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JOINT PROGRAMME ON GREEN PRODUCTION AND TRADE
TO INCREASE INCOME AND EMPLOYMENT OPPORTUNITIES FOR THE RURAL POOR

# REPORT

## CLEANER PRODUCTION AND DESIGN FOR SUSTAINABILITY ASSESSMENT

### IN RATTAN VALUE CHAIN


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## I. INTRODUCTION

In recent years, great development has been recorded in Vietnamese economy with the average growth of 6-7% GDP/year and since 2010, Vietnam has officially become the medium-income country. Along with fast economic growth are the 20% annual increase of export value, the creation of about 1,7 jobs and the 14% reduction of poor households. However, the gap between the poor and the rich, between urban and rural area, especially in remote and mountainous areas are becoming bigger.

Export handicraft sector attracts a lot of attention recently and is considered as an immerging market. Generally, handicraft production in Vietnam is often at household scale while Small and Medium-sized Enterprises (SMEs) supply materials, finish, pack and export products which creates the value of about 1,5 billion USD every year.

One of the biggest problems at this moment is the over usage and overexploitation of resources in Vietnam, leading to the shortage of resources for domestic production, therefore, there is the need for resource import. In addition, many enterprises and households at small production scale do not pay much attention to material preservation, causing spoilage for 10-30% materials before processing.

Formerly, Vietnamese handicraft sector has the competitiveness advantage of low labor cost; however, the cost is increasing, dimming that advantage. One of the reasons that impact on the Vietnamese handicraft's competitiveness is the excessive usage of resources, energy per product unit like the excessive consumption of coal, electricity, dyestuff, water discharging a big amount of wastewater.

Thus, the CP and D4S assessment for the whole value chain of rattan, lacquer, sea grass, silk and craft paper is necessary for evaluating current status of each sector, proposing technical innovation options and utilizing waste, properly using natural resources to save production cost, prevent environmental pollutions and ensure sustainable development. Besides, enterprises get chances to approach the concept of designing new products which are environmentally friendly and consumer attractive.

The assessment is carried out for the whole process from cultivation, harvest, collection, transportation to pre-process, process, finishing and packaging in households and enterprises located in 4 provinces: Nghe An, Thanh Hoa, Hoa Binh and Phu Tho, under the framework of project "Green Production and Trade to increase Income and Employment Opportunities for the Rural Poor".

## II. ASSESSMENT METHOD

### II.1 Value chain assessment

Value chain is identified from cultivation, harvest, collection, transportation to pre-process, process, finishing and packaging. Each unit of value chain can be executed in one enterprise, or each enterprise, household is in charge of one unit in value chain.

**Data collection**

- Before doing surveys, all data and information on current status of the chain in the project areas are collected via papers, documents to identify existing problems.
- At-site data are collected from households and enterprises through the samples which are designed for project.

**Interview**

Questions are developed to ask about existing problems at commune, district and province level in 4 targeted provinces of the project

### II.2 Quick assessment at enterprises

Vietnam Cleaner Production Centre will work directly with enterprises to evaluate the current production status and provide consultancy on resource and energy efficiency, product quality improvement, design innovation... The project assesses 27 enterprises in 4 targeted provinces, and 23 other enterprises in other areas (Hanoi, Ha Nam…) which are in the last link of value chain.

The assessment includes following steps:

- Collecting database
- Identifying unsuitable factors during production
- Proposing improvement opportunities
- Proposing necessary technology and equipment to improve capacity and product quality.

### II.3. Cleaner Production (CP) and Design for Sustainability (D4S) methodology

CP and D4S .the continuous application of an integrated preventive environmental strategy applied to processes, products, and services in order to increase efficiency and reduce risks to humans and the environment.

Targets of cleaner production is to increase profits and prestige of enterprises, reduce pollution as well as bad affect on human and community's health. Experiences show that CP is suitable for all company's size from big size to household scale. CP and D4S methodology consists of 6 following steps:


Cleaner production options can be:

- Avoiding leakage, spillage during transportation and production called good housekeeping options;
- Ensuring optimum production conditions relating product quality, productivity, resource consumption and emission;
- Avoiding using toxic materials by using other materials;
- Upgrading equipment to improve production;
- Installing efficient equipment; and
- Redesigning products to reduce resource consumption.

Some basic D4S techniques:

- Selecting the materials of little impact
- Reducing material consumption
- Optimizing production technology
- Optimizing distribution system
- Reducing impacts during usage
- Optimizing initial steps in life cycle
- Optimizing product discharge step

## III. OVERVIEW ON RATTAN AND BAMBOO SECTOR

Currently, the area of bamboo over the country is nearly 1,4 million ha (occupying 10,5% total forest area). About rattan, there are estimated to be 30 rattan species (10 are of high economic value) of 6 lines, mainly distributed and exploited in Phu Yen, Khanh Hoa, Gia Lai, Đac Lac, Đong Nai and Quang Nam… Important thing is that rattan and bamboo have wide biological range, therefore they can be grown centrally in hilly area or dispersedly. Moreover, the cultivation, exploitation and process of rattan and bamboo are contributing to the job creation, poverty eradication, living improvement for the households that earn living from forests. Through the surveys at local areas that have potential for growing rattan and bamboo, this sector has brought about a lot of economic benefits. For example, in Thanh Hoa province, luong bamboo cultivation has created the income for 30% household with the income of nearly 100 thousand VND/day/capita. Or cultivation of nep rattan in Thai Binh province after 5 years can get the stable profits from 60 to 90 million VND/ha/year... In addition, there are 723/2.017 rattan and bamboo craft villages, creating jobs for 342 thousand labor. According to the estimation, every year, Vietnam consumes from 400 to 500 million bamboo and 600 to 800 ton rattan to produce product for domestic and export market.

Although Vietnam has many potentials for growing and developing bamboo and rattan products, it has to import about 33 thousand ton/year of rattan material from countries in the region. However, the export market share of Vietnam is only nearly 3% world market.

According to forecast of the rattan product market share, Vietnamese rattan products occupy about 12% in the period of 2010-2015. To adapt that growth, to the year 2020, the demand for bamboo and rattan material must be at least a billion bamboo trees/ year. Therefore, beside preserving and developing bamboo in natural forests (about 1,3 million ha) and cultivation forest (about 88.000 ha) currently, our country needs to grow about 60 thousand ha bamboo and luong bamboo more, increasing the total number to be more than 1,5 million ha. Following the development trend, to the year 2020, rattan demand for production and process is estimated to be about 100 thousand ton. At present, we have to import about 33 thousand ton rattan from other countries each year.

