(Vatica cinerea)*, Tau muoi *(Vatica diospyroides)*, Mun sung *(Diospyros mollis)*, Mun soc *(Diospyros labata)*, Truong sang *(Pometia pinnata)*, Sen mat *(Madhuca pierrei)*, Sen *(Madhuca pasquieri)*, Gu *(Sindora siamensis)* and other timber species: Lim xet *(Peltophorum pterocarpum)……*

- Non-timber forest products group: is used for subsistent demand and for raising family income of local people, which include fruit species, vegetable, ornament trees, medicinal plants, fibre trees, handicraft material trees: such as rattan species (May) *(Calamus spp),* species for making leaf hats *(Licuala spp, Rhapis spp),* Mon *(Homalomena pierreana)*, Rau sang *(Meliantha suavis)*, Gam *(Gnetum montanum)…*

4.1.4.2. The diversity of faunal species

* Bird system

- The findings recorded that there are 162 species of birds, which belong to 50 families and 15 series. In terms of quantity of species, bird system in the study area accounts for 19.56%, number of family accounts for 61.72%, number of series accounts for 78.94% in comparison with number of species, of families and series in Viet Nam (Quy Vo and Cu Nguyen, 1995). In comparison with the national park Phong Nha Ke Bang, number of bird species in Truong Son forestry company accounts for 63.52%, number of families accounts for 91% and number of series accounts for 83.33%. In comparison with the Vu Quang National park, number of bird species in Truong Son the forestry company accounts for 59,55%, number of families accounts for 98.03% and number of series accounts for 100%. In comparison with Viet Nam, number of bird species in the Truong Son forestry company accounts for 9.56%, number of families accounts for 61.72% and number of series accounts for 79%.

- The findings recognized that there are 33 rare and precious birds of genetic protection and economic value, which account for 20.50% the total bird species in the Truong Son forestry company.

Of 33 rare and precious bird species of genetic protection and economic value, 14 species are listed in the Viet Nam Red Book, 2000 including: 2 species at class R, 11 species class T, 1 species class EN. There are 9 species listed in the IUCN Red List, 2006, including: 7 species in the class NT, 1 species in the class VU, 1 species in the class EN. There are 21 species in the Cites List, 2006. There are 14 species in Decree 32/2006 (6 species in group I, 8 species in group II).

* System of animal and reptile

The findings recognized that there are 66 species of animal, 33 species of reptile. The key characteristics of this system is it bear the most indigenousness, characterize the animal, reptile system of the North Truong Son. Given this, in this area, there are up to 8 species which is given the 1st priority for conservation in Viet Nam including Red-shanked douc langur *(Pygathrix nemaeus)*, Northern white-cheeked gibbon *(Nomascus leucogenys)*, Stripe-headed Black Langur *(Trachypithecus hatinhensis)*, Viet Nam warty pig (Heude's pig) *(Sus buculentus)*, Annamite Striped Rabbit *(Nesolagus timinsi),* Golden coin turtle *(Cuora trifasciata)*, King Cobra *(Ophiopagus hannah),* and Asian rock python *(Python morurus).*

4.2. Identification of forest functions and management zones

- The study identified 13 specific functions for the 3 main groups of functions including: economic, social, and ecological groups of functions in the study area, which is shown in the table below:

Table 4.7: Overview forest functions on respective areas

Forest functions	Abbreviation	Area	
		Ha	Proportion
1. Ecological and environmental function			
- Soil protection	SP	4,321.48	13.45
- Soil conservation	SC	4,981.38	15.51
- Water resource protection	WSP	953.44	2.97
- Water basin conservation	WCC	7,302.65	22.73
- Protection of wildlife	NWP	3,661.83	11.40
- Conservation of habitats for wildlife	NWC	9,956.79	31.00
- protection of representative ecosystems	NREP	378.62	1.18
- Protection of rare and precious ecosystems	NEP	412.90	1.29
- Protection of riparian area	WRB	790.00	2.46
2. Social function			
- Use forest products for demand at site by local people or for commercial purpose	SoLC	4,501.78	14.01
- Buffer zone of the border with other countries	OBB	1,856.40	5.78
- Buffer zone for routes	ORB	1,300.00	4.05
3. Economic function			
- Production and business	TP	12,281.10	38.23

- Based on the result from the function identification, all the forest functions were grouped and managed in 3 zones, specifically: the production zone covering an area of 12,281.10ha, the limited zone covering an area of 11,922.42 ha and the no production zone covering an area of 7,919.02 ha.

- The software Mapinfo was used to digitalize, edit and present the functional map and management zones at a scale of 1/25.000 of the study area.

