The Swedish Forest Industry and Lessons for China: Production and Environmental Objectives on an Equal Footing?

Ying Wang

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Ying Wang

Supervisor: Gloria L. Gallardo Fernández
Evaluator: Eva Friman
## List of Abbreviations

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Full Form</th>
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</thead>
<tbody>
<tr>
<td>FAO</td>
<td>Food and Agriculture Organization of the United Nations</td>
</tr>
<tr>
<td>FSC</td>
<td>Forest Stewardship Council</td>
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<tr>
<td>IEA</td>
<td>International Energy Agency</td>
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<tr>
<td>LRF</td>
<td>Federation of Swedish Farmers/ Lantbrukarnas Riksförbund</td>
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<tr>
<td>MOU</td>
<td>Memorandum of Understanding</td>
</tr>
<tr>
<td>MDF</td>
<td>Medium Density Fiberboard</td>
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<tr>
<td>NBF</td>
<td>National Board of Forestry in Sweden</td>
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<tr>
<td>NBSC</td>
<td>National Bureau of Statistics of China</td>
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<tr>
<td>NFI</td>
<td>Swedish National Forest Inventory</td>
</tr>
<tr>
<td>NWFP</td>
<td>Non-wood Forest Products</td>
</tr>
<tr>
<td>PFE</td>
<td>Program for Improving Energy Efficiency in Energy Intensive Industries</td>
</tr>
<tr>
<td>SCA</td>
<td>Svenska Cellulosa Aktiebolaget</td>
</tr>
<tr>
<td>SFA</td>
<td>Swedish Forest Agency</td>
</tr>
<tr>
<td>SFA.PRC</td>
<td>State Forestry Administration P. R. China.</td>
</tr>
<tr>
<td>SKFP</td>
<td>Six Key Forestry Programs in China</td>
</tr>
<tr>
<td>SSNC</td>
<td>Swedish Society for Nature Conservation</td>
</tr>
<tr>
<td>UNECE</td>
<td>United Nations Economic Commission for Europe</td>
</tr>
<tr>
<td>WCED</td>
<td>World Commission on Environment and Development</td>
</tr>
<tr>
<td>WWF</td>
<td>World Wildlife Fund</td>
</tr>
<tr>
<td>WKH</td>
<td>Woodland Key Habitat</td>
</tr>
</tbody>
</table>
The Swedish Forest Industry and Lessons for China: Production and Environmental Objectives on an Equal Footing?

YING WANG


Abstract: The forest industry plays a key role in global economic development and environmental conservation. The Swedish forest industry has a leading position in world forest clusters. The strategy of the Swedish forest industry is giving the environmental and the production objective the same high priority. On the other hand, China, as the second largest economy in the world, operates the forest sector in a different way. The aim of this paper is first to look at how sustainable the Swedish forest industry is and learn what aspects of it can be possibly applied by China, by making a limited comparison between these two countries.

Literature review is the main method, combining with SWOT-analysis and comparative study. After analyzing the environmental economic and social aspects of sustainable development within the forestry sector in both countries, a brief summary is made using SWOT-analysis, which highlights strength, weakness, future potential and threat. The study and analysis shows that a delicate balance between the production and the environmental objective is kept in Sweden. Even though the forest industry is one of the most energy intensive industries, Sweden has accumulated some experience in streamlining production line and enhancing the resilience of forests aiming for climate change mitigation. As the biggest developing country in the world, China’s forestry has developed extensively. China shows limitation in extraction and handling with forest resources, but also potential in the forestry industry. Though limited, this comparison gives some clues on how and what policies and measures could be applied in China. China could draw some experiences from Sweden in forestry development, technology innovation and operation patterns.

Keywords: Sustainable Development, Climate Change, Forest Industry, Sweden, China.

Ying Wang, Department of Earth Sciences, Uppsala University, Villavägen 16, SE - 752 36 Uppsala, Sweden
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Summary: Forest is known as the lung of the earth. Nowadays, its capability to absorb and store huge amount of CO₂ makes it even more precious for the whole biosphere. Furthermore, it is also an important part of the modern industry for countries gifted with abundant forest resource. Swedish forest industry has achieved some success in balancing environmental and economic goals. By contrast, China, the biggest developing country and the largest CO₂ emitter in the world, has much to improve in its forest sector despite its large forest land areas and diverse forest eco-system. The aim of this paper is first to look at how sustainable the Swedish forest industry is and learn what aspects of it can be possibly applied by China, by making a limited comparison between these two countries. Literature review is the main method, combining with SWOT-analysis and comparative study. By analyzing the environmental economic and social aspects of sustainable development within the two countries’ forest sector, a brief summary is made using SWOT-analysis, which highlights strength, weakness, future potential and threat. The study shows that Sweden has accumulated much experience on sustainable forestry management while China is just at its initial stage. On the other hand, there are still great potential in China’s forest industry and still many possibilities are open to incorporate sustainability in its development.

Keywords: Sustainable Development, Climate Change, Forest Industry, Sweden, China.

Ying Wang, Department of Earth Sciences, Uppsala University, Villavägen 16, SE - 752 36 Uppsala, Sweden
1. Introduction

1.1 Background

Forests are seen as the lung of the earth. The function of forests is vital for human and animal life. They provide a diverse range of goods and services. Different kinds of forests cover 30 percent of the total land area, or approximately 8 percent of the earth’s surface (FAO, 2009b). About 90 percent of the terrestrial biodiversity in the world is contained in forests (World Bank, 2003). Moreover, forests are highly sensitive to regulate climate change. The ecosystem of forests is a link between climate and human activities, with highly complex interactions. They play a significant role in storing carbon, purifying water, and preventing soil erosion (Baer, 1996). Consequently, forests utilization and conservation is one of most significant elements to sustainable development.

Forests are a crucial part of the global carbon cycle. Plants can absorb the carbon dioxide from atmosphere through photosynthesis and release oxygen (Joint Liaison Group, 2010). Besides, many products made of forest raw materials, such as paper, timber, can also store carbon dioxide remains (Skogsindustrierna, 2010). Therefore, the forest can be seen as a carbon sink, which makes a great contribution to mitigating the greenhouse effect. “The total carbon content of forest ecosystems has been estimated at 638 Gt for 2005, which is more than the amount of carbon in the entire atmosphere” (Joint Liaison Group, 2010). Forests also have economic functions. A great deal of goods and services generated by forests can benefit human beings. These values can be classified roughly in two categories. The direct use values refer to the values stemming from consumptive and non-consumptive uses of the forest, such as timber and fuel. The indirect use values refer to values stemming from various forest services such as conservation of rainforests and carbon storage (Pearce, 2001). Forests are an important source of bioenergy. Bioenergy is a kind of domestic and distributed fuel, which can increase “local security of energy supplies, income and employment in rural areas in Europe” (Lunnan et al., 2008). Biofuels can replace part of the fossil fuel. Consequently, bioenergy could have great contribution to regional and national economic growth and development.

