21 Sustainability of Wood Supply: Risk Analysis for a Pulp Mill in Guangxi, China

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Abstract: Finnish-based forest corporation, Stora Enso, is developing and purchasing eucalypt plantations, and establishing a large pulp mill with an approximate production capacity of 1 million tonnes of pulp per year in southern China. The project has been evaluated by recognised international assessment, which concluded that it would be profitable and environmentally and socially sustainable. Wood supply from existing and new plantations was assessed to be sufficient to meet the need of the pulp mill. The conclusions on wood supply were based on very simple estimates and risky assumptions on mean annual increment (MAI) and areas of plantation estate available without fully taking into account many high-risk factors, or at least data are not available in the public domain. This paper discusses several elements that have an effect on sustainability of wood supply, including factors and risks affecting wood production and land availability. The results demonstrate a close relationship between wood production of the plantation itself, and the total area needed to produce a certain amount of wood. At the scale of the case study involved, every 10% change in MAI is equivalent to about 5000 to 40 000 ha of land, depending on growth rates. We show that many new fast-growing eucalypt plantations, in addition to existing ones, are needed for long-term sustainability of wood supply. Moreover, substantial investments in strategic and applied research would be required to achieve high and sustainable production per unit area in the given environment. This means that more actions will be required in the establishment and management of new plantations. The results from the wood supply scenario also reveal the growing importance of corporate responsibility (CR) in the corporate governance agenda of the forest sector. In order to achieve the desired economic, environmental, and social outcomes, national macro-economic planning, a consistent policy and management framework, and a systematic, focused and institutionalised approach to CR are therefore expected from the government and the private sector, respectively.

Keywords: corporate responsibility, environmental impact, eucalypt, growth rate, land availability, plantation forestry, pulp and paper industry, sustainable development, wood supply scenario

21.1 Introduction

The significance of planted forests is likely to increase in coming decades (Carle and Holmgren 2008). The greatest change in planted forest area to date has been during the period 2000–2005, with the highest rate being in Asia (2.8%/year), which has nearly half (49%) of the world's planted forests (Del Lungo et al. 2006). According to the latest study, the highest absolute increase of planted forests area in the future will also be in Asia – from 0.9 million ha to 1.9 million ha per year, depending on the scenario, which equals to some 55% increase globally (Carle and Holmgren 2008). Most of the area increase will occur in forests planted for production purposes. South America and Asia will have the most dynamic future, in this regard, compared with other regions. The wood production increase will mainly be in various species of *Eucalyptus*, as well as other hardwood species. It seems evident that industrial plantations in the South will play increasingly important roles in future global wood production (Mather 2000). The greatest pulp capacity growth occurred in Asia and Latin America during the years 1996–2003 (Spek 2006), and this trend seems likely to continue.

Globally, pulp and paper industries are a big business. As investments grow, North American and Nordic companies play a major role, but new companies, especially in Asia, are increasing their investments. Spek (2006) estimated that in 2003, global pulp production capacity was 187.6 million air-dried tonnes per year. The average 3.9% growth of global pulp production capacity in seven-years (1996–2003) was concentrated in developing countries, being as high as 37%. Brazil, Indonesia, and Chile alone accounted for 73% of the observed net capacity growth. Between 1994 and 2002, 25.5 million tonnes of new pulp capacity were proposed, 60% of which was for new pulp mills, mainly in Asia, Latin America, and Europe. About 40% of the proposed projects are going ahead, raising pulp capacity by some 12.7 million tonnes per year. During the latest years, new producers have entered the field of pulp production, with China at the head (Spek 2006).