4.3. Identification of forest with high conservation value

The map showing the allocation of 6 types of forest with high conservation value covering a total area of 17,840.01 hectares (on the same area, there maybe the presence of different high conservation values) is presented in the study report. The Truong Son Forestry company, in the same time proposed measures for management, protection, maintenance and development the high conservation values therein. The result is seen matches with reality of natural resources, compliant to current regulations and observant to principle 9 of the FSC standard. The table below shows the allocation of high conservation values in the study area

Table 4.8: Overview of location, forest areas with high conservation value

Plot	Area HCVF(ha)	Of which			
		HCV1	HCV2-HCV3	HCV4	HCV5-HCV6
257	1,090.51	1,090.51	1,090.51	1,090.51	-
263	1,274.13	1,274.13	1,274.13	1,274.13	-
264	1,681.47	1,681.47	1,681.47	1,681.47	-
273	997.20	997.20	997.20	997.20	-
275	909.21	-	-	909.21	-
278	1,350.13	-	-	1,350.13	-
281	1,022.11	1,022.11			
300	1,016.94	1,016.94			
301	794.79	794.79			
302	932.44	932.44			
326	1,354.35	-	-	-	1,354.35
327	438.52	-	-	-	438.52
328	158.43	-	-	-	158.43
329	411.80	-	-	-	411.80
340	1,601.70	1,601.70	1,601.70	1,601.70	-
341	1,396.12	412.90	412.90	412.90	983.22
342	665.14	-	-	-	665.14
343	313.51	-	-	-	313.51
344	176.81	-	-	-	176.81
351	254.70	254.70	254.70	254.70	-
Total	**17,840.89**	**11,078.89**	**7,312.61**	**9,571.95**	**4,501.78**

4.4. Formulation of the plan for natural forest sustainable management

4.4.1.General objective

- To sustainable exploit and use forest and forest land, conservation and improve forest capacity, ensure the multifunction of forest with reasonable cost and good benefit, ensure a stable and long-term economic effectiveness.

- To strengthen protection functions of forest, improve forest coverage. Maximize the function of soil protection, water resource protection; conservation of genetic resources and rare and precious faunal and floral species and biodiversity through measures on maintenance and development of forest functions, forest with high conservation value of the no production zone.

- To create job, improve income, living condition of local people who live nearby or at by the edge of forest, especially the community of ethnic minority people. Respect and create favourable conditions for maintenance habits and customs of the local community.

4.4.2. Specific objectives in the period 2016 – 2040

a) Economic objective

- Harvest and provide stably the timber output from natural forests for the market at a volume of 9,917.0 m3, from the whole harvesting rotation cycle to reach 247,925.0 m3. Until 2040 forest areas and quality will be recovered, forest reserve will be improved through silvicultural technical measures such as forest improvement which will be conducted across 1,780.6 ha, zoned regenerated across 891.3 ha and forest enrichment across 175.0 ha, forest management and protection across 11,326.48 ha. The annual average economic targets will reach a turnover of VND 73.433,17 million, at a cost of VND 68,320,355 million, before tax benefit will reach VND 5,112,815 million, after tax benefit will be 4,090,252 million, tax to be paid to the State budget will be VND 7,310,020 million

b) Social objective

- To address the demand for forestry land of the local community as the land under the forestry company's management locates near hamlets and villages are highly suitable for combined agriculture and forestry production; to improve income for households living in the operational area of the forestry company through forest management and business activities; annually to support the community in development of the forestry sector, improve the living condition of local community; to develop infrastructure, inter-commune transportation routes, inter-hamlet transportation routes, to organize service in order to promote the consumption of local products.

c) Environment objective

Reduced impact logging will be applied in order to minimize the damages to ecosystems, improve the proportion of timber utilization, forest area and quality is ensured after harvesting as a result, forest continue to grow well after that; forest environment is well controlled and protected; to maximize forest functions, conserve existing biodiversity value in the forest stance through identification and zoning forest functions and adjust the impact to each forest function. Step by step to cover the whole area of barren with green tree, increase the forest coverage, improve the value and quality of all forest types, contributing to environment protection, and mitigate climate change impact in the area.

4.4.3. Planning for utilization of forest resources

Findings from the survey and assessment of the current status of forest resources and forest land aforementioned, the forest area under management by the forestry company is divided into 3 management zones: no production, limited production, production zones.

 a) The no production zone is planned to cover an area of 7,919.02 ha. Where there is no production and business activities and measures are conducted to manage and maintain forest functions, maintain and develop forest with high conservation value.

b) The production zone is planned to cover an area of 24,203.52 ha, of which the limited production zone (RTP) covers an area of 11,922.42 and the production zone covers an area of 12,281.10 ha.