According to investigation, there are 713 rattans and bamboo craft villages, occupying 24% total craft villages in Vietnam and has greatest labor force – 342 thousand labors. Rattan and bamboo villages are located widely over the country in which half are in Hong River Delta. Everyday, Vietnamese people, from mountainous to plain area are making products from rattan and bamboo like trays, baskets, tables and chairs…

| **Location** | **Hong River Delta** | **North East** | **North West** | **North Central region** | **South Central region** | **Highland** | **South East** | **Cuu Long River Delta** |
|---|---|---|---|---|---|---|---|---|
| Number of rattan craft villages | 337 | 77 | 45 | 121 | 34 | 0 | 26 | 73 |
| % | 47,3% | 10,8% | 6,3% | 17% | 4,8% | 0 | 3,6% | 10,2% |

*Source: JICA – MARD 2002*

| Year | Rattan and bamboo material consumption (ton) | Turnover of rattan and bamboo export (thousand USD) | Growth rate (%) |
|---|---|---|---|
| 1999 | 6,523 | 48,216 | |
| 2000 | 5,068 | 65,932 | 37% |
| 2001 | 4,626 | 73,216 | 11% |
| 2002 | 7,621 | 88,747 | 21% |
| 2003 | 8,830 | 99,737 | 12% |
| 2004 | 9,911 | 138,218 | 39% |
| 2005 | 9,000 | 140,000 | 27% |
| 2007 | n/a | 219,000 | 25% |
| 2008 | n/a | 224,700 | 3% |

*Source:MARD, national project on preservation and development non-timber forest products in the period of 2006-2020in combination with the statistics of Ministry of Trade*

According to the statistics, the export turnover of rattan, bamboo, leaves, lacquerware of Vietnam in 2008 was 224,7 million USD, increasing 3% in comparison with 2007. The key markets for Vietnamese rattan, bamboo, leaves, lacquerware in 2008 are Germany with 37 million USD, USA with 32,3 million USD, Japan with 31,1 million USD, France with 12,8 million USD, Spain with 10,8 million USD, Taiwan with 10,4 million USD

Among exported rattan, bamboo, leaves and lacquerware products in 2008, the export turnover of bamboo products occupied the highest rate, about 55,6 million USD, increasing 17,5% in comparison with the same period of 2007 and occupied 24,8% total export turnover of rattan, bamboo, leaves and lacquerware while that number of 2007 was 21,6%. After bamboo products are rattan products, in 2008, export turnover of rattan products was 33,1 million USD, decreasing 17,9% in comparison with the same period of 2007 and occupied 14,7% total export turnover of rattan, bamboo, leaves and lacquerware while that number of 2007 was 18,4%. Among all export rattan products in 2008, turnover of rattan table and chair occupied the highest rate with 15,3 million USD, decreasing 9,5% % in comparison with the same period of 2007 and occupied 14,7% total export turnover of rattan products. Some other export products in 2008 also got rather high turnover like: rattan trays, baskets, boxes, bowls, shelves… Key export markets for rattan products in 2008 were Germany, USA, Germany, Japan, France, Spain, Italy, Sweden, England, Poland, Netherland, and Belgium...

Rattan and bamboo craft villages play important roles in creating jobs and income in rural area, reducing the immigration stress to big cities that created a lot of problems in national socio-economics. Beside the creation of 342.000 jobs, in term of household's income in 2008, the households of ceramics, wood and lacquer craft villages have highest income (2,5 – 3 million VND/month), then households of rattan and silk craft villages (2,3 million VND/month). Comparing to other agricultural households in the same regions, income of rattan craft households is 2,3 times higher.

Thus, craft village plays an important role in creating jobs for labor and transferring the economic mechanism in areas. However, there are many other chances to increase income for labor in craft villages through improving material efficiency, proper production rearrangement

(reducing input cost), diversifying products, especially high value products (increasing selling price), promoting marketing program… These are the factors contributing to the creation of high and stable income for craft villages.

## IV. CP ASSESSMENT FOR RATTAN AND BAMBOO VALUE CHAIN

### IV.1 Rattan and Bamboo Value Chain

Though rattan and bamboo are two different species, they share some similarities and processes in handicraft sector. Similarities between rattan and bamboo:

- Naturally growing in forests from Hoa Binh to Quang Ngai province
- Growing in clump, knots in the body, small and pointed leaves
- Often being attacked by mould, wood eaters and white aunts while using
- Being used to weave handicraft products

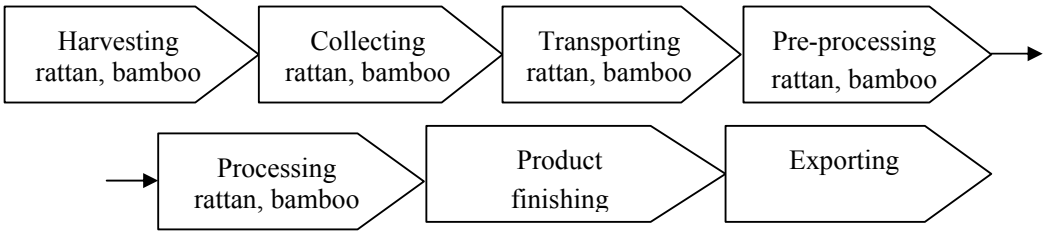



**Figure 1.** Rattan, bamboo value chain

### IV.2. CP assessment for bamboo (Lùng) value chain

#### *IV.2.1 Harvest*

At present, Lùng bamboo mostly grows up naturally in Nghe An and Thanh Hoa province. Because they naturally grow, so farmers can harvest without permission and they are not trained about harvesting and selecting process to ensure the sustainability, so the capacity is becoming scarcer, waste materials are being discharged more.

For sustainable development of material trees to serve the long-term production, beside the research on cultivation new trees, the methods of exploiting and selecting qualified trees should be introduced to avoid damaging immature and unqualified trees.

Identification of qualified trees:

- Green bark
- Height from 6-8 m
- Diameter of more than 60 cm
- Age from 1,5 to 3 year, too old trees are difficult for weaving products.

Other factors should be considered during harvest:

- Selecting qualified tree clumps
- Avoid impacting immature trees, 3 tree generations should be left for breeding and developing
- Cutting 10-15 cm higher from root and avoiding plunging trees, causing accidents
- The best harvest season is dry season which facilitates the transportation, drying process and water prevention from creating mould, damaging materials.

### *IV.2.2 Material transportation*

As only the outer layer of Lùng bamboo is used, the surface of this layer is very important. If the surface is scratched or broken, the whole tree can not be used, therefore, transportation avoiding damage is very important. Although this matter has long been discussed, the farmers or transportation service providers are not usually informed about this, so damage still occurs. To avoid this matter, during the transportation from forests or from collection points to enterprises, following things should be paid attention to:

- River transportation: transporting by rafts, so Lùng bamboo is always immerged in water. Too long time being immerged in water can make bamboo blackish, so bamboo should not be transported by water way in more than three days.
- Transportation by pulling bamboo from forests: after harvesting, bamboo is often pulled so the surface is often scratched. To avoid bamboo from being scratched, bamboo should be pulled in an incline direction and there should be an inlay between bamboo and the ground.
- Bus transportation: bamboo is rearranged in layers with soft layers like straw, stubble in the middle to avoid shock.