At the present time, the total forest standing volume is decreasing worldwide whereas the situation is reverse in Sweden (Skogsindustrierna, 2005). More than 100 million m³ sk (m³ sk=forest cubic meters) forests grow each year in Sweden. The total net change in the world forest area during 1990–2000 is estimated at -8.9 million hectares per year (FAO, 2005). The forest area change situation worldwide can be seen from Table 1:

<table>
<thead>
<tr>
<th>Region</th>
<th>Forest area 1990</th>
<th>Forest area 2000</th>
<th>Annual change 1990-2000</th>
</tr>
</thead>
<tbody>
<tr>
<td>Africa</td>
<td>699361</td>
<td>655613</td>
<td>-4375</td>
</tr>
<tr>
<td>Asia</td>
<td>574487</td>
<td>566562</td>
<td>-792</td>
</tr>
<tr>
<td>Europe</td>
<td>989320</td>
<td>998091</td>
<td>877</td>
</tr>
<tr>
<td>North and Central America</td>
<td>710790</td>
<td>707514</td>
<td>-328</td>
</tr>
<tr>
<td>Oceania</td>
<td>212514</td>
<td>208034</td>
<td>-448</td>
</tr>
<tr>
<td>South America</td>
<td>890818</td>
<td>852796</td>
<td>-3802</td>
</tr>
<tr>
<td>World</td>
<td>4077291</td>
<td>3988610</td>
<td>-8868</td>
</tr>
</tbody>
</table>
With the increasing of forestland area, there will be more CO$_2$ absorbed by forests in Sweden. Simultaneously, the forest industry in Sweden is also successful in emission reduction during the production process. As can be seen from the following bar chart, carbon dioxide emission in Sweden is the lowest among these countries for per ton of paper and pulp produced.

Figure 1. CO$_2$ emissions from per ton of paper and pulp produced in different countries (Tons) (IEA, 2007)

According to the 1993 Forestry Act, the Swedish Parliament decided that the environmental objective and production objective are equally important. It can be seen as a turning point in Swedish forest industry (Nylund, 2010). Given such legislation background, the Swedish forest industry can be seen as a role model in sustainable development. Sweden occupies only about one percent of the world’s commercial forest area, however it provides ten percent of the sawn timber, paper and pulp in the world (Barklund, 2009).

China on the other side is the largest CO$_2$ emitter and the biggest developing country around the world. China’s performance is decisive for the world to mitigate climate change issue and economic development. The forest industry in China is not only important for China’s economy, but also an indispensable part for China’s ecological and social development. Yet there are huge challenges for China to tackle before its level of progress can be on a par with Sweden or any other developed country.

China and Sweden varies a lot in many aspects of political and economic development, which will be considered further on in this paper. But here is first a short overview of some key forest indicators:

<table>
<thead>
<tr>
<th></th>
<th>China</th>
<th>Sweden</th>
</tr>
</thead>
<tbody>
<tr>
<td>Forest coverage in 2012</td>
<td>20.36%</td>
<td>68.7%</td>
</tr>
<tr>
<td>Per capita forest area in 2008</td>
<td>0.15 ha</td>
<td>2.983 ha</td>
</tr>
<tr>
<td>Per capita forest standing volume in 2008</td>
<td>10.15 m$^3$</td>
<td>326.49 m$^3$</td>
</tr>
<tr>
<td>Per capita GDP in 2011</td>
<td>5414 US$</td>
<td>56956 US$</td>
</tr>
<tr>
<td>Forest industry's share in total GDP in 2010</td>
<td>0.8%</td>
<td>3%</td>
</tr>
<tr>
<td>Ratio of forest industry employment to entire industrial employment in 2010</td>
<td>5-6%</td>
<td>10-12%</td>
</tr>
</tbody>
</table>
1.2 Purpose and methodology

Considering the significance of forest industry to global sustainable development, the Swedish forest industry will be studied as a good example in my paper. The aim of this paper is first to look at how sustainable the Swedish forest industry is and learn what aspects of it can be possibly applied by China, by making a limited comparison between these two countries.

Literature review is the major methodology used in my study, combining with SWOT-analysis and comparative study. I have read through scientific papers and reports on the topic of Swedish forestry management and sustainable utilization of forest resources. Some related information, such as facts and figures and annual reports came from the Swedish Forest Industries Federation (Skogsindustrierna) and the Swedish Forest Agency (Skogsstyrelsen). The information about China’s forest industry is mainly collected from the Food and Agriculture Organization of the United Nations (FAO) and Chinese authorities such as National Bureau of Statistics of China (NBSC) and the State Forestry Administration of China.

The part on Sweden’s forestry is the main text. Some information on China could not be found, even in Chinese. Consequently, the analysis on Swedish forest industry has to be the centerpiece of the thesis, but also due to its forestry policy, which hopefully could be something that could be emulated, though with caution, by the Chinese forest industry.

The disposition of the thesis is as it follows: Firstly, from the basis of the conceptual framework, I try to describe how the Swedish forest industry strikes a delicate balance between environmental objective and production objective by looking into the three pillars of sustainable development, namely its environmental, economic and social aspects. In each aspect of three pillars, I start with the advantages and then try to look into the disadvantages. After that, I undertake a SWOT-analysis (Strengths, Weaknesses, Opportunities and Threats) to identify the future potential and threat of Sweden’s forest industry. I will secondly, do the same as above for China. I discuss thirdly the possibility and feasibility of China in learning from Swedish experiences on forestry management.
2. Conceptual framework

Our Common Future defines sustainable development as “development which meets the needs of the present without compromising the ability of future generations to meet their own needs” (WCED, 1987). It is widely consented that sustainable development needs a combination between the three pillars, environmental survival, economic development and social equity (Drexhage and Murphy, 2010). Shaping the use of forest resources entails a big challenge (Susanna, 2004). “Management should make sure forests are able - now and in the future - to fulfill important environmental, economic and social functions on local, national as well as global levels without harming other ecosystems” (Skogsstyrelsen, 2012b).

Environmental sustainability of forestry

Environmental sustainability refers to protecting the natural world, with particular emphasis on preserving the capability of the environment to support human life. It concerns elements like: greenhouse gases, biodiversity loss, deforestation, recycling and renewable energy (UNEP, 2011).

“With its renewable raw materials, environmentally adapted processes and recoverable products the forest industry is well placed to contribute to sustainable development” (Lunnan et al., 2008). Forest plays a key role in climate change. Woods and paper are environmental friendly alternatives, and bio energy from forest can replace some fossil fuels to some extent. The use of recovered paper and other renewable raw materials can reduce greenhouse gases. Besides, the conservation of biological diversity and minimizing species extinction is crucial for environmental sustainability (Noss, 2001). Hence, the environmental sustainability of forestry can be described as “making the best use of the great growth potential that exists in the forests, while also taking the need for biological diversity into account” (Skogsindustrierna, 2008).

Economic sustainability of forestry

Economic sustainability can be described as “an economy that is able to sustain GDP growth without having a negative impact on the environment” (UNEP, 2011). This pillar supports factors like: stable economic growth, technology innovation, investments, efficient allocation of materials and fair market.

A sustainable economy should ensure that the economic growth maintains a healthy balance with ecosystem, and sustainable economic growth may be achieved by raising the utility rate of resources (WCED, 1987). What makes the forest industry different from many other sectors is its close relation with natural resources (Lunnan et al., 2008). Markets play an important role in deforestation, at the same time that commodity markets can stimulate demand for green forest commodities and offer economic substitutes that facilitate more sustainable forest use (Hecht, 2004). In this period of climate change, the forest industry has a challenge to respond to the increased demand of becoming greener.

Social sustainability of forestry

Social sustainable development, in a word, refers to the inter-generation equity as well as the intra-generation equity for mankind on the social resource (Sen, 2000). This pillar concerns elements like: living quality, social equity, property, security, human relationship to nature, traditional cultural (Drexhage and Murphy, 2010).