In order to make an investment workable and profitable, companies have to establish or purchase large-scale plantations to supply raw material for their pulp mills. The land may be owned by the company, but is often leased from the government under a long-term contract. Typically, large industrial forest plantations consist of monocultures of a few, or maybe only one, tree species using varieties of clones that are intensively managed. After final harvest, a new rotation crop is established without delay using improved germplasm, nursery practices, site preparation, establishment, tending, and other silvicultural treatments in new stands (Varmola et al. 2005). The most commonly used tree genera are eucalypts, acacias, pines, and poplars. Cossalter and Pye-Smith (2003) estimated that in 2003 there were 10 million ha of so called "fast-wood" plantations worldwide, and that 0.8 million–1.2 million ha were planted every year. The total area of productive forest plantations accounted for 1.9% of global forest area in 1990, 2.4% in 2000, and 2.8% in 2005 (109 million ha), corresponding to an annual increase of 2.0 million ha during 1990–2000 and 2.4 million ha during 2000–2005 (FAO 2006). Of the global planted forests area – 271 million ha in 2005 – productive plantations constituted altogether 110 million ha (Del Lungo et al. 2006).

Both expansions of existing pulp mills and new projects tend to be large. A typical new pulp mill has a capacity of 1 million tonnes of pulp per year. The investment cost equals approximately 1 billion USD (HCG 2004). Production of 1 million tonnes of pulp requires large forest areas. In Sumatra, Indonesia, a 2 million tonnes per year pulp mill requires over 700 000 ha of fast-growing plantations to run at capacity. Depending on the process and tree species used, producing 1 million tonnes of pulp needs 4.0 million–5.0 million m^3 of roundwood overbark (Cossalter and Pye-Smith 2003).

Multinational companies seem to have globally expanded to the most promising fast-growing markets (e.g., Brazil, Russia, India, China, or the so-called BRIC markets), particularly from the year 2000 onward. As many international players are striving for the same investment opportunities in the same geographical locations, one of the decisive factors is the availability of wood source, which is dependent on the size of the plantation estate, the plantation growth rate, and land availability within reasonable proximity to the mill. Industrial plantations may grow at high rates, but the wood demand of a large pulp mill is also huge. As fibre cost at the mill has become a globally critical factor determining profitability and company survival due to the severely imbalanced regional distribution of forest resources, achieving a sustainable wood supply will become more and more essential. This is particularly true in a country like China, which has a clear disadvantage on costs of recycled fibre due to severe domestic shortage of wood supplies. According to a recent forecast by RISI-company, with the notable high growth and aggressive investments, China will overtake Europe and North America in terms of total production capacity of paper and board products by 2020 (Ernst and Young 2009). Although China has made significant progress in plantations, how its tremendous appetite for wood supply will be filled still remains challenging and uncertain.

The forest products industry has a crucial role in global sustainable development (regarding such things as maintaining biodiversity, being part of global water issues, combating forest degradation related to global climate change) because of its unique raw material basis. As the central role of business has extended from the traditional economic actor to a political and social actor, concerns about corporate responsibility (CR) have, consequently, become an increasingly high profile issue in many countries and industries – including in the forest sector (Li and Toppinen 2009).

The ever-growing public interest in and global consciousness about environmental and social issues has intensified pressure on forest industry companies in their efforts to effectively balance potentially conflicting stakeholder demands (Li and Toppinen 2009). Being directly and heavily involved in individual, cultural, and biodiversity issues, forest industry companies have great potential for substantial negative and positive impacts on location (Ketola 2009). As the forest industries, on the whole, are experiencing significant consolidation and globalisation, the roles they play in global sustainable development have become more and more salient. Massive pulp mills and their associated industrial plantations have become increasingly controversial, and there is an international convergence on their economic, environmental, and social impacts in the public debate.

Given its current limited capacity to serve the raw material needs of its aggressive development of pulp, paper, and wood products, fuelled by a variety of financial and tax incentives designed to accelerate the development of its pulp and paper industry, the Chinese government is promoting plantations to increase its domestic wood fibre base. This has not merely created "a bonanza for Northern consulting firms, machinery suppliers, and paper companies" (Lang 2007), but has also raised substantial challenges to the environmental and social sustainability of the host country and those foreign companies involved. Recent studies have stressed that in addition to the economic assessment, the environmental and social impacts from international operations should also be integrated in the decision making (Christmann 2004, Vermeulen and Ras 2006, Locke and Romis 2007).