Only the outer layer of Lùng bamboo which occupies 30% total weight can be used for weaving and other purposes, the rest 70% is discharged. In addition, the water content in Lùng occupies a big amount of 20-40%, depending on the seasons and tree's ages, causing a big cost for transportation per product unit. To reduce transportation cost, enterprises can consider the option of moving production area nearer to the collection area to create more jobs for local people and at the same time, reduce the waste generation in crowded area.

### *IV.2.3 Pre-process at households*

Lùng bamboo has 3 layers: outermost layer, outer layer and core. The outermost layer is very thin, protecting the outer layer; however, its structure is not uniform, so it can not be used. The outer layer has spongy structure and contains many other components: thread, pentose, lignin, wax… and the core contains unwanted components: pentose, water… with higher amount in comparison with non-timber forest products, therefore it is easy to be attacked by wood eater and white aunt. Thus, only the thin outer layer of Lùng bamboo can be used for weaving after its surface is finely graved.

**Figure 2.** Graving the surface (left), graving layer (middle) and graving knife (right)

At present, farmers are using traditional fine graving method by simple knife like demonstrated above, so the efficiency is not high, just 40-50 kg/day. Meanwhile, many enterprises use the newly designed knife which can bring two to three times higher efficiency and does not impact the layer's quality. Some other enterprises even cooperate with mechanic ones to produce automatic machine to improve both efficiency and quality.

**Figure 3.** Newly designed graving knife (left) and graving manipulation (right)

### *IV.2.4 Material process at enterprises*

After being finely graved and preliminary dried, Lùng bamboo is transported to the factory for process and production. Following is the production flowchart:

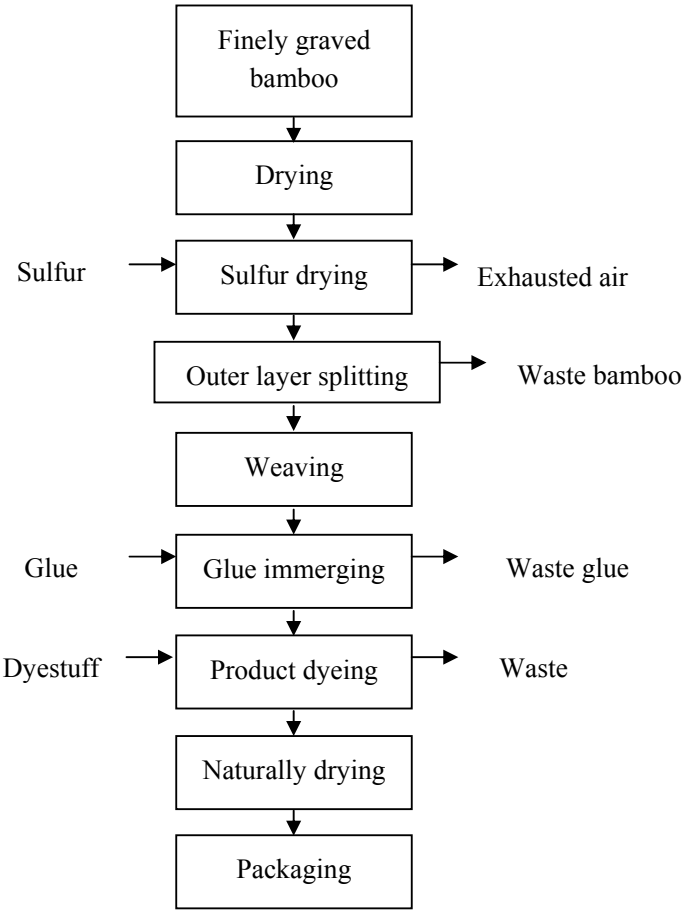



**Table 1.** Specific consumption (for 1 kg product)

| ***No*** | ***Inputs*** | ***Unit*** | ***Year 2008*** | ***Year 2009*** |
|---|---|---|---|---|
| 1 | Bamboo material | kg | 14.2 | 14.2 |
| 2 | Paints | Liter | 0.013 | 0.013 |
| 3 | Chemical (sulfur) | Kg | 0.004 | 0.004 |
| 4 | Dyestuff | Kg | 0.004 | 0.004 |

| | | | | |
|---|---|---|---|---|
| 5 | Glue (water base) | Kg | 0.0036 | 0.0036 |
| 6 | Electricity | kWh | 0.088 | 0.086 |
| 7 | Coal | Kg | 0.053 | 0.051 |
| 8 | Gas | kg | 0.007 | 0.007 |

It can be seen from the table of consumption that the highest consumption is bamboo material with the consumption of 14,2kg/kg product. After drying, due to the water loss, the consumption of dry bamboo is 11,36kg/kg product. That means major part of bamboo is discharged or attacked by wood eater and white aunt, causing waste. Currently, in Vietnam there is no standard benchmark for bamboo processing enterprises, however, through in-company consultation, following problems can be raised:

- Too high bamboo consumption as bamboo is easily attacked by wood eater and white aunt, the useful ratio is low
- High sulfur consumption because the chamber is not tight and there is no standard process
- High paint usage per product unit because there is no proper painting chamber, causing high leakage and loss
- Water based paint is not reused and is spilled a lot

Material drying

Material is dried under the sun in collection households; however, many enterprises have to dry the materials again to ensure the quality. Purpose of drying material is to reduce water content to avoid mould. However, this drying method depends entirely on the weather, so enterprise can not be active in production. In case there is not enough room or rain comes suddenly, material is not covered in time, it can easily be spoilt.

To be more active, enterprises can use drying technology by hot air which is indirectly heated by waste bamboo, rattan…

**Figure 4.** Drying material in the factory (left), mouled bamboo (right)

Sulfur drying

Lùng bamboo is of bamboo line, so it is easy to be attacked by mould, wood eater and white aunt that can damage material and products. In many enterprises, 30% Lùng material are attacked by wood eater and white aunt (such as Duc Phong Conpany in Nghe An Province). The cheapest way to solve this problem is to apply sulfur drying to sterilize. However, this is not the best measure as it can not entirely solve the problem and it also cause environmental pollution, especially it can damage labor's health, even corrupt and damage shop.

Bamboo (Lùng, Luồng) has the same components with various content:

- Cellulose: 30-40%
- Water: 20-30%
- Pentose: 10-15%
- Wax: 5-10%
- Lignin: 2-3%
- Others

The content of these components varies depending on the types and ages… among components, cellulose is the main component while others are unexpected as they may damage the materials and products. In which:

- Water: causing moisture, mould
- Pentose: attracting wood eater and white ant
- Wax: causing difficulties in sizing and curving

To remove wood eater and white aunt, the efficient way is boiling to remove pentose and other components like wax, lignin from bamboo so that wood eater and white aunt do not have food to eat.