Safe work environment and competence development are crucial elements behind a sustainable industry. Moreover, fair and equitable sharing of benefits deriving from forest resources is quite significant (SCBD, 2009). In addition, reducing conflicts among diverse forest utilization can promote social sustainability (SCBD, 2009). From local perspective, dependency on local forest resources, traditional culture and local participation in forest are at least as crucial as economic development for local quality. And prosperity of local society and welfare of inhabitants play an important role in sustainable development (Thellbro and Lidestav, 2008).
3. Sustainable development and Swedish forest industry

3.1 Short overview of Swedish forestry development

The current national forest policy is mainly developed from 1993. The 1993 Forest Act represented a turning point, in that it introduced environmental objectives as equally important as production (Nylund, 2010). Moreover, a national strategy to support wood constructions in multi-storey buildings and public buildings was presented in 2004, which has made the market share of wood building has dramatically grown in recent years (Ekdahl, 2011).

The Boreal zone of Sweden and its sub-zones account for the major area in the country, which is dominated by coniferous forests (Barklund, 2009). Norway spruce accounts for the greatest proportion (44%) of standing volume, Scots pine makes up 38% and birch 12%. The rest part is some other deciduous species (Barklund, 2009). The land use in Sweden can be seen from the pie chart, forest land accounts for the greatest proportion of total land area.

In regard to ownership, individual private owners are the largest ownership category, owning 52% of the productive forest area in Sweden. Large industrial forest enterprises and state-owned companies own 25% and 14% of forestland respectively (Nylund, 2010). There are some famous leading forest corporations, such as Stora Enso, Svenska Cellulosa Aktiebolaget (SCA), Holmen, Södra, Billerud and Sveaskog. The rest of forestland ownership is divided between the other public sector and state (NFI, 2012a).

3.2 Environmental aspects

Advantages of environmental aspects

Looking at the advantages that the Swedish forestry offers, we find that forests and forest products are already helping to absorb and store more carbon dioxide than the entire fossil CO₂ emitted in Sweden (Skogsindustrierna, 2008). Specifically, forests in Sweden can absorb approximately 110 million tons of carbon dioxide each year, which is classified in this way:
In Sweden, around 100 million m$^3$ sk forests grow each year, while the annual felling is around 80 million m$^3$ sk in recent years (NFI, 2012b). This indicates that the forest growth exceeds what is felled, and the potential for harvesting is positive. In fact, mandatory reforestation is required after final felling. At least two trees are planted for every harvested tree in Sweden (Barklund, 2009). According to Swedish Forest Industries Federation’s assessment, the harvesting volume can be increased even further (Skogsindustrierna, 2005).

On the other hand, Sweden’s standing volume of forest has a stable growth since 1920s when the National Forest Inventory began to collect data (NFI, 2012b). Around 1920s, the standing volume was 1718 million m$^3$ sk. The volume has grown to 3100 million m$^3$ sk in 2010. Swedish forest annual gross increment has risen substantially from 1970s (NFI, 2012b). As a consequence, the productivity in Sweden’s forests keeps at a high level. This trend can be seen from the following graph:

According to Gustavsson and Sathre (2005), wood can be seen as environmental friendly material for construction. In their study, one wood frame building and one concrete frame building were researched. They assumed that the two buildings have a lifespan of 100 years. They compared carbon dioxide emissions by a life-cycle perspective. The result shows that the concrete frame building release 96 tons of carbon dioxide emissions while the wood frame building does not produce emissions, instead it absorbs 150 tons of carbon dioxide (Gustavsson and Sathre, 2005). As a result, the benefits for mitigating climate change are apparent when wood is used for construction and manufacturing process. And carbon dioxide is stored in the wood as long as the wood building exists (Lenz, 2009). Nowadays, use of wood frames in multi-storey buildings accounts for 15% of new buildings in Sweden, and 20%
bridges use wood frames. Increasing public hall buildings tend to use wood as construction material as well (Hemström et al., 2011).

Comparing with many countries Sweden has a high level of collection of recycled paper. Producer’s responsibility for paper recycling was introduced in 1994, and Sweden has since then implemented statutory system of producer obligation (Skogsindustrierna, 2008). The total quantity of paper collected in Sweden was 1.6 million tons in 2007, which is about three fourths of the total paper consumption in the country. In Europe, the paper industry has set an objective of increasing the recycling rate to 66% by 2010, and that target was achieved in 2008. However this rate was exceeded some time ago in Sweden (Skogsindustrierna, 2010). At present, recycled paper is used mainly in the following items in Sweden:

Producers' responsibility for paper recycling in Sweden has resulted in a high level of collection of recycled paper. Paper and wood recycling ensures that forest raw materials are used in a more efficient manner than if no recycling was done. This means energy saving, and a reduction in the amount of waste can be implemented simultaneously.

The Swedish forest industry is the largest renewable energy provider in Sweden (Zhang et al., 2006). There are several types of forest fuels provided for energy production, logging residues, refined wood fuels (such as briquettes and wood powder) and forest by-products (such as wood chips and sawdust) (Lestander, 2011). Biomass residual from forest has been utilized in a large scale in Sweden over the past decade, which contributes around 20% of the total energy consumption (Zhang et al., 2006). The biofuels supply has ascended by 179% from 1970 to 2007, much owing to expansion of municipal district-heating networks using various kinds of biofuels (Lestander, 2011). Oil was the main fuel in 1970, while more than 62% of districting heating fuel is bioenergy nowadays (Ottosson, 2011). Actually, forest industry is not only the largest producer but also the largest user of bioenergy in Sweden (Skogsindustrierna, 2008). The Swedish forest industry accounts for 51% of Swedish industrial energy use. The forest industry use huge amounts of biofuels, which primarily consist of black liquor, branches, trees tops and so on. Those fuels are mainly applied in combined power generation (Lestander, 2011). Owing to the increasing use and demands of forest resources, the competition of raw materials is stiff. However the forest land is limited and it is utilized by multiple ways (Berg, 2002).

The forest sector has consistently increased the energy efficiency by technology progress (Lestander, 2011). Meanwhile, the dependence on electricity has increased in past decades. SCA invested billions of Swedish kronor in 400 wind turbines expected to generate 2.8 TWh of electricity per year (Ottosson, 2011). Almost every pulp and paper mill in Sweden takes part in the program for improving energy
efficiency in energy intensive industries (PFE) (Swedish Energy Agency, 2011). This program was introduced in 2005 and is a voluntary long-term agreement between the Swedish state and energy-intensive industries. In this program, energy-intensive firms are offered a discount on the electricity tax if they fulfill requirements of increased energy efficiency (Ottosson and Peterson, 2007). Besides, most of pulp, paper and sawn timber mills participate in EU system for trading emission rights. Furthermore, there are some new types of wood fuels such as stumps, which are not being explored yet. Thus it is estimated that the unused potential is around 20 TWh in the long term, which can heat 450,000 houses for one year (Skogsindustrierna, 2010).

Although the Swedish forest industry is one of the energy intensive industries, it has been active for energy efficiency improvement (Berg et al., 2009). For companies, production and profit is more important than the environment. They make big efforts in responding to the increased environmental demands. Of course, such endeavor is mainly driven by the pursuit of profit (Sahlin, 2011).

Challenges of environmental aspects

Looking at the challenges that the Swedish forestry faces, we find that the forest industry can be seen as part of the problem as well as the solution to some environmental issues (Ottosson, 2011). On one hand, bioenergy, which can be major products of forestry, plays a crucial role in reducing carbon dioxide emissions (Lindholm, 2006). Hence, in order to mitigate the climate change issue, the need for forest resource in the near future will be growing. The National Board of Forestry is positive towards the use of forest fuels, thus the Swedish policies on bioenergy have stimulated rapid growth in the energy production facilities capable of utilizing forest fuels. This trend has been accelerated during past decades and continues to progress at present (Lestander, 2011).