Of perhaps far greater concerns to the plantation project are the increasing competition for land and the sustainability of wood fibre supply. Concurrently with the government's aggressive move to expand domestic industrial plantations, local people's livelihoods and the lands upon which they depend are frequently threatened because people can be marginalised by a decision making process that excludes consideration of their needs and that will lead to intensified environmental and social issues, such as destruction of natural forests, illegal logging and trade, and land dispute.

We investigated the Finnish-based company Stora Enso's Guangxi plantation investment project in southern China, especially its wood supply sustainability and related risks that depend on the plantation areas available and the growth rate of these plantations. The project has been assessed by a recognised international organisation, the United Nations Development Programme (UNDP) China.

21.2 The Guangxi Case Study

21.2.1 Background and Context

Guangxi Zhuang autonomous region has a land area of 23.6 million ha, of which 13.6 million ha (57.5%) were classified as forestry land in the 1999 inventory (Cossalter and Barr 2005). Forests are divided into commercial forests (7.8 million ha) and forests for "public use" (5.8 million ha). Over 90% of forests are collectively owned, over 8% are state owned, and 1% have other types of ownership. *Pinus massoniana* Lambert, *P. elliottii*, *P. yunnanensis* Franchet, *Cunninghamia lanceolata* (Lamb.) Hook, and several eucalypts are the most important and common tree species for forest plantations.

Eucalypts were first planted in China in the 1880s, but the area of eucalypt plantations did not increase rapidly until the 1980s. In Guangxi, eucalypt planting began in the 1960s with windbreaks around rubber plantations and agricultural crops (UNDP 2006). *Eucalyptus exserta* F. Muell. and *E. robusta* Sm. were the earliest species used. The development of eucalypt plantations in Guangxi was based largely on a Chinese-Australian afforestation project and intensive tree-breeding program. Most of the plantations were established on degraded land or replaced former lower-yielding pine plantations and unproductive fruit tree orchards. The main eucalypt species are *E. urophylla* S.T. Blake, *E. tereticornis* Sm., and a number of hybrids like *E. grandis* x *urophylla*, *E. urophylla* x *grandis*, and *E. urophylla* x *tereticornis* (UNDP 2006).

Relatively little information about Guangxi Province plantation areas is available in the public domain. In the report of the Center for International Forestry Research (CIFOR) to the World Bank, no plantation area figures could be given, but in 2004, the area for fast-growing plantations was 134 000 ha. Potential land area for plantations was estimated as high as 3.7 million ha (Cossalter and Barr 2005).

In the UNDP Environmental and Social Impact Analysis (ESIA) of Stora Enso's plantation project in Guangxi, however, a detailed description of eucalypt plantations was given based on fieldwork and interviews. According to that description, there were 350 000 ha of eucalypt plantations in Guangxi in 2002, plus about 100 000 ha of "four-sided" plantings (along contours of roads etc.), 430 000 ha of pine and bamboo plantations, and 20 000 ha of acacia plantations (UNDP 2006). By 2010, the aim was to increase eucalypt plantations to 670 000 ha and the total area of industrial fast-growing plantations to 2 million ha, of which 1 million ha would be for the pulp industry.

Total timber harvest in Guangxi was 4.2 million m^3 in 2001, and 4.5 million m^3 in 2003 (Cossalter and

Barr 2005). The forest industry in Guangxi consists of small sawmills, wood-panel industries, pulp and paper mills, woodchip mills, and furniture factories. Pulp mills are small and, up to now, only 35% of pulp used in paper mills comes from wood-based pulp. The effective wood demand of the seven largest pulp mills was 1.6 million m^3 in 2003 (Cossalter and Barr 2005). According to Guangxi's provincial forest plan, annual wood production is targeted to reach 10 million m^3 in 2010, and 12 million m^3 in 2015, fast-growing plantations for pulp production corresponding to 1 million and 1.3 million ha, respectively, including 230 000 ha of bamboo.