**Figure 5.** Sulfur drying (left) and bamboo boiling (right)

Outer layer's splitting

After being treated, bamboo is transferred to households for splitting and weaving following samples and transferred back to the enterprises. Splitting in household does not bring high efficiency. At average, a person can only split 300 gram outer layer in 4 hours then weave products. Thus, for lantern product, a person who splits and weave can only finish 3 products and the most time consuming is splitting process. In some enterprises like Duc Phong, Quoc Đai which are using machines for splitting, the efficiency is 20 times higher while the dimension and quality of products are considerably better. However, due to limited budget, these enterprises can only equip some equipment but not enough to adopt household's demands.

**Figure 6.** Manual splitting (left) and splitter (right)

Thus, to improve working efficiency, enterprises and households needs to be encouraged and supported to use splitters. However, as that machine requires maintenance and is too big for the usage of the household, and waste is difficult to entirely collected, there need to be more researches to support small-sized enterprises and households in using this kind of splitters.

Weaving and finishing products

Outer layer after being splitted is used to weave some products like: lantern, basket, bowl… and then products are transferred to the enterprises to complete. Finishing process includes some steps:

a. Product sanitation

This is the step to correct the position of laths and use gas to burn fringe. This step consumes a lot of gas, so attention has to be paid to:

- Turn down the burner if unnecessary
- Turn off burner at interval
- Preparing all products before burning to eliminate useless combustion

b. Gluing

This is the step to use PVA water glue to locate the weaving position to avoid deflection during transportation and usage. Although this is the water based glue and it does not harm the health, discharge into the environment should be avoided and glue should be recirculated at site by recollecting the glue after glue using a spout.

**Figure 7.** Correcting products (left) and recycling used glue (right)

c. Product dying and finishing

Depending on the demand, products are dyed or not. Products are dyed by immerging into colour sollution in about 1 minute and then dried. During dyeing, wastewater can be emitted due to leakage, so be noted that:

- After dyeing, products should be picked and left 30 seconds for the sollution to drained before drying
- Calculating carefully the order to avoid losses of dyeing sollution while changing colour
- Utilising condensing water to add heat for dyeing process

### *IV.2.5 Waste from bamboo process*

Mainly all bamboo processing enterprises have the same processes and technology, so this report just focus on the case study of Duc Phong company during CP implenmentation.

1. Air environment

Below table shows the indicators that reflect the quality of air surrounding the company and the comparison with TCVN 5937-2005 and Decision 3733/2002/QĐ-BYT of Ministry of Health.

Causes of air pollution

- Dust and soil generated during storing materials and from buring.

- Flue-gas from boiler.

- SO2 from sulfur furnace

**Table 2.** Quality of air surrounding the company

| No | Indicator | Unit | Result (K1) | Result (K2) | Result (K3) | Standard following TCVN 5939-2005 column A | Standard following Decision 3733/2002QĐ-BYT |
|---|---|---|---|---|---|---|---|
| 1 | $SO_2$ | $\mu g/m^3$ | 100 | 1650 | - | 1500 | 10 |
| 2 | NO | $\mu g/m^3$ | 45 | 171 | - | 1000 | 20 |
| 3 | CO | $\mu g/m^3$ | 5 | 1007 | - | 1000 | 40 |
| 4 | Dust | $\mu g/m^3$ | 15.3 | 348 | 1,13 | 400 | 6 |

Sampling date: 2/12/2009

Sampling position:

K1: sampling position at the gate of sulfur drying chamber.

K2: sampling position at the boiler's stack.

K3: sampling position at the material storage point of the company

Mesurement results show: Sulfur content exceeds the permitted level TCVN 5939-2005, and many times exceeds the permitted level in Decision 3733/2002/QĐ-BYT on 10/10/2002 on labor sanitation standards.

After applying CP and getting the financial support from Cleaner Production in Industry Component (CPI), company installed the sulfur treatment system and applied some options to reduce Sulfur consumption, then the measurement results are all below permitted level.

2. Solid waste

- Annual bamboo discharge due to wood eater and white aunt: 10% bamboo material, equivalent to 300 ton

- The bamboo core that can not be used: 90% input bamboo, equivalent to 2430 ton

- Annual coal slag: about 2.4 ton

- Ash from using waste bamboo as fuel: 12 ton/year

A small part of bamboo that is attacked by wood eater and white aunt and waste bamboo is used as fuel of the boiler, and the major part is used as fuel by farmers. However, wood eater and white aunt can create a great amount of dust, affecting labor health and and environment. Because only 10% of Lùng bamboo can be used to weave products, the rest 90% is discharged, a great amount of waste is generated. Moreover, if wood eater and white aunt is not solved, more waste may be generated. This is the imperative for both enterprises and households as only a small part of waste can be utilised for daily cooking and boiler fuelling.

**Figure 8.** Waste in the company

To make use of this waste, companies should use new technology to produce useful by-products:

- Tooth-pick
- Joss-stick
- Skewer
- Energy ball
- Filler in particleboard production

**Figure 9.** Utilising to waste to fuel boiler (left) and produce tooth pick (right)

### *IV.2.6 Technology and equipment needs*

Surveys at enterprises show that the current imperative is research to find out proper ratio of solution in boiling process and suitable mechanism to substitute sulfur. In addition, it is necessary to invest equipment of different scale to improve productivity and quality.

Company scale:

- Bamboo boiling equipment
- Carbonization equipment that can sterilise and create natural colour for products
- Splitting machines for producing tooth pick, skewer, joss stick to make use of waste
- Energy grinding and casting equipment to substitute coal and firewood.

Household and household group scale:

- Outer layer splitter

**IV.3. CP Assessment for rattan value chain**

***IV.3.1 Harvest***

Rattan in Vietnam is mainly harvested from natural source (forest rattan). However, garden rattan has recently been cultivated rather widely in many provinces, especially in some northern (Thai Binh, former Ha Tay, Tuyen Quang…) and middle provinces (Nghe An, Ha Tinh, Quang Ngai…). These two species play an important part in increasing local people's income, not only for the ethnic minorities, but also for rural people during crop interval. In 5 recent years, the harvestable rattan has reduced considerably, villagers have to go deeply into the forests, consuming even a half day to harvest rattan. With simple harvesting tools, sometimes villagers have to cut surrounding trees to make space, affecting ecosystem and may be a reason for fire. In addition, for cultivated rattan, a great amount of biomass is discharged during harvesting. Thus, to ensure the sustainability for future demand, beside cultivation, the standards to choose qualified rattan to harvest needs to be disseminated among villagers to avoid harvesting immature and unqualified rattan.