On the other hand, according to the Swedish Forest Industries Federation’s report “Living Forest”, one of the objectives is “managing the forest so that all species in the Swedish forest landscape can live on” (Skogsindustrierna, 2011b). In that sense, extracting biomass from forest can have negative impact on biodiversity preserving. However, if restrictions are imposed on the exploitation of forestland, the shortage on raw materials will consequently drive up the bioenergy price (Lindholm, 2006). Apparently, this contradiction may never vanish. What can be done is mitigating it.

Another environmental challenge is the fact of increasingly reduced tree species. Sweden’s forestland is dominated by coniferous forests at present. Tree species covering in Sweden during the last 2000 years show a rapid and widespread transformation from rich, mixed deciduous forest types to species-poor, coniferous-dominated forest types (Björse and Bradshaw, 1998). Especially during the last 500 years the dramatic changes have taken place in Swedish forest composition. Norway spruce took the place of deciduous trees gradually. The beech forest which covered major part of southern Sweden is heading for extinction at present (Fries et al., 1996). This phenomenon has become a big threat for the biodiversity of Swedish forests. Such decreasing diversity is the combining results of climatic causes, changing soil factors and human activities (Wright et al., 1993). As the original forests are gradually replaced by monoculture, the newly planted homogenous plantations can never achieve the diversity of the original ones (Sahlin, 2011). Besides, alien tree species are being introduced on around 3% of the productive forest land, replacing the former old growth forests (Larsson et al., 2009). After the intensive cultivation of forest for a century, the landscape is majorly “comprised of managed forests and plantations in various stages of development from clear cuts” (Sahlin, 2011). Even though developing nature-based silviculture has been given much attention in recent years, the lack of detailed historical forestry knowledge is still a problem when mimicking the natural conditions (Larsen, 2012). Various tree species can provide greater diversity of timber products and biological value for the future. Therefore, ecological sustainable development in Sweden should be based on a large range of tree species (Björse and Bradshaw, 1998).

3.3 Economic aspects

Advantages of economic aspects

Looking at the advantages the Swedish forest industry offers, we find that it contributes to jobs creation. For each direct job opportunity in forest industry, two indirect jobs are created in the supply chain, such as transport and chemical industry (Skogsindustrierna, 2008). The leading forest corporations in
Sweden have highly skilled and professional research engineers and scientists. The whole industry is pushed and improved by the leading enterprises, which have affluent capital, and many employment opportunities are created (Barklund, 2009).

In sparsely populated rural areas, mills are necessary for the basic service functions. Aside from the tax revenues, those mills create demands for schools, shops, banks etc. The local service sectors are dependent on the purchasing power, which is generated by local forest industries. Besides, the forestry sector stimulates great potential for infrastructure investment. The forest industry is the largest buyer of transportation and as such the forestry sector’s needs of transport services can be viewed as essential for capital investments in ports and railway terminals (Aruna et al., 1997). But transportation of forest products uses large amounts of energy, and cause CO2 emissions (Berg et al., 2009). For forest enterprises, they try to save the cost and reduce impact of CO2 emission at the same time. In most cases, transportation by train emits less CO2 and has lower cost compared to lorry (Berg et al., 2009).

The Swedish forest industry is strongly export-oriented. Sweden gains very high exports revenues from the forest industry (Skogsindustrierna, 2011). It is the third largest exporter of sawn timber products and the fourth largest exporter of pulp and paper in the world (Skogsindustrierna, 2011). As can be seen from the bar graph, the forest industry’s contribution to the trade balance is very important (Aruna et al., 1997).

![Figure 6. Exports and imports of the Swedish forest industry products in 2011 (units: billion SEK)](SCB, 2012)

Of the sawn timber production, around 70 percent is exported. For the paper and pulp production, the corresponding figure is 85 percent approximately. Within the EU, the Swedish forest industry is a large supplier of wood and paper products. Nearly 20 percent of EU countries’ sawn timber consumption are manufactured in Sweden (Skogsindustrierna, 2011a). On a global level, Sweden is one of the biggest suppliers of forestry products, as can be seen in table 3.

<table>
<thead>
<tr>
<th></th>
<th>PAPER (1000 Tons)</th>
<th>PULP (1000 Tons)</th>
<th>SAWN PRODUCTS (1000m³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>EU</td>
<td>6910</td>
<td>2380</td>
<td>7510</td>
</tr>
<tr>
<td>REST OF EUROPE</td>
<td>830</td>
<td>230</td>
<td>870</td>
</tr>
<tr>
<td>NORTH AMERICA</td>
<td>100</td>
<td>30</td>
<td>160</td>
</tr>
<tr>
<td>LATIN AMERICA</td>
<td>120</td>
<td>20</td>
<td>10</td>
</tr>
</tbody>
</table>

Table 3. Sweden’s exports to various regions in 2009 (Skogsindustrierna, 2010).
<p>| | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>AFRICA</td>
<td>300</td>
<td>20</td>
<td>2450</td>
</tr>
<tr>
<td>MIDDLE EAST</td>
<td>400</td>
<td>80</td>
<td>450</td>
</tr>
<tr>
<td>REST OF ASIA</td>
<td>940</td>
<td>640</td>
<td>890</td>
</tr>
<tr>
<td>OCEANIA</td>
<td>80</td>
<td>0</td>
<td>10</td>
</tr>
<tr>
<td>TOTAL</td>
<td>9680</td>
<td>3400</td>
<td>12350</td>
</tr>
</tbody>
</table>

The Swedish forest industry is technology and knowledge intensive from the raw material to the final products, and has a leading role in technology development. In terms of the technology and forestry, the European forest industry is leading in the world, with Sweden in the top (Barklund, 2009). Corporate investment accounts for 27% of the forest industry research and development (R&D) input in Sweden, which is 4% higher than the average figure in Europe (Skogsstyrelsen, 2012). One target of the Swedish forest industry in the long term is that the R&D investments should double by 2030 (Skogsindustrierna, 2010). Besides, the forest industry has a close cooperation with universities, institutes of technology and research. Cooperation and investments can be conducive to developing employees’ competence at the same time that they can provide job opportunities for well educated graduates.

Innovative and high technology play a crucial role in harvesting system and timber processing (Berg, 2002). Firstly, GPS and GIS are widely applied in measuring and fixing position of trees, these technologies help workers to decide which tree should be harvest and which one should be left behind (Swedish wood, 2011b). And there is a harvest data system, which is used to measure and calculate diameter, length and taper of each trunk. The system can also divides trees into optimum number of logs before cutting (Berg, 2002).

Secondly, in terms of timber standardization, X-ray and 3d technologies greatly benefit Swedish forest industry. Logs are X-rayed in the lab to measure durability, type, density and proportion of heartwood. Multi-sensor technology can generate complete 3d images of timber’s interior (Skogsindustrierna, 2010b). Hence, this enables sawmills to have better quality guarantee, and the timber fits for the purpose according to customer demands. Concerning the timber processing, it is automated and computerized fully from debarking of logs to drying of sawn timber in most cases (Berg, 2012). Last but not least, Swedish paper mills mostly adopt automated production line. Only three or four workers are required for each production line, which produce 60-120 tons paper each day in most paper mills (Li, 2010).

**Challenges of economic aspects**

As Ottosson (2011) suggests, “forest industries, enterprises and resources arguably do not exist in isolation”. These entities interrelate with various actors. Håkansson and Snehota (1989) stated that business strategies and utilization of company resources are the products of networks of many actors external to the company, such as customers, suppliers and authorities. In past decades, the Swedish forest industry is experiencing the shift from industrial modernity to ecological modernization (Ottosson, 2011). For the Swedish forest industry, how it should respond to the demands of moving towards “greener” is a huge challenge.