21.2.2 Impact Study

UNDP China's ESIA report for the Guangxi project (184 pages plus ten annexes) contained chapters on eucalypt plantation management, environmental impact analysis, social impact analysis, integrated analysis of social and environmental impacts, recommendations, and conclusions (UNDP 2006). Growth rates were discussed on half a page titled "Commercial eucalypts and productivity sustainability." The conclusion of the evaluation was based mainly on the works of Nambiar (1997) and Binkley and Stape (2004), that "given appropriate silviculture, wood production should face no barriers in sustainability." No growth rates for existing plantations were given.

There was no information in the ESIA about the growth rates of plantations in Guangxi, except one personal communication. References were given only from Brazil (UNDP 2006), and the basic message was to assume a remarkable increase in growth rates. This increment was expected to come from clonal forestry and tailor-made silvicultural techniques. Mean annual increment (MAI) of 35 m^3/ha (net growth) was reported as a target average value during the third rotation (Kari Tuomela, personal communication).

21.2.3 Plantation Estate for Stora Enso

Most of the eucalypt plantations in Guangxi Province are located near the southern coast and thus around Stora Enso's planned pulp mill in Bei Hai. According to the provincial forest inventory of 1999, there were around 30 000 ha of eucalypt plantations in the prefecture of Bei Hai at a distance of less than 150 km from the mill and some additional 22 000–38 000 ha of land could be suitable for eucalypt plantations (Cossalter and Barr 2005). The area of eucalypt plantation has since increased, but exact figures do not exist. According to provincial plans, however, 130 000 ha of fast-growing plantations have been or are to be established in both Bei Hai and Qin Zhou prefectures, close to the planned pulp mill (UNDP 2006), either on suitable commercial forest lands or by converting slow-growing pine plantations to faster-growing eucalypt plantations.

Stora Enso has announced that it aims to select lands close to the planned mill (originally within about 75 km) in blocks of at least 100 ha and at a maximal slope of 15° (UNDP 2006). In 2005, the company had about 60 000 ha of eucalypt plantations through land concession rights and fully owned plantations (SE 2006b); by early 2009, the area had increased to 93 000 ha. There exist different estimates for plantation area needed for the planned pulp mill. According to the ESIA, an area of 120 000 ha by 2010 would meet the wood demand for the mill (UNDP 2006), but Stora Enso has increased the area needed to 160 000 ha (SE 2006a). Seventy percent of plantation areas are stated to be established on state forest farms, the rest on collectively owned village lands.

The philosophy behind plantation establishment is most likely similar to that of the company's Veracel pulp mill in Brazil, where all the wood comes from the company's own 78 100 ha of clones obtained from the crossing of *Eucalyptus grandis* and *E. urophylla* species (Veracel 2006). The MAI of 51 m^3/ha (underbark) and rotation length varying from 7.2 to 9.6 years are mentioned by the company to supply a pulp mill with the capacity of 0.9 million tonnes of pulp, this probably being the most effective plantation and pulp mill integration in the world, as regards growth rate and land use efficiency (Veracel 2006).

21.2.4 Stora Enso's Investment Plan

Although a decision is still pending, Stora Enso is planning to establish on the southern coast of Guangxi Province an integrated pulp and paper mill with a production capacity of about 1 million tonnes of eucalypt pulp annually (UNDP 2006). In 2007, Stora Enso announced that it had signed a mill site land acquisition agreement with Bei Hai city government in Guangxi. The agreement will provide Stora Enso a total of 250 ha of industrial land for possible future use as a mill site. The purchase price was about EUR 27 million (SE 2007).

Stora Enso is still assessing the industrial process – whether Chemical Thermo Mechanical Pulp (CTMP), or Bleached Hardwood Kraft Pulp (BHKP), or both – to be used in the pulp mill. CTMP is less demanding in wood quantities (2.5 m^3 of wood to produce 1 tonne of pulp) than BHKP (4.1 m^3 of wood to produce 1 ton of pulp), but requires higher en-

Table 21.1. Growth and rotation period data of *Eucalyptus* species in subtropical humid ecological zone.