Identifying qualified rattan (mature rattan):

- The thorns turn into black and dry leaves fall down
- Leaves at the bottom get dry and mostly fall
- Rattan body turns from light yellow into dark green
- There are both flower and fruit
- Length is more than 5 meters

During harvesting, pay attention to:

- Identify the right rattan type, avoiding harvesting immature rattan
- Harvest rattan in autumn which can facilitate the transportation and avoid mould, ensuring rattan quality
- During cutting rattan, not affect surrounding trees
- Cut tree at the position 10-15 cm from bottom and utilize biomass for composting

***IV.3.2 Transportation***

Water content (moisture) in rattan materials is very high, which occupies about 55%-65% total rattan weight. Therefore, after harvesting, rattan is easily attacked by fungi and mould, reducing quality and increasing transportation cost (mainly water transportation). Decreases quality of materials due to mould and wood eater, especially when the weather is bad or in rainy season, the transportation and collection consumes more time which affects directly rattan quality.

Basically, 2 main means of transportation are road route and water way. Only rattan from headwater is transported by waterway which is of low cost. However, rattan will be dirtied by alluvium and other contaminants, which would cause an increase in the cost of labour and water consumption after boiling process. The more popular transportation is road route.

To reduce transportation cost, rattan should be processed right after harvesting: boiled, spitted, sized, dried, and then transported according to orders. This can also reduce waste, overharvest as well as increase profit for the whole sector.

### *IV.3.3 Material preprocessing*

*Oil boiling*

Rattan is natural material. Beside the main components of mature rattan which are cellulose (20-30%), water (50-60%), lignin (15-20%) there are some other components like pentose, wax (5-10%), which connect tightly to cellulose, making rattan hard to be woven. Moreover, water and pentose attack mould, wood eater and white aunt. Thus, immature rattan which contains a lot of pentose and water can easily be attacked by fungi and mould.

According to the author Yudodibroto (1985), there are some advantages of oil boiling:

- Preventing fungi and mould
- Preventing partly wood eater and white aunt
- Removing wax, resin and pentose
- Boosting up drying process
- Improving rattan durability after boiling
- Improving rattan colour

**Figure 10**. Oil Boiling

In this process, one type of oil or oil combination can be used among which diesel boiling is considered as the most economic and efficient method which can bring best and natural colour result. However, diesel usage, especially waste diesel may pollute the environment surrounding company and the residual oil existing in products may harm consumer's health, therefore, European organizations require companies to use more environmentally friendly technologies. Vietnam Cleaner Production Centre has corporate with Polymer Centre (Hanoi University of Science and Technology) to carry out experiment of boiling method using secondary palm and soya oil added a small amount of salt. Some experiences in Vietnam and Cambodia have shown positive results. Last but not least, rattan should be boiled with oil when it is fresh. The sooner rattan is boiled after harvesting; the better quality and color can be achieved.

Dimension of a boiling tank is usually 1 m x 1 m x 5 m and the usual fuel are firewood and coal, average boiling time is from 45 minutes – 1.5 hour, depending on the freshness, diameter and rattan type.

*Drying and preservation*

After boiling, rattan is dried. Normally, sunshine is always utilized to naturally dry rattan to remove moisture and prevent fungi, mould during processing. However, there may be some difficulties in rattan natural drying especially in rainy season. Therefore, by utilizing waste rattan to be the fuel in drying, enterprises can be more active in processing material. Depending on the rattan quantity, drying temperature and time can be adjusted to achieve required quality.

**Figure 11**. Natural drying

At present, instead of investing on drying systems, many enterprises just focus on natural drying on the ground or concrete yard. The best drying way is to hang rattan vertically so that water and pentose fall down, boosting up the drying process and avoid dust from adhering rattan. For smaller rattan, selves can be designed to avoid rattan from directly contact with ground, speeding up drying.

Material and product preservation is very simple, so rattan easily gets mould and moisture, affecting product quality.