In recent years, field research carried out by Swedish NGOs demonstrates that amounts of loggings implemented by Forest Stewardship Council (FSC)-certified enterprises do not fulfill environmental criteria of the FSC-standard (Lööf and Sahlin, 2009). Thus, some researchers consider that FSC certification as a market tool fail to safeguard forest values (Sahlin, 2011). To be specific, although FSC-certified companies declare that they will not fell trees in forests with Woodland Key Habitat (WKH), Swedish Society for Nature Conservation (SSNC) has revealed that some forests with WHK structures and qualities being slated for logging as well as being felled (Sahlin, 2011). Actually, WKH is extremely significant for the flora and fauna. Majority of the Woodland Key Habitats contain red-listed species, which are facing extinction risk (Gustafsson et al., 1999). Furthermore, FSC-standard
states that natural forests with high nature values must not be felled (FSC, 2010). Yet, the FSC-certified companies which violated FSC-standard have not been sanctioned. That way, some forest companies can earn extra profit by violating regulations that are commonly accepted among parties of the Swedish forestry industry (Sahlin, 2011).

However, except the FSC-standard, forest enterprises in Sweden face some other environmental regulations. For instance, some specifications are from the Law of Planning and Building, some provisions are established by the local authorities (Nylund, 2010). But in some cases, the environmental regulations might slow down industrial expansion. It sometimes takes several years to obtain all permissions needed when the enterprise apply to build a larger paper mill (Wibe and Carlén, 2002). This long handling time is an obstacle to these enterprises’ investment. Taking SCA as an example, which is one of the leading forest enterprises in Sweden. It failed to get the permission for increasing production by 5% (Wibe and Carlén, 2002). A large amount of details is needed to meet the requirements of environmental impact assessment for investment or industrial expansion (Wibe and Carlén, 2002).

Therefore, regarding the effects on market operating and biodiversity of Swedish forest, how these regulations are formulated and carry out on these forest enterprises can be a huge challenge for the Swedish forest industry.

3.4 Social aspects

Advantages of social aspects

The social aspect of sustainable development is getting more and more public attention. Well-being of both the common public and employees of forest industry are the essential subjects of the social dimension of forestry sustainable development (Barklund, 2009). On one hand, there shall be equal right for everyone to have the access to the forest resource. On the other hand, for forest industry employees, safe working environment and opportunity to individual development are the indispensable part of the forestry sustainable development (Skogsindustrierna, 2005).

More than half of all forest land in Sweden is privately owned, and contains common goods such as cultural heritage, biodiversity and recreational function (Stenseke, 2008). Everyone in Sweden has the public access to private land which is not cultivated or a garden (Stenseke, 2008). Besides, according to legislation, “one must not cause damage to a forest owner’s property or to objects or sites of natural, historical or heritage value” (Barklund, 2009). The main leisure activities in forest among the Swedish public are picking mushrooms and berries, bicycle trips and walks (Hörnsten, 2000). By visiting forests, people can obtain not only knowledge about trees and wild animals, but also some practical experiences. According to Thellbro and Lidentav (2008), the dependency on local natural resources is higher than statistics available in official employment data. Forest resources are crucial for local municipality development. Especially, the demands for recreational function and culture value grow increasingly in recent years. For instance, a shorter distance between residential districts and forest is desired increasingly by the Swedish people (Hörnsten, 2000). Hence, the planning on forests in urban and rural areas is facing higher requirement and greater challenges.

One motto of the Swedish forest industry is “health, efficiency and profitability all depend on each other” (Skogsindustrierna, 2005). Safe work environment and competent personnel are essential for social sustainable development in forest industry (Thellbro and Lidentav, 2008). Firstly, the Swedish forestry industry has been in the efforts for improving work environment, safety and health (Skogsindustrierna, 2008). In Swedish paper and pulp industry and sawmills, the most common injuries in work related accidents are the result of falls, trapping and cuts (Skogsindustrierna, 2010). Although statistics on accidents and occupational diseases shows a steadily decline trend, the industry is continually implementing more active measures to prevent few fatal accidents and improve health condition for employees, especially female employees (Barklund, 2009). To be specific, there are reporting systems established for companies which need to obtain injury statistics. By following up the information, the companies with similar workplace can prevent injuries (Skogsindustrierna, 2010). And in recent years, installing barriers and switch locks are required increasingly in forestry operation machines to advance safety levels (Skogsindustrierna, 2010). Secondly, competence development and equality of opportunity are becoming increasingly important in the Swedish forest industry. The
The educational level of employees in the forest industry is rising over the past decades (Skogsindestrierna, 2008). Moreover, equality in the forest sector refers to many aspects, such as gender, equal opportunity on promotion, equal salary for work of same value. According to the official statistics, increasing numbers of women are appointed to be managers in forest companies, around 25 percent of appointed managers were women in 2008 (Skogsstyrelsen, 2012).

Last but not least, there are different types of owners and diverse utilization in the forest sector. Sweden has a long tradition of creating opportunities for different interests participating (NBF, 2002). Different kinds of forest-related organizations play a positive role in respecting minimizing conflicts and promoting rational use of forest resources (Ezebilo, 2012). These organizations cooperate with other regional agencies and bodies, and engage in dialogues with voluntary organizations, municipalities and other stakeholders. In this way, the forestry monitoring and management can be implemented in a more fair and open environment (Ezebilo, 2012).

To be specific, the Swedish Forest Industries Federation (SFIF) is the employers’ organization for paper, pulp and wood mechanical industries (Skogsindestrierna, 2012). It represents about fifty paper and pulp enterprises and 140 wood processing enterprises (Skogsindestrierna, 2011). Its role is to promote efficient use of wood-based products and advance the competitiveness of its member companies. It also makes big efforts on promoting the forest industry to provide safe workplaces and develop their employees’ skills (Skogsindestrierna, 2012).

On the state level, there is the national authority Swedish Forest Agency (SFA), main function of SFA is to see that forest policy to be attained (Skogsstyrelsen, 2012). SFA play a vital role in ensuring observance of relevant regulations and providing information and training on forestry (Barklund, 2009). Based on high level of knowledge and many years of experience in silviculture, helping forest owners plan forest operations is one of the most important tasks for SFA (Skogsstyrelsen, 2012).

Among the organizations representing individual forest owners we find the Federation of Swedish Farmers (Lantbrukarnas Riksförbund - LRF). LRF is the largest interest and business organization for the farmers and foresters in Sweden (LRF, 2012a). The mission of LRF is “enabling individual members to realize their goals in terms of profitability, growth and quality of life” (LRF, 2012b). LRF has 170 000 individual members, and they represent 90 000 enterprises. LRF is not affiliated to any political party, and it is financed by membership fees and income from subsidiaries. Besides, LRF also focus on creating positive public opinion for agriculture and forestry sectors (LRF, 2012a).