Table 4.9: Overview of land use planning

Or.	Planning content	Area (ha)
	Total (I+II)	**32,122.54**
I	**Planning for production**	32,114.54
A	**Planning for no production zone**	7,919.02
-	Protection of soil, water resource, wildlife, buffer zone at the borders with other countries, protection of riparian areas, buffer zone along routes, protection of rare and special ecosystems, HCVF1. HCVF 2, HCVF 3 and sub area for protection of HCVF 4	7,919.02
B	**Planning for production zone**	24,195.52
-	Planning for harvesting of timber in natural forest	7,373.00
-	Planning for forest improvement after selective harvesting	1,780.60
-	Planning for zoned forest regeneration (for forest has no reserve yet)	891.27
-	Planning for forest enrichment (for forest has no reserve yet)	175.00
-	Planning for forest plantation (on barren)	977.1
-	Planning for harvesting in planted forest (planted forest)	1,672.00
-	Area for protection, development of forest capital (rich forest, indigenous plants forest)	11,326.48
II	**Other planning**	**8.00**
	Construction of offices	8.00

4.4.4. Forest business activities

4.4.4.1. Selective harvesting of timber from natural forest

a) Scientific basis

The forest that is applied with the method of selective harvesting in natural forest is the one in the very rich status covering an area of 7,373.0 ha, with the average value of target as follows: density of high layer tree 1,027 tree/ha; area of cross-section is 39.1m^2/ha; reserve of standing tree is

$340.0 m^3/ha$; density of naturally regenerated trees is 3,564.0tree/ha; annual comparatively growth in terms of reserve is 1.0%; reserve of timber qualified as C level is 10.3%;

Based on the principle in timber harvesting in order to ensure the business objective set forth without any abuse to the forest capital, the annual output harvested must be constantly equal or smaller than the forest actual growth, technical factors for the method of selective harvesting in natural forest are also identified in the study as follows:

* Annual harvested output in theory

The annual harvested output is calculated based on the average reserve of the very rich forest after deducting the reserve of timber qualified as C level which needs to be cleared up, eliminated. Specifically, the average reserve of standing tree before harvesting is calculated with the following formula:

$M = 340 \, m^3/ha - (340 m^3/ha *10,3\%) = 305.0 \, m^3/ha$

- the following theoretical formula is used to calculate the annual output to be harvested:

$L = 2,248,765,0 * 1.0\% * 0.70 * 0.70 = 11,019.0 m^3/year$
Of which:
+ M_t is the total reserve of the forest to be harvested:
$M_t = 305.0 m^3/ha * 7,373.0ha = 2,248,765.00 m^3$.
+ P_{tb} is the forest growth rate or the comparative growth of the annual reserve of the forest to be harvested which is 1.0 % per year based on actual calculation.
$P_{tb} = 1.0 \%$
+ R is the timber salvage rate (%): R = 0.7
+ K is the approach coefficient (%): K= 0.7
- The maximum output can be harvested annually in the targeted forest is calculated based on the theory is $11,019.0 m^3/year$.

* Proposed an annual output to be harvested based on reality

In order to really ensure the sustainability in harvesting in natural forests, an actual annual output is proposed in the study based on the following arguments:

- Average reserve of the forest to be harvested

Average beginning reserve of the forest to be harvested after eliminating the volume of trees qualified as C level which is: $M_{bđ} = 340 - 340 * 10.3\% = 305.0 \, m^3/ha$

- Identification of the annual reserve of the forest to be harvested

The annual reserve to be harvested of the targeted forest is calculated based on the annual growth rate of such forest as follows [8]:

$M_{kt} = 7373.0 * (305.0 * 1\%) * 0.7 = 7373.0 * 3.05 * 0,7 = 15,741.4 \, m^3/year$.

- Identification of harvesting intensity

+ The reserve of harvested tree and level of devastation happened to the approached area (m^3/ha) is calculated as: $M_{kt} = 305 * 22.5\% + 10\% * 22.5\% * 305 = 75.5 \, (m^3/ha)$.

+ The reserve of trees that reach size to be harvested and the level of devastation happened to the whole area (m^3/ha) is calculated as: $M_{kt} = 75.5 * 0,7 = 52.9 \, m^3/ha$

Based on the result of an inventory of forest reserve, the author Schindele identified that the maximal reserve allowed to be harvested in the targeted forest in Truong Sơn forestry company is

not more than 65m^3/ha, in equivalent to 18 tree /ha which must be logged following the aforementioned principle.

The result of implementation of annual harvesting plan of the Truong Son forestry company over years from 2010 to 2015 is 24.6%; 22.0%; 23.6%; 23.1% and 23.1%, on average, the average harvesting intensity of all 5 years is 22.5%. With those harvesting intensity, the forest after harvesting was assessed and found satisfied technical factors for post harvesting as prescribed in regulations.

If the harvesting intensity is calculated as an average of this value in 5 previous years in a row (22.5%) the harvesting reserve on a hectare of trees that reach harvesting size and level of devastation in the whole area (m^3/ha) is: $M_{kt} = 75.5 * 0.7 = 52.9$ m^3/ha, this result is seen lower and still within a limit that is inline with the previous study result by Schindele.

Given this, the proposed harvesting intensity identified in this study is 22.5%, this intensity completely complies with provisions prescribed in Circular 87/2009/TT-BNNPTNT on guiding design and selection of natural forest timber.

- Identification of harvesting area and cycle

    + The annual harvesting areas is calculated as: $S_{hn} = 15,741.4/52.9 = 297.8$ha.