**Figure 12.** Indoor preservation

**Figure 13.** Outdoor preservation

**Figure 14.** Simple material preservation

**Figure 15.** Preservation with classification and moisture insulation

***IV.3.4 Rattan process***

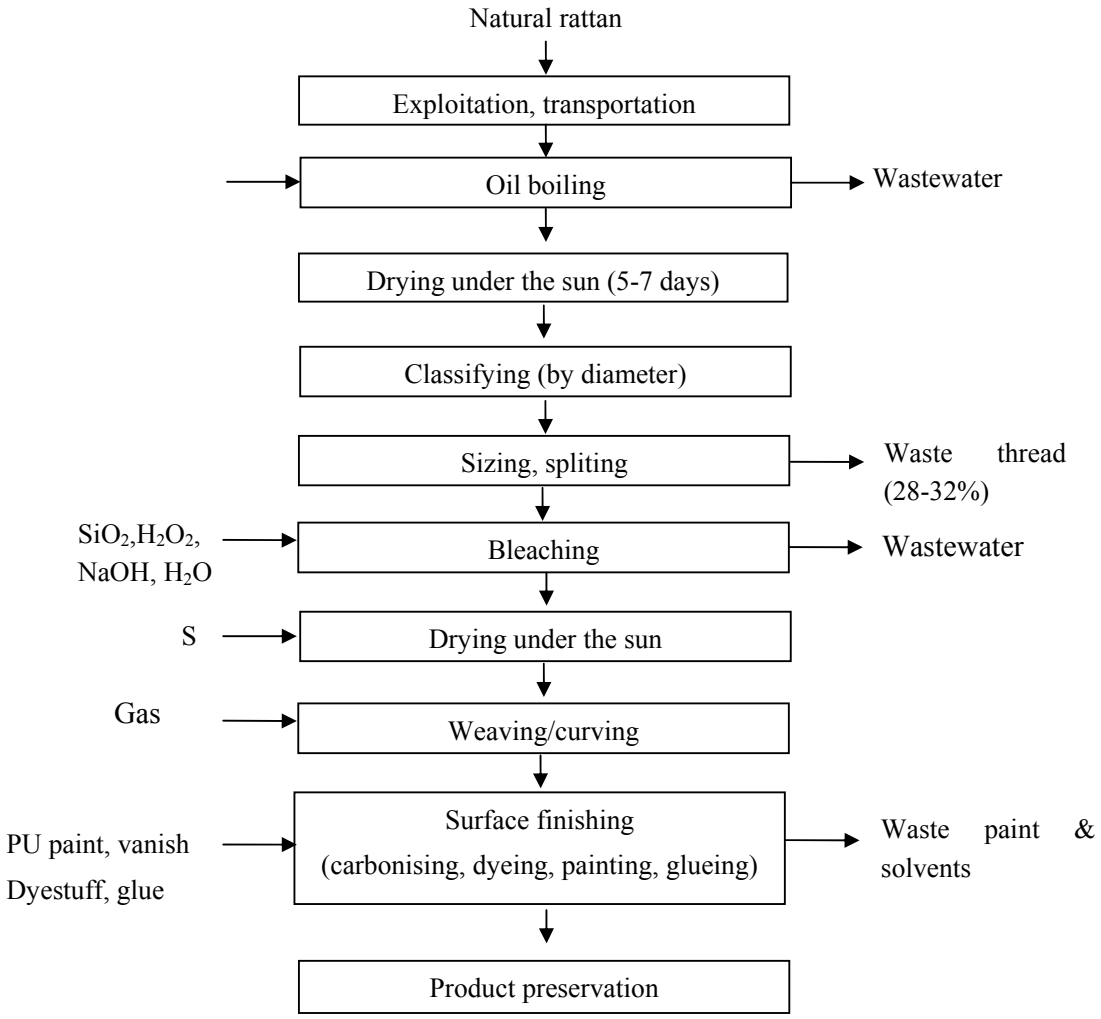



**Figure 16**. Detail process flowchart of Calamus Armarus

Presently, mostly all of rattan process enterprises have no data on material and energy consumption. Thus, data collection for the assessment is very difficult. Following is the table of material consumption in one enterprise that is implementing CP assessment for reference.

**Table 3.** Material consumption benchmarks for 1 ton product

| No | Input | Unit | 2009 | 2010 |
|---|---|---|---|---|
| 1 | Rattan material | Ton | 2.170 | 2.010 |
| 2 | Electricity | Kwh | 329 | 339 |

| | | | | |
|---|---|---|---|---|
| 3 | Diesel oil<br>- Power generation<br>- Oil boiling | <br>Liter<br>Liter | <br>-<br>4 | <br>-<br>10 |
| 4 | Gas | Kg | 11 | 9.3 |
| 5 | Water | $M^3$ | 25 | 25 |
| 6 | Adhering glue | Kg | 5 | 5.1 |
| 7 | - Gloss/ TOA Varnish<br>- Polishing oil | Liter<br>Liter | 11<br>4.5 | 10.6<br>4.2 |
| 8 | Chemical: $H_2O_2$-50% + $Na_2SiO_3$ | Liter | 23.45 | 21.6 |
| 9 | Polishing paper<br>- For manual operation<br>- For machine | <br>Piece<br>Piece | <br>13<br>11 | <br>13<br>11 |

*Splitting, sizing*

Splitting and sizing is the most important process which affect product quality. Normally, enterprises use machine for splitting and sizing, however the quality is not high because:

- Obsolete machine
- Blunt splitting knives
- Not dry rattan
- Improper labor's manipulation

Thus, the most noticeable options here are choosing the qualified splitting and sizing knives which can split a lot of rattan and maintaining machine regularly. Too dry and old rattan roots need to be cut. Labor should pay more attention to the manipulation, depending on the rattan size to place properly into the splitter.

*Bleaching*

Due to the colour requirement, bleaching chemicals need to be used. In fact, bleaching process is often implemented in various ways and mainly through experience exchange. There is no full research on chemical's role as well as its components. Moreover, wastewater analysis shows big amount of residual chemicals which are not used entirely during bleaching. After being consulted, Au Co company has saved 50% bleaching chemicals and reduced bleaching period from 48 hours to 24 hours by applying heat added bleaching process. Vietnam Cleaner Production Centre and Polymer centre have succeeded in researching rattan bleaching formula in which chemical consumption is reduced considerably while the quality is still ensured.

Following is the standard bleaching process for Calamus Armarus (for 100 kg rattan):

+ Chemical: NaOH: 5 kg; $H_2O_2$: 24 – 25 kg; Silica: 5 - 6 kg, fresh water 6 liter/1 kg rattan

+ Mixing technique:

Step 1: Pouring all alkaline into water

Step 2: Adding ½ silica

Step 3: Adding all $H_2O_2$

Step 4: Adding the rest silica

Stir solution and immerge rattan from 1 to 2 cm in water. Take the transparent plastic film to place on rattan surface and take a strip to thrust rattan.

After 4-5 hour of reaction, take away the strip and turn rattan upside down to get good colour, then immerge rattan again for 5-7 hour. After picking up, rattan is snow white. Depending on rattan type, bleaching time may be longer or shorter. For immature rattan, bleaching time is short while for the moulded rattan, bleaching time is longer. The $2^{nd}$ and $3^{rd}$ batch can be added without adding more chemical, bleaching time varies depending on product's characteristics. Normally, reaction is strongest from the $2^{nd}$ to the $4^{th}$ hour, then lighter, so too early turning rattan should be avoided to reduce chemical loss. After 4 hour, rattan can be turned upside down. After picking up rattan, do not wash rattan but let water drain in about 30 minutes to 1h, then spray water lightly to wash alkaline in rattan's surface.

With such bleaching process, rattan is ductile while chemical is saved.

Role of each chemical in rattan bleaching:

- Alkaline (NaOH)

Alkaline softens rattan by diluting rattan's components: lignin, pentose… and avoid wood eater and white aunt. On the other hand, alkaline is the agent that boosts up $H_2O_2$ decomposition reaction and goes deeper into rattan fiber.

- Peroxide $H_2O_2$

Forming atomic Oxygen to bleach rattan. Reaction happens as followed:

$$H_2O_2 + 2OH^- = 2H_2O + O_2 + O$$

Atomic Oxygen is the decisive factor in bleaching rattan.

- Silica liquid glass

Silica is the surfactant in which main component is $SiO_2$, slowing down the reaction, facilitating the absorption of bleaching chemicals, prolonging reaction and eliminating $H_2O_2$ evaporation. However, silica is not used in some companies.

*Washing*

After bleaching, to remove the residual chemical on rattan, rattan is washed. Most of companies utilize water from ponds, lakes and rivers for washing and directly discharge without any treatment process. The best option is to recovered chemical-contained wastewater and then adding more chemical for bleaching following cascading wash method.

**Figure 17.** Washing rattan after bleaching

*Processing, weaving, curving and finishing*

Improvement opportunities:

- Improving working conditions for workers: ventilation, lighting system and protective equipment
- Installing more fixtures and frames to boosting up curving process by gas to save fuel
- Applying steam curving to save fuel and get better quality and prevent products from getting black

**Figure 18.** Gas driven curving equipment

**Figure 19.** Using frame

**Figure 20.** Gas waste

- Glue should be recovered to avoid loss

**Figure 21.** Recovering used glue

*Surface finishing (painting, carbonizing, dyeing)*

Painting

- Using correct spraying guns
- Installing proper odor sucking and treating system

Carbonizing:

- Operating coal furnace at suitable and fuel conserving mechanism.
- Selecting and preserving carefully coal with uniform dimension
- Insulating steam piping system, avoiding leakage, installing steam driven equipment near the boiler to avoid heat loss

Dyeing

- Insulating dyeing equipment well
- Carefully planning dyeing process to avoid changing dyestuff so often
- After dyeing, water should be drained from rattan to be recovered to dyeing tank

**Figure 22.** Spraying painting with air sucking and treating system

***IV.3.5 Waste from rattan process***

*Solid waste*

Solid waste in rattan processing is mainly from barking, sizing and splitting which occupies 8-12% (in Vietnam), even 15-20% (in Cambodia) the whole rattan material. This quantity also depends on the rattan quality. Many enterprises do not control quality as well as have the options to treat mould, wood eater and white aunt which can damage rattan material. Nearly all enterprises do not utilize this waste. After applying CP options, some Vietnamese Calamus Armarus processing enterprise has used this waste as fuel for drying furnace. Some C. tetradactyl processing enterprises (in Thai Binh province) sell this waste for other enterprises to be the filler of pillow, mattress… however; this waste can not be used much as it contains residual sulfur during preprocessing. Many enterprises have no option other than burning this big amount of waste which may emit a lot of toxic gases (CO, CO2, SOx) and pollute environment.