**Challenges of social aspects**

Looking at the challenges in social aspects, reindeer husbandry can be one of the concerns. Boreal forests cover the majority of land area in Sweden, and boreal forests are vital habitat to the reindeer (NFI, 2012a). Reindeers are widespread in boreal coniferous belt of northern Sweden. In northern Sweden, the Sami herd reindeers by the ancient rights. Forest resources use rights have been a source of ongoing conflict between indigenous Sami people and forest owners (Baer, 1996). Currently, there are no wild reindeer in Sweden, which means all reindeer are semi-domesticated and thus owned by someone (Löf and Carriere, 2010). There are approximately 250 000 reindeers and 4 500 reindeer herdsmen in Sweden (Barklund, 2009). Reindeer herding is of particular importance for the Sami. There are 51 Sami ‘villages’ (geographical and economic associations) in Sweden. Reindeer herding is carried out at about in 52 percent of the country’s land area. Reindeer herding is dependent on large grazing areas because the reindeer move for seasonal changes (Sametinget, 2012). Sami have the right to use lands which belong to others for the sake of feeding and protect their reindeers. For the forest owners, they are obliged to accept reindeers on their properties, even if the reindeers can cause damage to the forest regeneration sometimes (Barklund, 2009). When the reindeers dig in the snow to find lichens they may break branches and shoots. According to legal provisions, “forest owners are not allowed to change the land use in a way that makes reindeer breeding impossible” (Baer, 1996). It is manifest that the land use regimes and overlapping property led to the conflicts between land users.

In order to resolving conflicts as much as possible, a wide range of measures have been taken. The consultation and dialogue are important measures for reducing conflicts. This kind of consultations usually takes place before regeneration felling and other forest operations are started. In terms of technology, some innovative tool such as GIS is applied (Skogsstyrelsen, 2012b). Conflicts could, in
the best of the cases, be reduced with better information of certain regions’ husbandry situation and forestation.

3.5 SWOT-analysis on the Swedish forest industry

Environmental, economic and social aspects of the forest industry in Sweden have been analyzed in the above section. By pulling some key points, a SWOT analysis can be performed here. Limitation of the studies must be considered as the analysis is merely based on the focused aspects. With the limitations of this kind of studies, the SWOT analysis below shows the main strengths and weaknesses in the Swedish forest industry and tries to identify the opportunities for and potential threats posed to the Swedish forest industry.

Table 4. SWOT analysis for Swedish forest industry

<table>
<thead>
<tr>
<th>Internal</th>
<th>Strengths</th>
<th>Weaknesses</th>
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<tbody>
<tr>
<td>- Per capita forest resource is much higher than the world average level</td>
<td>- Increasingly reduced tree species</td>
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<td>- Innovative and high-tech products</td>
<td>- Conflicts between different forestland use</td>
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<tr>
<td>- Forests provide a good deal of renewable energy</td>
<td>- Forest certification standards and regulations have some flaws</td>
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<tr>
<td>- Productive process is energy efficiency</td>
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<tr>
<td>- Widespread application of wood construction</td>
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<tr>
<td>- Forestry monitoring and management are implemented in a fair and open environment</td>
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<tr>
<th>External</th>
<th>Opportunities</th>
<th>Threats</th>
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<td>- Strongly export oriented</td>
<td>- Increasing demands of forest resources</td>
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<tr>
<td>- Sufficient funds for R&amp;D field</td>
<td>- Increasing price of renewable energy</td>
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<tr>
<td>- Active forestry science and technology exchanges</td>
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<tr>
<td>- Highly skilled and professional research engineers and scientists</td>
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4. Sustainable development and China’s forest industry

4.1 Short overview of China’s forestry development

China is one of the world’s major centers of biodiversity, and the variety of different forest types is remarkable (Harkness, 1998). Owing to the “Open Door” policy from 1978, China experienced a dramatic growth in economic development. “Open Door” policy becomes a significant turning point for China’s forestry, since then Chinese government has strengthened forestry development and related legislation. The government plays a major role in Chinese forestry development and government encouraged foreign investment in China (USCB, 2006). The State Forestry Administration of China is the central authority agency, which is in charge of areas of policy making, plantation establishment, conservation and wood industry management. Chinese Academy of Forestry is affiliated to it (UNECE and FAO, 2009).

Currently, China is the largest importer of logs around the world (USCB, 2006). The demand of logs for construction, pulp and paper exceeds domestic log supply, and the driver of this trend is China’s flourishing economy (Turnbull, 2007). The worsening imbalance between supply and demand of wood products has become a huge challenge for China’s future development. Moreover, due to the deterioration of ecological environment in China over the past decades, the government has implemented several ecological projects. These projects are making progress for green growth and sustainable development in recent years (Wang, 2009). Even though China has achieved some progress in forest sector over the past decades, it must be admitted that the forestry development still cannot meet entire economic and social needs on sustainable development (FAO, 2009a).

4.2 Environmental aspects

Advantages of environmental aspects

Forest in China covers 195 million hectares approximately by 2011, increasing by 62 million hectares from 1992 (SFA.PRC, 2012). The forest coverage of the total land area reaches at 20.4%, which is a 6.4% net growth in the period 1992-2011 (SFA.PRC, 2012). Besides, China is aiming at increasing the forest coverage to over 26% by 2050 (SFA.PRC, 2009). The diverse terrain in China breeds the most biologically diverse temperate forests on earth and sheltered them during ice ages for millions of years (WWF, 2012). There are more than 2800 tree species (Harkness, 1998). The forests are classified by climate zones from north to south of China: coniferous trees, mixed forest of deciduous and broad-leaved trees, deciduous broad-leaved forest, deciduous forest and rain forest (USCB, 2006). Furthermore, China’s non-wood forest products (NWFP) resources, such as bamboo, economic plantation products and flowers, are abundant and widely distributed (FAO, 2009a).

The authority starts to take the integrity of ecosystem as one of the top priorities by establishing forestry ecosystem framework. Since 2000, Chinese government has carried out a significant forestry reform which consists of six key forestry programs (SKFP) (Wang, 2006). Five of them are related to ecological sustainable development. The implementation of SKFP was the most significant action that China’s government has taken over the last ten years on forestry (Wang, 2009). According to Wang et al., (2007) and Wang (2006), the six programs can be briefly described as:

- Natural Forest Protection Program: rehabilitate and develop natural forests.
- Fragile Farmland Conversion Program: recover cultivated slope land and fragile grain land and turn them into forests or grassland.
- Forest Shelterbelt Program: rehabilitation of degraded and decertified land.
- Desertification Control Program (For Areas in the Vicinity of Beijing and Tianjin): reduce the hazard of sandstorms in areas surrounding Beijing.
- Wildlife Conservation and Natural Reserves Development Program: increase conservation of endangered species.
Fast-growing and High-yielding Timber Plantations Program: ease the shortage of timber supply and reduce the pressure of timber demands on forest resources.

Over the past decade, the implementation of the SKFP had some achievement and played a significant role in improving the ecological situation in China, facilitating rural development and increasing farmers’ income (Wang, 2009).

Challenges of environmental aspects

Now looking at the challenges China’s forestry faces, we find that even though the total quantities of forest resources are great, the per capita resources in forests are quite limited in China. The forest coverage of China is only 2/3 of the world average level, ranking 139th in the world (UNECE and FAO, 2009). Furthermore, per capita forest area is less than 1/4 of the world average level. Per capita forest stock volume is 10.15 cubic meters, and it is only the 1/7 of global average level (Wu, 2009).

China’s forestry is experiencing some arduous task, and the most urgent problem is the deterioration of the ecological environment. Specifically, the first thing is serious soil erosion; secondly, sandy desertification lands have expanded increasingly; last but not least, floods, droughts and other natural disasters are frequent (FAO, 2009). With these issues highlighted, the challenges may only be met by the essential ecological functions provided by forests (Bull and Nilsson 2004).