Species	Country	Rotation length (years)	MAI (m^3/ha), overbark	Source
E. globulus	Uruguay	10	30	FAO 2001
	Uruguay	na	25	FAO 1979
	Uruguay	16	18	Cubbage et al. 2007
	South Africa	25 to 32	12.8. to 27.4	Poynton 1979
E. grandis	Uruguay	10	23 to 25	FD 1994
	Uruguay	10	20 to 30	FAO 2001
	Uruguay	10	30	Cubbage et al. 2007
	South Africa	10 to 55	21.6. (11.8 to 35)	Poynton 1979
	South Africa	21 to 22	21 to 27	FAO 2006
	Argentina	21 to 22	21 to 27	FAO 2006
E. nitens	South Africa	10 to 25	19 to 26	FAO 2006
E. tereticornis	Uruguay	na	18 (max. 25)	FAO 1979
	Uruguay	na	Max. 18	Qadri 1983
Eucalyptus sp.	China	7	13,5	Elliott 1997
	China	5	14 to 21	Barr and Cossalter 2004a
	China	6	9 to 20.5	Cossalter 2004
	China	7 to 15	8 to 21	FAO 2006
	Uruguay	na	18	Neilson and Flynn 2003
Eucalypt hybrids	China, Guangxi	5	37 (20 to 57)	Hongwei et al. 2006

na means data not available.

ergy consumption in refining and for the final pulp cleanliness. The industrial process that Stora Enso will implement in its Guangxi mill is of primary importance when discussing future wood supply and total plantation area required to sustain the mill production. In 2005, Stora Enso filed an official application for an integrated project of about 1 million tonnes of both BHKP and CTMP, and about 1 million tonnes of paper and board. In the scenario, we used an assumption of 3.5 m^3 of wood to produce 1 tonne of pulp.

Guangxi province is one of the most forested provinces in south China, has a favourable climate for fast-growing plantations, and has good roads for transportation. Therefore, it is no wonder that other big companies are also planning wood-based pulp mills in the area. Asian Pulp and Paper (APP), an Indonesia-based company concentrated in Indonesia and China, is planning to build a pulp mill in Guangxi with a capacity of 0.3 million tonnes of pulp at the first stage (entire goal 1.2 million tonnes). APP already has a mill with a capacity of 1.1 million tonnes of pulp (entire goal 2.4 million tonnes) in the adjacent province of Hainan (Barr and Cossalter 2004a), and proposes further investments in Guangxi. Other mills are expanding, for example in 2003–2004, the Lipu and Jing Da Xing paper mill located in the interior of the province increased production to about 170 000 tonnes of pulp (Barr and Cossalter 2004b).

In 2003, China's wood-based pulp production was 9.2 million tonnes (22% of total fibre consumption) compared with, for instance, the United States of America (60.5 million tonnes) or Finland (14.3 million tonnes) (Spek 2006), and demand is projected to reach 15.1 million tonnes in 2010 (He and Barr 2004). Compared with these figures, Stora Enso's investment plan would cover some 7% of China's total estimated wood-based fibre production in 2010.

21.3 Wood Production Scenario

21.3.1 Growth Data Available

The ecological requirements and tree characteristics of eucalypt species, their genecology, provenance variation, and prospects for planting are well described in FAO (Food and Agricultural Organization of the United Nations 1979), Eldridge et al. (1993), and Williams and Woinarski (1997). In general, estimates of growth rates of eucalypt species, expressed as MAI and rotation length (RL), are based mostly on experimental sites. Guangxi Province is located in the subtropical humid ecological zone (FAO 2001). Table 21.1 presents growth rates for the most com-