*Exhaust gas*

Gas emitted mainly from rattan boiling and waste burning. However, this does not regularly occur. In addition, there is another exhaust gas source from product finishing when toluene solution for diluting PU evaporated during coating the product surface.

Sources of exhaust gas include:

- Rattan boiling, boiler, diesel driven engines: emitting NOx, SOx, CO, $CO_2$;

- Sulfur drying area; $SO_2$, $SO_3$;

- Mixing paint to finish products using solution: organic gases;

- Bleaching: chemical evaporate;

*Dust*

Dust is mainly generated in sizing, splitting and surface polishing. Besides, dust is also generated during shaving to make frames. This dust is not collected and still disperses in the environment of the workshop, affecting labor's health and productivity.

*Wastewater*

There are 4 main sources of wastewater: wastewater from rattan bleaching, boiling, washing and labor sanitation. However, wastewater from sanitation is not worrying as it is treated through digestion tank and most workers do not work at enterprises but at home. Thus, three rest sources are more worrying as most enterprises do not have wastewater treatment system as well as do not optimize the treatment system, so waste water still contains a lot of chemicals, polluting environment. Enterprises also do not care much about wastewater, so there is no full data on quantity and components of wastewater. The following table shows results of wastewater analysis before treatment in a rattan processing company (Au Co rattan, bamboo and leave company).

On average, an enterprise discharges about 20-30 $m^3$ wastewater/ton processed rattan.

**Table 4.** Quality of wastewater before treatment in Au Co company in 2007

| No. | Parameter | Unit | Testing method | Result | TCVN (*) |
|---|---|---|---|---|---|
| 1 | pH | - | Consort measurement | 6,86 | 5,5 - 9 |
| 2 | SS | mg/l | TCVN 6224-96 | 71 | 100 |
| 3 | $BOD_5$ | mg/l | TCVN 600-95 | 387 | 50 |
| 4 | COD | mg/l | TCVN 6491-99 | 554 | 100 |
| 5 | Residual chlorine | mg/l | Colour comparison | 0,12 | 2 |
| 6 | Iron | mg/l | TCVN 6177-96 | 0,14 | 5 |
| 7 | Coliform | MPN/100 ml | TCVN 2680-78 | 2100 | 10.000 |

(*) Standard TCVN 5945-1995 on wastewater column B

It can be seen from the table that wastewater quality does not meet the permitted standards in which BOD is 8 times higher and COD is 6 times higher than permitted level

### *IV.3.6 Technology and equipment requirements*

Through surveys, all enterprises know about the environment pollution from diesel boiling, but there is no other suitable technology to substitute the existing one. However, there are many other technologies which can help enterprises save chemicals, energy to reduce environment pollution.

Company scale:

- Boiling technique using plant oil
- Carbonization equipment that can sterilise and create natural colour for products
- Splitting and sizing equipment which can bring high productivity and quality
- Chemical saving bleaching technology and equipment
- Material and product drying chamber using solid waste from processing and utilizing solar energy

Household and household group scale:

- Rattan splitting and sizing machine

## V. SUSTAINABLE PRODUCT DESIGN FOR RATTAN VALUE CHAIN

### V.1. Current status and unsustainability

The most common and outstanding feature in rattan, bamboo enterprises is the unclear and passive development trend. Most enterprises wait for orders from familiar consumers. In this way, potential consumers bring their design and order to the enterprises and enterprises just process basing on consumer's design with not very high profit and the price is often affected by the consumers.

However, some enterprises really have production strengths and stable consumers. In addition, they have proactive campaigns to develop products and introduce to the consumers via relation ships, national and international exhibitions. Therefore, they have created the difference and considerable development. To adopt new situation, these enterprises develop and produce products with the combination of different materials.

Beside products, production contains a lot of imperatives for enterprises. At present, they are using obsolete technology and equipment which consumes a lot of energy, can not utilize all biomass, create a lot of waste and exhaust gas, harming environment and human, for e.g.: although sulfur drying method has long been prohibited in developed countries, many enterprises still use this method as there is no alternative method. In nearly all enterprises, heat is often added using different types of coal (coal, briquette coal…) while the un optimized furnace can cause more than 30% fuel loss. In addition, the heat piping system without insulation causes big heat loss, heating surrounding environment. Machines in enterprise are mainly not maintained which reduces the product efficiency and quality, causing energy loss. Workshop, ventilation, dust sucking and lighting system are not cared much, so the working environment is not good and a big quality of dust is discharged into environment.

lack of cooperation, individual economic trend, lack of business sensitiveness are existing problems with rattan bamboo enterprises. Products are too boring and can not create outstanding feature for the enterprises. Exploitation and process are not linked and contain a lot of unsustainability issues. Enterprises are operating in a passive way without any sustainable product development to get higher added value. Enterprises often adopt to the available design with few modifications which are mainly visual and spontaneous. Moreover, many enterprises copy or even buy design from other enterprises to shown in the showroom and introduce with the potential consumers. Thus, there is no motivation for the consumers to maintain the long partnership with enterprises, except for low price.

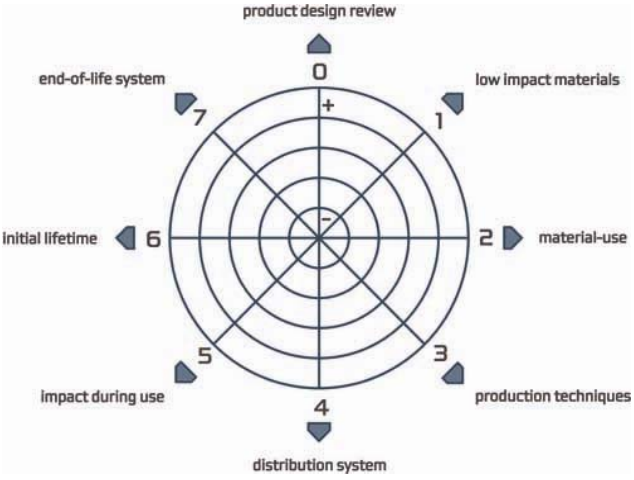
**V.2. Analysis and option generation**

The lack of research and technology factors in product design and production strategy seems to be the weakest point for all enterprises in five targeted sectors.