4.3 Economic aspects

Advantages of economic aspects

Among the advantages of forest industry in China, we find that Chinese government has given high priority to promote pulp and paper industry’s modernization in recent years. In order to improve the production efficiency, Chinese government encourages technology transfer and developing joint ventures (Wang, 2009). For instance, China’s State Forestry Administration and the Federation of Swedish Farmers (LRF) have some exchange visits over the past decade. According to their cooperation MOU (Memorandum of Understanding), Sweden offered technological guidance and introduce innovative products to China’s forest industry (Turnbull, 2007). With these technological guidance and imported production lines, the quality of wood products have been improved in some sawmills (Huang and Xiao, 2011). Plywood, particleboard and medium density fiberboard (MDF) are the main wood products in China nowadays (USCB, 2006). With the upgrade of production capacity in MDF, China has become the largest MDF producer in the world (Turnbull, 2007).

In terms of forest products trade, China is one of the largest players in the world. It imports most of raw materials from countries in Europe and North America and exports the final products back to them (UNECE and FAO, 2009). International demand for China’s low-cost finished forest products is increasing (WWF, 2012). Furniture is the main export products, and China has become the largest furniture producer and exporter in the world. The amount of furniture exports value was $7.7 billion in 2008 (Huang and Xiao, 2011).

There is another economic incentive for China’s forest industry, which cannot be found in most other countries (Liu, 2007). It is called “Lin Xia” economy which can be translated as “under-forest economy”. Under-forest economy is based on the ecosystem of the forest land. It fully utilizes the forest resources under the tree canopy by combining forestry, agriculture and livestock herding together (Liu, 2007). Traditional Chinese crops, such as red date, Chinese chestnut, edible tree fungus, ferns and traditional Chinese herbs are planted below the tree canopy. They are important source of food and livelihood for hundreds of millions Chinese people (Liu, 2011). These crops are harvested and consumed mostly in East Asian region, and there is huge domestic demand in China’s food market. This kind of Chinese economic pattern in forests can complete the woodland ecosystem material cycling and energy flow. Thus, not only the natural resources can be fully utilized, but also economic benefits can be brought to local people (Gu, 2008).

Challenges of economic aspects
Owing to rapid growth of forest products demand and bans on felling in some natural forests with high values, wood supply shortage in China has become increasingly acute (Turnbull, 2007). The huge demand is largely a result of improvement of people’s living standard, and the increasing demands for housing, furniture and paper. It is estimated that the gap between timber supply and demand will arrive at 150-170 million m³ approximately by 2020 in China (FAO, 2009a). Meanwhile, China’s unbridled economic growth causes much criticism. McCarthy (2005) stated “China is already the biggest driver of rainforest destruction. Half of all rainforest logs head for China”.

Furthermore, most of paper mills and sawmills in China are small-scale, and their equipments are outdated. They also have problems with effluent disposal facilities and chemical recovery systems, so the production potential was not fully utilized (Turnbull, 2007). Even though the government has helped them with updating equipments these years, China’s forest industry still develop extensively in general. The forestry products are mostly low-end, and the processing equipments for sophisticated productions in China are mostly imported (Huang and Xiao, 2011). In terms of the utilization of raw materials, China's forest utilization rate is only 25% of the whole tree, while the corresponding figure in most of developed countries is up to 80% (Li, 2009).

4.4 Social aspects

Advantages of social aspects

The undergoing forest ownership reform is revitalizing the China’s forest industry (Turnbull, 2007). Poverty in rural areas is the biggest driving force for the reform. The introduction of land leasing rights and transferability of leases bring market mechanism into the forest industry (Wang et al., 2007). The government gives 70 years land use right to peasants, and gives individual more management freedom. The reform is guided by the principle of “who cultivates who owns, with equal rights to clarify the peasants’ property rights” (Wang, 2009). Moreover, through reducing forest taxation and encouraging rather than controlling commercial forest products trade, the enthusiasm of peasants are greatly stimulated. It is recognized as the second most important action on China’s forestry. Introduction of comparatively freer market and competition has stimulated the booming of forest industry in China (Wang, 2009).

Some remote forest areas, where national minority groups inhabit for generations, are not carrying out the ownership reform. The inhabitants still maintain traditional way to carry out the forestry activities (FAO, 2009a). There are 55 minority groups in China, many of which have a long history living in the forests. Those people have little chance to get market information, and lack of participation on forestry legislation. However, the traditional knowledge and its practice have sustained the forest and agricultural resources of indigenous communities in China for hundreds of years (Liu et al., 2012). These minority groups have developed rich forest-related knowledge systems through their lifestyles. The knowledge systems tightly linked with traditional religious beliefs, folklore, burial practices, and land-use practices. According to Liu et al. (2012), traditional forest knowledge is significant for the protection of various forest types, and the knowledge has demonstrated a certain amount of resilience and vitality in dealing with the changing social, environmental and economic conditions.

Challenges of social aspects

Among the challenges of China’s forest industry, I find that there are some problems in the process of forestry property transfer. Some speculators who are not peasants purchase forestland on low price, and sell the forestland on quite high price. Some of those speculators are staff in government and forest authorities (He and Zhu, 2006). They can obtain high profits by violating the peasants’ right. Moreover, after the forest tenure reform, some individual forest owners take economic interest as their primary concern. They convert the original structure of forest tree species. As a result, the forests ecological balance is damaged due to owners’ shortsighted pursuit of short-term economic profit (He and Zhu, 2006). And the quality and long-term natural value of forests are jeopardized.

Furthermore, most of forestry institutes are organized and managed by the central or local government (Wang, 2006). The lack of transparency on relevant policies and participation of other stakeholders can be a serious problem in the long run (Wang, 2006). Another shortcoming caused by the highly centralized forest authority is the inevitable gap between the central and local government. For instance,
the central government has been supplying much funding for tree planting, yet there is still lack of effective implementation on the provincial and local level (Wang et al., 2007).

Another challenge is the difficult situation of the vast grass-root class workers in China’s forest sector. Employees in forest industry generally have low level of education and few chances to learn advanced skills, which hamper their opportunities to improve their social and economic status (Huang and Xiao, 2011). For the farmers who cultivate on their own forestland, technical guidance and medical security system are inadequate (Wang et al., 2007).

4.5 SWOT-analysis on the China’s forest industry

Environmental, economic and social aspects of the forest industry in China have been analyzed in the above sections. To make the points mentioned more straightforward, SWOT analysis of China’s forest industry can be summarized as followed:

Table 5. SWOT analysis for China’s forestry.

<table>
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<tr>
<th>Internal</th>
<th>Strengths</th>
<th>Weaknesses</th>
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<tr>
<td></td>
<td>- Great variety of forest types and biodiversity</td>
<td>- Per capita forest resource is well below the world average level</td>
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<tr>
<td></td>
<td>- Growth of production capacity in forest enterprises</td>
<td>- Deterioration of ecological environment</td>
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<tr>
<td></td>
<td>- “Lin Xia” economy</td>
<td>- Advanced technology is not widely applied in forest sector</td>
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<tr>
<td></td>
<td>- Valuable traditional forest-related knowledge in ethnic minority areas</td>
<td>- Employees in a lower level of education</td>
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<td>- Poor supervision of forest industry</td>
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<td></td>
<td></td>
<td>- Poor quality of forest products</td>
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<tr>
<td>External</td>
<td>Opportunities</td>
<td>Threats</td>
</tr>
<tr>
<td></td>
<td>- Huge demand for forest products</td>
<td>- Forest products supply shortfalls are acute</td>
</tr>
<tr>
<td></td>
<td>- The largest furniture producer in the world</td>
<td>- Lack of participation of all stakeholders</td>
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<td></td>
<td>- Potential of wood residues’ reuse is not fully explored</td>
<td>- Extensive operations</td>
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<td></td>
<td>- Great potential of non-wood forest products</td>
<td>- Stiff international competition in wood market</td>
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<td></td>
<td>- Increasing investment and technology guidance</td>
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5. Discussion

Based on the limited SWOT analysis performed in this study, China may draw some lessons from the Swedish forest industry in the fields of environmental conservation, technology innovation, forestry policy making and so on.