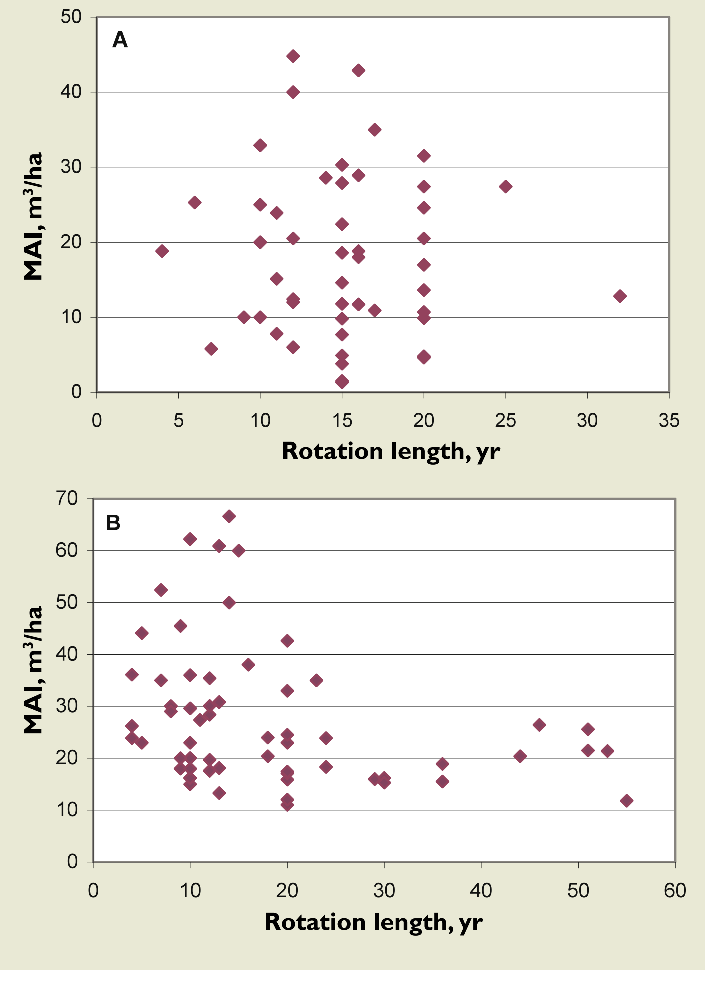

Figure 21.1 Mean annual increment (MAI) overbark and rotation length globally for A) *Eucalyptus globulus* and B) *E. grandis.* Based on literature survey from Varmola and Del Lungo (2003).

monly used eucalypt species in this ecological zone, primarily based on compilations by Varmola and Del Lungo (2003).

There is a large variation in growth rates of the main commercial eucalypt species (Figure 21.1). Most of the values available are from experimental and successfully managed sites or growth plots where many silvicultural and environmental factors (such as fertilisation, weeding, pest and fungi disease control) would have been well regulated. At the large operational scale, and taking into account site variation and possible reverses, growth rates may be lower. Tomé (2001) reported that in Portugal, the MAI of *E. globulus* plantations varied greatly from inland plantations (4 m^3/ha) through an average of (14 m^3/ha) to the best sites on the coast (30 m^3/ha). Such large variations in growth rates are also found in Australia (Sadanandan Nambiar, personal communication). FAO estimated that in China, the MAI of eucalypts might vary from 8 m^3/ha (min.) to 21 m^3/ha (max.) and a rotation length from 7 to 15 years (Del Lungo et al. 2006).

On the other hand, genetically improved planting stock can increase growth of eucalypts substantially, but only if all other factors are supplied, as well. In Portugal, genetic gains have been estimated at 20–40% both in volume and wood density (Tomé 2001). In Brazil, the MAI of eucalypt plantations has increased from 10–15 m^3/ha to over 40 m^3/ha due to better site matching, silviculture, and tree breeding achievements (Binkley and Stape 2004).

It is unclear which of these factors has the greatest effect on productivity gains. Pallett and Sale (2004) suggested that silvicultural treatments, fertilisation, and weeding were the largest contributors to productivity. In Brazil, Campinhos (1999) reported that due to intensive silviculture, a tree-breeding program with tree selection, the use of hybrids (*E. grandis* and *E. urophylla*), and clonal plantings, the average MAI rose from 28 to 45 m^3/ha, the consumption of wood needed to produce one tonne of BHKP decreased from 4.9 m^3 to 4.1 m^3 wood overbark, and the productivity of pulp increased from 5.9 tonnes/ha to 10.9 tonnes/ha.