    + The harvesting cycle is identified as: T = 7,373.0/297.8 = 24.7 year, which is rounded up to 25 year

    + As the harvesting cycle is rounded up, so the area of annual harvesting is calculated based on formula is: 7,373.0/25 = 294.9 ha.

    + The actual harvested output on each hectare on the harvested area which is approachable is: L= 305 * 22.5% * 0.7 = 48.04 m^3/ha (0,7 is the rate of timber salvage).

        - Identification of the actual harvesting output

        - The calculated actual harvesting output is: L = 48.04 * 294.9 * 0.7 = 9,917.05 m^3/year (0.7 is the approach coefficient – the proportion of the approachable forest area in harvesting).

So, the proposed actual annual harvesting output of the targeted forest area of Truong Son forestry company is: 9,917.0 m^3/year.

The actual annual harvesting output proposed in the study is calculated based on scientific basis and taking into account sustainability. Nevertheless, harvesting of forest timber is also influenced by other objective factors such as: (1) Terrain, climatic, weather conditions, (2) capacity in terms of production and equipment,(3) Natural disaster related risks such as storms, land depression … so depending on the practical conditions in production and business, forest owners can decide by their own a reasonable annual harvesting output which must not exceed the calculated harvesting output proposed as 9,917.0m^3/ha.

*** Forecast about forest condition after harvesting***

- The average reserve of the targeted forest in the Truong Son Forestry company is 305.0m^3/ha, in each hectare, harvesting reserve is 75.5m^3 (68.60 m^3 to be harvested and 6.9m^3 as devastated volume) the remaining harvesting reserve is 229.5 m^3/ha.

- After harvesting, the forest has a reserve of 229.5 m^3/ha, after harvesting, the nutritious space of each tree is improved, especially because low quality trees are cleared off so the growth rate is forecasted as 1.2 %. The progressive growth volume after 25 years is 79,7 m^3 and the forest

reserve after 25 years will be 309.0 m³/ha, which is higher than the forest reserve of 305.0m³/ha to be harvested at the beginning of the cycle, satisfying standard for a continuous harvest in the ensuing cycle.

b) Arrangement of harvesting momentary time and location

- In the period from 2016 – 2020 harvesting will be conducted on an area of 1,475.0 ha with a total output of 49,585.0m³ in the plot number: 275; 277; 278; 279;280; 281; 299; 300; 301; 302; 303; 304; 305; 306; 316; 317; 318; 326; 327; 328; 329; 335; 336; 342; 343; 344. On average 294.9 ha/year
- In the period 2021 – 2040 harvesting will be conducted on an area of 5.898,0 ha with a total output 198,340.0 m³ in plots: 276A; 276B; 274; 275; 277; 278; 279; 280; 281; 299; 300; 301; 302; 303; 304; 305; 306; 316; 317; 326; 327; 328; 329; 335; 336; 342; 343; 344.

c) Identification of species prohibited for harvesting

During the implementation of harvesting based on the plan, it is supposed that timber harvesting regulations must be observed. It is forbidden to harvest species under risk of extinction, species with high conservation value,… species listed in the Viet Nam's Red Book. Attention should be paid to mother trees, protection trees, measures for mitigation of impact should be applied in the limited production zone;

- Species prohibited for harvesting: Tram gio (Aquilaria crassna Pierre et Lec), Khoi tia (Ardisia silvestris Pit), Cu gio (Balanophora laxiflora Hemsley)...

d) Harvesting procedure, technology

* Harvesting procedure: to apply reduced impact logging technique (RIL), the designed procedure in harvesting, with the following main issues are ensured:

- On each hectare average number of trees will be well controlled (not more than 18 trees/ha).

To identify coordination of the trees to be harvested by setting tree lines clusters and cells for inventory after that measure and count trees regarding parameters including diameters, height, quality, identify trees names, code trees, and map trees locations in maps. Based on the result of that exercise, to select trees to be harvested, mother trees to be retained applying the following principle:

+ The biggest diameter tree, tree with highest commercial value is harvested first, the minimum gap between harvested tree is 10 m.

+ Mother tree: to retain at least 4 mother trees / ha or 1 tree / 2.500 m², do not retain many individual trees of the same species, priority is given to mother trees of high economic value.

+ Protection trees: are trees locating in sloppy terrain, at the riparian areas, areas prone to erosion;

- To mark trees to be logged and also protection and mother trees.

- Develop a scheme for RIL as follows:

+ Draw the harvesting map at a scale of 1:1.000 on which zones of forest functions are clearly demonstrated. During tree logging process, the forest function of soil protection, riparian area protection, two edges of road protection, wildlife habitats protection, biodiversity, water flows and resources protection need to be taken into account and harvesting intensity should be adjusted reasonably accordingly.

- The density of skid trail must observe to the procedure prescribed in RIL and must be as least as possible.

- Number and area of timber sites must be as least as possible and observe to procedure prescribed in RIL.

-Harvesting activities must be monitored on a regular basis and in a continuously careful manner; environment impact assessment must be conducted for harvesting activities.