In regard to the use of wood in constructions, China and Sweden have quite different development patterns. More and more skyscrapers are built in cities, a great quantity of concrete and other non-environmental friendly materials are used in buildings. The total demand of cement for construction in Beijing alone is 28 million tons in 2007 (NBSC, 2008). Quite on the contrary, wood construction is becoming increasingly popular in Sweden. Increasing wood construction in Sweden has been effective to mitigate greenhouse effect (Ekdahl, 2011).

There is a similar material to the wood in China that could be used in construction. Bamboo is one of the most important forest types in China, and it is an ecological material (Chen et al., 2009). Actually, in many places of China, bamboo could be applied in construction. China has vast rural areas, and the practice of bamboo construction may be more feasible especially in these places. China has abundant resources of bamboo in forests, so bamboo is an ideal substitute for timber in China. For many places in south of China, transportation cost can be reduced by using local bamboo. Meanwhile, carbon footprint can be decrease. In addition, a remarkable feature of bamboo is the high tensile strength. Since the application of bamboo material is still limited in decoration, there is much potential in further utilization of bamboo in China.

The low utilization rate of wood aggravates the shortfall between the timber supply and demand in China. The low utilization rate of forest resources led to a huge waste of raw materials. And most of waste wood cannot be used for energy resource. The negative aspects may interact with each other and further worsen the situation of China's forest resource. In order to utilize the material more efficiently, China’s forest industry needs to upgrade its outdated equipment by introducing foreign investment and cooperation. According to the experience in Sweden, China can fully utilize the bark, branches and tree tops. Thus the shortage of wood supply may be relieved. Besides, some employment opportunities can be offered by the diversified forms of wood processing. According to examples in Sweden, if plenty of untreated wood products and waste wood residues could be used as energy for district heating, then more energy can be provided for rural areas in China.

Furthermore, improving recycling and recovery may ease the shortage of wood supply in China. The reality of recycling in China is pessimistic. Many local government policies fail to establish effective recycling system. Statistics shows that the recovery rate of waste paper in China is 25% approximately (Li, 2009). At present, the most cost effective way of improving recovery rate is to begin from the household. But there are many difficulties in implementation. Many Chinese lack the public awareness to practice recycling, even though the recycling theme has been gradually propagated in mass media and education. Therefore, for China, the most critical thing for recycling is to improve the public awareness along with the solid waste sorting rate. There is no denying that China needs to start from the most junior. Besides, government should set explicit goals and provisions on recycling.

In order to enhance public participation and reduce conflicts among diverse forest utilization, China needs independent unions and organizations established by nongovernmental power. For producers, there is no federation like Swedish Forest Industries Federation in China. In Sweden, its role is “to foster the competitiveness of its members and promote greater use of wood-based products” (Skogsindustrierna, 2012). For other stakeholders, there is no organization like LRF (The Federation of Swedish Farmers) which can represent individual forest owners and farmers’ interests (LRF, 2012). Moreover, according to Sweden’s experience in Swedish Forest Agency, Chinese State Forestry Administration should take similar measures to raise the level of knowledge and technology for the entire forest industry stakeholders. Various forms can be implemented, such as holding training courses, providing technology consulting services and handing out brochures.
Last but not least, corporate investment accounts for 3% of the forest industry research and development (R&D) input in China, while the corresponding percentage in Sweden is 27% (FAO, 2009a). Chinese forestry companies may also increase R&D investment by cooperating with universities and research institutes. For the government, a great deal of fund shall be invested for R&D projects in forest sector. It is imperative to set explicit goal like Sweden does in order to boost R&D field for China. For China’s State Forest Administration, their cooperation with the Chinese Academy of Forestry and forestry universities in different provinces is quite important for encouraging technology advancement. In regard to international cooperation, China sends a large number of students abroad every year, around 284000 Chinese students went abroad for higher education in 2010 alone (Chen, 2011). But only small amount of students study in the forestry related major. For instance, Beijing Forestry University sends exchange students to study in Swedish University of Agricultural Sciences and Uppsala University in recent years, but the number of students is quite small (BJFU, 2012). The government and universities should encourage this kind of collaboration, and increase the scope of cooperation with foreign institutions.
6. Conclusion

As one of the leading countries in forest industry, Sweden’s experience in sustainable management on forestry is quite impressive. The study shows that a delicate balance between production and environmental objective is kept in the Swedish forest industry. The standing volume of forest has increased steadily in past decades. Forest raw materials are used in an efficient way by recycling of paper and wood. The forest harvesting and production of forest products are implemented by systematic guidance. The government and forest corporations invest heavily on R&D field. And forest management is carried out in comparatively open and fair environment. However, the Swedish forest industry still faces some challenges on extraction and handling with forest resources. The demand for bioenergy in forests has grown, and the increasingly reduced tree species has threatened Swedish forest biodiversity. The environmental regulations and standards on forest enterprises have some flaws. The forestland use conflicts caused by reindeer herding is also a challenge for forestry development.

The study on China’s forest industry shows that even though the Chinese government has put increasing emphasis on ecological preservation in the past decades, the ecological situation is still fragile. On the basis of China’s national condition, the economic interests largely outweigh environmental concern at present stage. In recent years, due to the growth of production capacity, China has become the largest furniture producer. But the technology level is still low in most forest enterprises, so production potential is not fully utilized. Consequently, it leads to waste of raw materials and aggravation of the shortfall between timber supply and demand. The ongoing forest land ownership reform brings opportunities for peasants’ income increment. Meanwhile, there are some problems on supervision in the process. If there can be more public participation from the civil society and all types of non-governmental power, like Sweden does, new vitality can be brought to China’s forestry development in the near future. With the economic globalization’s deepening, China’s forest industry may explore its capability by optimize the industrial structure.

On each aspect of forest industry development quality, there is huge gap between China and Sweden. Sweden has accumulated some experience on the sustainable forestry management while China is just at its initial stage. After limited comparison between these two countries, we conclude that there are still great potential in China’s forest industry if China diverge from its development path and draw some lessons from countries like Sweden.
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8. References


Gu, X., 2008. studies in the mode of under-forest economy and the development countermeasure of under-forest industry, 上海农业学报 20 08 , 2 4 (3 ) : 2 1 - 24 Acta Agriculturae Shanghai


Joint Liaison Group (Joint Liaison Group of the Rio Conventions), 2010. Forests Climate Change, Biodiversity and Land Degradation. UNCCD and UNFCCC.


Lenz, S., 2009. Shaking it up - a test to improve mind-rise, wood framed building design.


Li, X., 2009. 从对比中看中国的废纸回收利用,北京大学化学与分子工程学院.


LRF, 2012 a. We make the country grow. The Federation of Swedish Farmers / Lantbrukarnas Riksförbund.


SCB (Statistics Sweden), 2012. Statistics by subject area/Agriculture, forestry and fishery.

Sen, A.K., 2000. The ends and means of sustainability, keynote address at the International Conference on Transition to sustainability, Tokyo.


Skogsindustrierna, 2008. The forest industry – A natural part of Sweden.


Skogsindustrierna, 2011b. Living forests.


UNECE (United Nations Economic Commission for Europe) and FAO (Food and Agriculture Organization of the United Nations), 2009. The Importance of China’s Forest Products Markets to the UNECE Region. Geneva Timber and Forest Discussion Paper 57.