Most enterprises develop their products in a spontaneous way without any really effective methodology or step-by-step process. Thus, their products just adopt the current demand. There are three most popular ways to develop products in enterprises: the first way is copying the design of rivals and sell to consumers. The second way is to exactly process following the consumer's design, and the last way is to develop products themselves basing on their own tastes, heuristics and show in exhibition. These are passive and unsustainable ways to invest at large scale and high efficiency. Sometimes, such spontaneous methodology make enterprises get stuck and can not find out market for products.


To solve this problem, enterprises must be proactive in choosing a smart product strategy and applying new and efficient methodology for product development. Enterprises should identify short-term and long –term targets in the strategy and focus on market segment which is suitable with enterprises' capacity. A product development team should be established so that D4S (Design for Sustainability) methodology can be well applied.

Enterprises also cope with limit and difficulties with advanced technology and equipment. Some enterprises start to be aware of sustainability needs and environmentally friendly to adopt foreign market's requirements. Enterprises desire innovation but do not know how to get start, how to adjust budget and how to find out reliable technology transfer organizations. The question here is in what way the project can support enterprises to deal with existing problems?




With the current experiences from activities, the project should support enterprises in energy efficiency, maximum biomass utilization and waste reduction. Project should focus on gasification technology to apply for agricultural products, production waste and solar energy technology to create heat for production. New

material process technologies should be used to substitute the traditional immerging, dyeing and bleaching technologies.

If only D4S methodology can be applied accurately and efficiently in enterprise's product strategy, results may be over expected. However, the D4S application may face to some certain difficulties. For example, in case, the companies use a lot of materials and product of different suppliers, the proactiveness of the strategy and enterprises may easily lose control for quality, price and time. These are caused by existing weaknesses of the business that is strongly individual. At present, the auxiliary industry is low developed and lack of community feature. The relationship among enterprises within a sector is not really tight. Thus, enterprises have to do everything on their own and can not utilize the strengths of other enterprises into their own business. As a result, the labor force is much but efficiency is not high, products and functions may overlap, leading to the severe internal competition inside sector. To get strong resources to develop products, production and business, enterprises should sit together and negotiate to create a network which can support each other basing on each enterprise's strengths and weaknesses and can be linked by sector's profits.

Beside applying proper methodology for product and production strategy, enterprises should promote their own internal strength and develop a support network basing on the whole sector's profits. Enterprises should make use of associations to research on national and international development trend and develop brands, promote trade, improve capacity and competitiveness towards sustainability.

For targeted enterprises in the project, new options can be applied in process, preservation and production to improve quality and reduce transportation, production cost, add more value to products. These are new technology in rattan boiling, steaming which can replace traditional oil boiling and immerging; heat circulation technology with insulation which can utilize maximum excessive material, agricultural by-products, hauler, husk in drying and insulation for preservation…

Enterprises may think of the option to short down the product list but focus on higher quality and competitive products which have advantages in price and design.

Research on the trend of supplying lump-sum products to adopt nearly all daily demands. To achieve that, enterprises need to agree on responsibilities under the coordination of a committee established by volunteering enterprises.

### V.3. Case studies in Vietnam

Rolling bamboo products are unique products of Vietnam. They are favorite in moth domestic and foreign markets. With good product design and strategy, we can produce impressive products.

Lacquerware products which use bamboo as a core is always highly appreciated which can connect bamboo enterprises and lacquerware ones.

With endless creativeness, various high quality products can be made from traditional rattan and bamboo materials which bring a new vision on rattan and bamboo.

The tendency to combine rattan, bamboo with other materials is now more popular and plays an important role in promoting creativeness on rattan and bamboo.

Sustainable products made from waste of rattan and bamboo sector attract a lot of attention as well as order in Vietnam LifeStyle Arts and Handicrafts Fair 2011.

Together we develop a Green Lifestyle, using natural resources in a useful and economical way.

Rattan, bamboo and their products can entirely replace all unsustainable materials that are existing in our daily life.

As mentioned above, the amount of waste fiber in rattan processing is very big. With the purpose of utilizing entirely rattan biomass, the current need is to develop products that can utilize waste and outer layer. At present, rattan core has the highest commercial value while outer layer is just considered as auxiliary material. Nam Phuoc Company is a good example for being proactive in adjusting the order between rattan outer layer and core. Meanwhile not many enterprises can balance the ratio between product/material, thus rattan outer layer is stagnant and must be used to substitute fuel like waste rattan.

Another trend is to combine different types of materials including rattan to develop new products. Case studies for this trend are enterprises in the South of which the strengths are water fern – rattan or forest string – rattan.

For rattan of small diameter, products woven directly from rattan should be developed to eliminate sizing, splitting. In addition, rattan outer layer has highly mechanical feature and durable, so weaving the whole tree can utilize this advantage.

Bird net decorated from waste rattan

Straw broom made from waste rattan

**V.4. Development trend analysis in Vietnam and on the world**

In Vietnam, the tendency of sustainable production and consumption is more and more popular, especially in urban area and in the young generation. They have deep awareness and abundant experiences on sustainable products.

With a modern life which consumes a lot of time and money of people, human and community's health are paid more attention. There are the severe needs for clean food, environmentally friendly and healthy products. Thus, the development of production and distribution capacity for sustainable products is smart strategy which complies with social laws.

In addition, the State is encouraging and supporting enterprises and organization in sustainable development which creates jobs for rural labors. This has been expressed in State's mechanism and policies in recent years on controlling the exploitation and process of agricultural, forestry and maritime products, including the control of exhaust gas, production waste and municipal waste, the prohibition of toxic chemicals, the reduction of chemical fertilizers and insecticides…

The State is also developing suitable policies to ensure the national development, adopting international trends. This is very important when Vietnam is coming to the last steps in integrating into World Trade Organisation (WTO). If national industry in general and enterprises in detail do not innovate to integrate and compete with outside economy, right after

finishing WTO integration, international production and economy will become the threat for Vietnamese production and economy.

The concept of sustainability has been known for a long time and many sustainable products in both material and spiritual have been invented. In nearly all developed countries, the social pressure on sustainable development is very high for enterprises and producers, requiring them to comply with severe rules on working conditions, product safety, social contribution and human health. All these requirements have been stated in laws of many countries, territories and the world. Thus, exported products need to comply with the code of conduct of import countries. This is a great barrier for small and medium-sized enterprises in Vietnam. Thus, cleaner production and D4S is the mandatory requirement and decisive factor to the company's existence and development in the near future.