* Harvesting technology: Mechanization, tree logging down trees should be conducted using chain saw, transportation of timber should use motorized vehicles such as Reo, DT55..buffaloes and hoist are used as a transportation means in highly sloppy and difficult to access places.

4.4.4.2. Forest maintenance

Forest maintenance aims towards forest intensive plantation, setting up forest stance of high productivity, stable quality which can grow towards a developed population of trees with selective and compact species composition, a forest structure that meets well requirements of forest business.

a) Scientific basis

The findings from forest inventory has found that the average targets of the status of medium forest is**:** the density of high layer trees is 606 trees/ha; the area of cross-section is $18,1m^2$/ha; the reserve of standing tree is $132,0m^3$/ha; the density of naturally regenerated trees is 3.600trees/ha. The result shows that the medium forest which is depletedly harvested before, in which forest structure is broken, the forest then has a low reserve, the growth capacity and naturally development so that its ability of yielding output for the next rotation cycle is very low, given this, forest maintenance activity is needed in order eliminate bad quality trees, create nutritious space for existing trees, so that they can further develop, meanwhile clear off the cultivation site and salvage timber applying the technique of maintenance thinning for the final goal of make big timber business possible in the next rotation cycle.

* Identification of main tree species

Based on findings from the study upon groups of dominant tree species of the medium forest status, the main tree species for the medium forest in the Truong Son Forestry company are proposed as follows: Nang *(Alangium ridleyi King);* Ngat *(Gironniera subaequalis);* Xoan dao *(Prunus arborea)*; Nhoc den *(Polyalthia thorelii);* Vang trung *(Endosperrmun sinensis);* Truong mat *(Paviesia annamensis)*; Chua luy *(Bursera tonkinensis);* Mau cho la lon *(Knema pierrei);* Chua *(Garuga pierrei);* De ke *(Quercus kerrii).*

* Identification of logging methods and trees to be logged

The findings on average targets shows that in the medium forest, the average intensity is 606 tree /ha, this rate is lower than that of the rich and very rich statuses of forests in the study area. However, according to the structure for reference identified by the author De Van Dinh for the rich forest in the Con Cuong forestry company, in Nghe An province, accordingly, the density is 554 trees/ha the current density of the medium forest in the study area is higher which ensure the forest improvement for big timber business in the ensuing cycle.

Given this, the forest improvement based logging method identified as: Basically keep the existing density, only conduct logging that help to balance the structure of the forest meaning C level trees, crooked and twisted trees, pestilent trees, improper trees are logged down…in combination with clearing off the forest environment, clearing off liana, thinning qualified regenerated trees,

unqualified trees in high density places, salvage regenerated trees of high economic value by include them in layers under cultivation for the next rotation cycle.

* Identification of intensity and reserve of timber to be logged down for salvage purpose

The density of high layer tree of the forest medium status is 606 tree /ha with an average reserve of standing tree is 132,0m^3/ha, of which the reserve of standing tree at C level, pestilent trees is 5,33m^3/ha.

So the logging intensity is calculated based on the timber volume of the given forest status using the formula $P_v = v/V * 100\%$

Of which: Pv: the logging intensity based on the volume (%)

v: Volume of each logging (m^3/ha)

V: Volume of the given forest status (m^3/ha)

So the logging intensity calculated is: Pv = 5,33/132 = 4,03%

- Timber reserve salvaged with this logging method

With the status of medium forest identified covering an area of 1.780,6ha total reserved to be logged is: M = 5,33m^3/ha * 1.780,6ha = 9.490,6m^3

- the annual reserve of logged timber using this method

With total area of the given status of medium forest, with a harvesting cycle of 25 years as identified aforementioned, based on the financial capacity and human resource available for production, the logging area is approached based on the forest management plan which lasts for 25 years, specifically, the annual logging area is identified as 71,2ha/year, with a reserve of 379,6 m^3/year and annul output is 265,72m^3/year

c) Plan for momentary time, area and location of forest improvement

- In the period from2016 – 2020 forest improvement activity will be conducted on an area of 356,0ha in the plots 279; 280; 316; 328; 335.

- In the period 2021 – 2040: forest improvement activity will be conducted on an area of 1,424.7ha in plots: 279; 280; 281; 301; 302; 303; 304; 305; 306; 316; 317; 329; 335; 336.

d). Implementation method

Forest improvement based logging will be conducted based on the following instructions:

- Improper purpose trees are logged for the aim of adjustment of species composition in the newly regenerated generation of trees.

- Improper purpose trees in the high layer, pestilent trees are logged ...to ensure appropriate light intensity for the development of forest ecosystem.
- Bushes, liana are cleared off but not shrub, fresh vegetation.

e) Forecast of forest quality after forest improvement

The average forest reserve after forest improvement activity is 126,67m^3/ha (the beginning reserve is 132,0 – wit 5,33 deducted during logging as part of forest improvement activity), after forest improvement logging, the nutritious space of the forest is improved, especially low quality trees, pestilent trees have been logged down so the growth rate is forecast as 1,2 %. As a result, the progressive growth rate after 25 years will be 44.01 m^3 and the forest reserve under cultivation until 2040 will be 170.68m^3/ha, satisfying standard of harvesting in the next cycle.

4.4.4.3. Zoning for natural regeneration

a) Identification of object

The study identified 891.27 ha of non-productive forest. According to FSC-based forest management orientation, all kinds of forest are managed and traded in the natural and environmentally-friendly manner with the aim of restricting to break structure of forest and its surrounding ecosystems, and environment protection. In such point of view, the Dissertation suggests applying the management method of zoning for natural regeneration for non-productive forest.

b) Identification of location, area and progress of implementation

- *Location:* In the period of 2016 – 2020, zoning for forest regeneration at compartments: 276B; 274; 275; 277; 278; 279;280; 281; 299; 300; 301; 302; 303; 304; 305; 316; 317; 318; 326; 328; 329; 335; 336.

- *Area and progress:* In the period of 2016-2020, zoning for forest regeneration will be implemented in all 891.27 ha of non-productive forest as planned. After 5 year implementation, forest quality assessment will be conducted to select the appropriate silviculture method such as forest maintenance and forest enrichment. When the duration for forest zoning ends, forest maintenance or enrichment will be applied if forest is rehabilitated and its canopy closes; afforestation will be applied if forest is still rehabilitated in order to improve forest productivity and quality as well as diversify forest products.

c) Applied technical method: comply with the Norm 14 – 92

4.4.4.4. Forest enrichment

Forest enrichment aims to make the best use of old forest ground to establish a new forest dominated by enrichment trees mixing with existing trees in the natural forest. Trees for forest enrichment are local varieties which have high economic value, easy plantation condition, and fast growth, especially height growth.

a) Identification of object

This method is applied for non-productive forest which is planned for forest enrichment with area of 175 ha.

b) Time and location

- In the period of 2016 – 2020: forest enrichment will be implemented for 35 ha at compartments of 316 and 305.

- In the period of 2021 – 2040: forest enrichment will be implemented for 140 ha at compartments of 279, 304, 305, 316 and 329.

c) Applied technical method: comply with the Norm 14 - 92

4.4.4.5. Protection, maintenance and development of forest capital

a) Identification of object

To be the rich forest areas which have not meet standards for harvesting (10,892.88 ha), the forest areas for indigenous tree plantation (433.6 ha), and the natural forest areas located in non-production area (7,919.02 ha).

b) Location and area of management, protection

Total area of managed and protected forest is 19,245.5ha, under compartments of: 257; 263; 264; 273; 274; 275;276A; 276B; 277; 278; 279; 280; 281; 299; 300; 301; 302; 303; 304; 305; 306; 316; 317; 318; 326; 327; 328; 329; 335; 336; 340; 341; 342; 343; 344; 348; 351.

c) Protection method: Comply with the Law on Forest Protection and Development

4.4.4.6. Monitoring forest cover change

The forest management plan is developed for a 25 year cycle and divided into 5 year phases to be in line with the provincial socio-economic development plan. Thus, after every 5 years, the plan has to be adjusted and supplemented for next 5 years based on the overall plan and actual condition of provinces at the moment of plan development. Before each 5 year period ends, forest inventory has to be implemented to update changes for developing the work plan for next 5 years.

4.4.5. Activities for supporting community development

Forest stand managed by Truong Son Forestry company is located in administrative border of 2 communes and 1 town. Most of villages of these communes and town are far from operational area of the company only 03 villages under Truong Son commune are located in the core zone of the company. To ensure sustainable forest management in terms of economy, society and environment, a plan for supporting and developing community forestry in the localities must be developed, especially focusing on villages located in the core zone of the company. Proposed activities for supporting community development include:

4.4.5.1. Assign and supplement land foundation for community to manage and use

According to the survey, local communities have demand of land, thus in the period of 2016-2020, it is proposed to continue assigning some areas close to villages which are managed by the company to localities for management so that communities will have more land for production and sustainable household economy development.

4.4.5.2. Arrange and create jobs for community

Based on contents of the Forest Management Plan, every year the company will give priority to create jobs for village communities through activities such as forest cleaning, forest enrichment, NTFP exploitation, including bamboo, rattan; collaboration in forest protection and management…

4.4.5.3. Supporting in seedling provision

Based on soil condition and actual situation of localities, afforestation for economic benefits is selected to support community development, accordingly acacia hybrid is the selected species. Local people who are living in the villages located in the core zone of the company are subject to be supported of which the poor households as ethnic minorities are given priority. The number of supported seedlings per year is based on assessment on actual demand of communities and financial capacity of the Enterprise. The proposed number of seedlings is at least 20,000 trees/year.

4.4.5.4. Providing technical support for community

Forest owner as Truong Son Forestry company will support local communities in implementing activities such as land use and forestry development planning for villages, communes; designing silviculture works such as afforestation, zoning and forest enrichment…

4.4.6. Activities of environment management and protection

To mitigate impacts of production and business activities on environment, environment management and protection must be integrated into technical processes corresponding with production and

business activities or be implemented through a separate process to control and protect environmental values.

Methods of environment management and protection for specific forest management activities as follows:

a) *Management of plantation forest*

Methods of environment protection are integrated in the process of plantation forest management include:

- Establishment of plantation forest must comply with current laws and regulations of MARD as well as FSC standard of sustainable forest management.

- Use of exotic species must be controlled strictly to avoid of ecological effect and use of GMOs. Use of fire for vegetation cover is restricted and not encouraged.

- Make a plan to protect animals and plants in adjacent areas if they are affected by afforestation and plantation forest exploitation.

- For high-slope areas, large stream, and especially areas located by reservoirs and hydropower dams, a minimum space regulated by the Government must be ensured.

- Latrines for workers are requested; it is banned to throw garbage in the site.

- if the area of afforestation is adjacent to natural forest, a belt of 25-30 m between the plantation forest and the natural forest is requested.

b) *Chemical use*

Chemical use (if any) must comply with the following requirements:

   + Use of plant protection drugs (if any) must comply with regulations under the Circular No. 10/2012/BNNPTNT dated 22/2/2012 by MARD on issuing the list of plant protection drug permitted for use, restricted for use and banned from use in Vietnam.

   + Use of chemicals under types 1A and 1B, hydrate carbon chlorine-contained pesticides under the list of WHO; difficult-to-be-decomposed pesticides, toxic products remained in bioactive substances in food chains, as well as all other harmful pesticides banned by international agreements are prohibited. If other chemicals are used, it is requested to use appropriate equipment, workers must be trained to minimize health and environmental risks.

   + Chemicals, packings, solid and liquid wastes, including fuel and oil, are treated outside forest through environmentally-safe methods.

   + Use of biological finished products is regulated in written, is restricted and controlled strictly in accordance with national laws and scientific processes.

   + Management systems must promote development and use of non-chemical and environmentally-friendly pest management methods, and avoid of pesticide use.

c) *Management of infrastructure building and development*

Building of new roads and exploitation of natural forest timber must comply with regulations on RIL.

d) *Waste management and disposal*

Waste from activities of production and daily life in the site must be managed and disposed appropriately, specifically:

- Inorganic wastes from equipment and machines such as lubricant, residue must be collected and held carefully in safe devices as well as appropriately disposed.

- The oil, gas, petrol reserve areas must be located far from rivers and streams. Oil, gas and petrol must be preserved carefully to avoid of spilling into environment.

- Domestic waste must be collected and disposed appropriately to ensure to not affect landscape environment.

- Camps for workers must ensure environmental sanitation and safety.

e) Environmental impact assessment

To assess and report on impacts of production and business activities on environmental values, including: Exploitation of natural forest timber; development of new roads, afforestation, exploitation of plantation forest, in order to restrict and mitigate impacts on forest environmental values.

f) Protection of high conservation value forest

The following activities are proposed to maintain and develop high conservation value forest in the selected location:

- Develop the detailed work plan and establish the dossier for protecting forest animals and plant diversify, specifically: inventory, assessment of and establishment of the dossier for managing endangered animals and plants; Assign stations and teams to protect and monitor high conservation value forest.

- Involve communities in protection of forest, biodiversity and high conservation value forest; restrict activities of forest use in the high conservation value forest.

- Frequently update new changes in high conservation value forest, and renovate, improve forest value in order to create a safe environment for biodiversity values.

- Communicate and guide sustainable forest use: establish bulletin boards on the forest, and propagandize forest protection; develop guideline and organize trainings on sustainable forest use; inform about allowed-to-use forest products, harvesting season, processing methods; develop provisions under conventions and regulations on allowed-to-use forest products.

4.4.6. Estimate investment fund and economic efficiency for the period of 2016-2020

a) Demand of investment fund

The investment fund is needed to implement the forest management plan in the period of 2016-2020 is 341,601.777 million dong. The fund is able to be mobilized in the period of 2016-2020 is 367,165.853 million dong.

b) *Economic targets in the period of 2016 - 2020*

The annual average economic targets: turnover is 73,433.17 million dong, expenditure is 68,320.355 million dong, earnings before taxes is 5,112.815 million dong, earnings after taxes is 4,090.252 million dong, contribution to state budget is 7,310.020 million dong.

4.4.8. Organization of the forest management plan implementation

To organize implementation of the proposed sustainable forest management plan, the Enterprise has to develop a Quality Management Manual with the aim of identifying scope, describing operational process into the Quality Management System according to FSC standard. The Quality Management Manual must contain the main contents as follow:

a) In terms of management: specify responsibilities and rights of key staff of the Enterprise in the Quality Management System to ensure that all staff are aware of their own assigned responsibilities and tasks.

b) In terms of technical issue: Identify and concretize laws, decrees, regulations and other legal documents related to activities under the Forest Management Plan to develop guidance for each activity and to integrate it into the Quality Management Manual.

c) In terms of finance: To ensure implementation of all production and business activities, the Financial Division of the Enterprise shall calculate and mobilize financial potential through selling the Enterprise's products to implement planned production activities.

d) In terms of monitoring and evaluation: assign a staff to be responsible for monitoring and evaluation for each content and operational area. Monitoring, evaluation and reporting shall comply with the Quality Management Manual, the Circular No. 38/2014/TT-BNNPTNT dated 3/11/2014 and FSC standard's regulations.

CONCLUSION, SHORTCOMINGS AND RECOMMENDATION

Conclusion

According to the study, the following is main findings:

1) Assessment on forest resources status

Results of forest assessment and classification reflected reality of current forest resources distribution and are conformity with current regulations as well as ensure reliability so that these results can be used for production activities in Truong Son Forestry company.

2) Identification of forest function and management zone

The Dissertation identified 13 specific functions for 3 main function groups as economy, society and environmental ecology in the researched site. Based on their areas, forest functions were digitalized and mapped, and integrated into 03 forest management zones, including the production zone with the area of 12,281.10 ha, the production zone with the area of 11.922.42 ha and the non-production zone with the area of 7,919.02 ha.

3) Identification of high conservation value forest

The Dissertation identified and developed the distribution map of 06 high conservation value forest types with the total area of 17,840.01 ha in the researched site, at the same time recommended methods for management, maintenance and development of high conservation values. The identification results are suitable to reality of forest resources distribution, current regulations and compliance with the Principle No.9 of the FSC standard set.

4) Development of the sustainable natural forest management plan

The Dissertation developed a long-term plan for forest management with the cycle of 25 years which is the same to a rotation of selective harvesting in natural forest under the Forest Management Plan.

- Objective of the Forest Management Plan follows closely FSC standard in terms of economy, society and environment that includes specific targets in line with natural, socio-economic conditions and production, business situation of the company. The objective are feasible and verifiable during monitoring and evaluation of the Forest Management Plan implementation.

- The Dissertation planned the non-production zone with the area of 7,919.02 ha and the production zone with the area of 24,203.5 ha for the Forest Management Plan with 03 main operational areas, including: forest production and business, community development support, and environmental protection and management.

- Activities of forest production and business are identified, including: selective harvesting in natural forest; forest tending; zoning for natural regeneration; forest enrichment; natural forest protection, maintenance and development; forest cover change monitoring every 5 years. Each activity is concretized to each object, area, time and location of implementation; is included into the map of forest business planning.

- Activities of community development support include: Planning and supplement of land fund managed and used by communities; job creation; provision of seedlings and consulting services for communities. Activities are identified based on assessment on local communities' need and in line with actual production and business conditions of the company that make sure harmonization of forest owner's benefits and local communities'.

- Activities of environment management and protection are incorporated with activities of plantation forest management, chemical use, waste management, infrastructure development, high conservation value forest protection and environmental impact assessment during implementation of the Forest Management Plan. Proposed contents of activities are in line with reality of production, current regulations and FSC standard.

- The Dissertation subject forecasted investment fund and economic efficiency of the Forest Management Plan, as well as suggested solutions for implementation organization.

Proposed activities under the Forest Management Plan are based on scientific foundation, totally consistent with objectives and comply with current regulations and the Principle No.7 of the FSC standard set.

Shortcomings

- The Subject focuses on researching production natural forest while other objects such as plantation forest, plantation forest exploitation…are not researched to be included in the Overall Management Plan.

- The Subject focuses on researching development of the sustainable natural forest management plan but does not have further studies on implementation deployment, monitoring, evaluation of the plan, as well as organization of monitoring indicators according to FSC standard.

Recommendations

For an overall view of the FSC-based sustainable forest management process, the Dissertation should continue studying on implementatiion of sustainable forest management according to developed plan and organizing forest certificate assessment according to FSC standard. The study will continue focusing on development of the quality management process for proposed contents under the Forest Management Plan. The study results will be a forest management handbook and manual for forest owners in general and Truong Son Forestry company in particular. Further, the Dissertation should study more on conflicts and barriers in the current regulations system on forest management in comparison with FSC standard to have synchronous solutions for sustainable forest management according to FSC standard in Viet Nam.

THE PUBLISHED SCIENTIFIC RESEARCHES OF THE AUTHOR

1. Nguyen Truong Hai, Tran Huu Vien (2016), *Research on characteristics of structure and regeneration of evergreen broad leaved natural forest in Truong Son Forest Management Enterprise – Long Dai Forestry Industry Company Limited in Quang Binh province*. The Agriculture and Rural Development Journal No. 12/2016, page 118-126.

2. Nguyen Truong Hai, Tran Huu Vien (2016), *Research and Recommendation on silviculture system for sustainable forest management planning at Truong Son State Forest Enterprise, Quang Binh province*. The Forestry Science and Technology Journal, No. 4/2016, page 11-24.