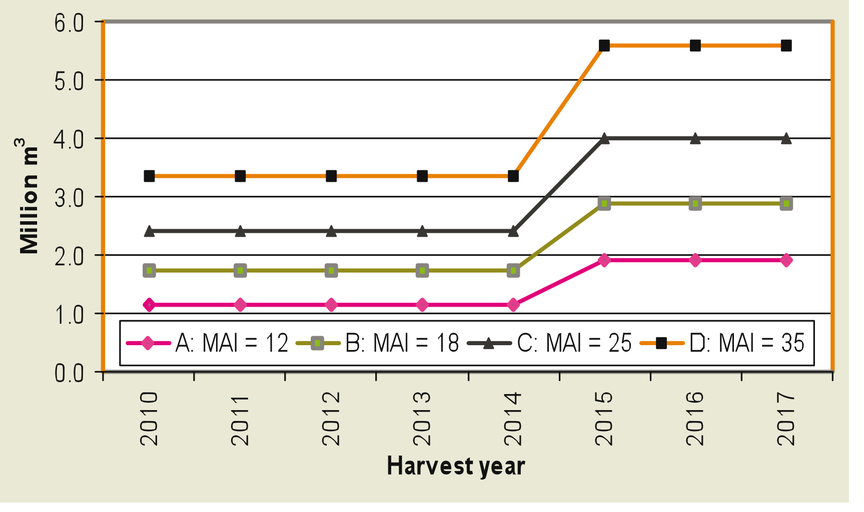

Figure 21.2 Wood supply (million m^3) scenarios with different growth rates (mean annual increment, MAI, underbark) (A, B, C, D) from eucalypt plantations estate for the area of 120 000 ha.

Genetic gains are often estimated. There is inadequate information about the potential of these gains to become realised gains in operational forestry. Biotic (insects, diseases, invasive species, human interventions) and abiotic (hurricanes, cyclones, droughts, floods, extreme hot or cold periods) factors can greatly affect productivity (see Evans 2001, Libby 2002) and are real threats in China, including in the Stora Enso work circle supply region in Guangxi. There are real risks in extrapolating plot level growth rates to an ecosystem as a whole. This problem would be greater when the estate is in fragmented locations, as will be the case in Guangxi.

21.3.2 Wood Supply Scenario

Wood supply scenarios were constructed using existing data on planting rates in China, and assuming a constant plantation area purchase in Guangxi during years 2007–2009. Four growth rates (MAI) were assumed, based on the literature and company announcement. An eight-year rotation length was used.

The company started the eucalypt planting program in 2002, had 60 000 ha in 2006, and aimed to have 160 000 ha of plantations under control in 2010 (SE 2006a), either as self-managed or via different contracts. In the beginning of 2009, the company announced it would have 93 000 ha, which means that the planting program is now delayed and most likely would reach 120 000 ha in 2010. There existed no detailed data about annual plantation purchases by the company, but some 12 000–20 000 ha of new plantations are needed annually during the eight-year project.

The wood use efficiency was set at the level of 3.5 million m^3 underbark to produce 1 million tonnes of pulp because no decision had not yet been made for the industrial process (CTMP or BHKP, or a production line of each). Growth rates were derived from Barr and Cossalter (2004a) for the conservative **A** (MAI = 12 m^3/ha), medium **B** (MAI=18 m^3/ha), optimistic alternatives **C** (MAI = 25 m^3/ha), and from Stora Enso's target value during the third rotation for **D** (MAI = 35 m^3/ha). Such a target can be difficult to achieve because the company estate will not be in a consolidated land mass. Plantations will be spread among many small sized units and will thus have large variations in soil and site environments. Corresponding overbark growth rates are 14, 21, 29, and 41 m^3/ha, respectively.

If silvicultural management and tree-breeding programs are not working well, and/or there are losses due to unclear land use rights, damage caused by such things as pests, fungi, fire, or typhoons, wood supply from the plantation estate may remain as low as 1 million–2 million m^3 annually (MAI stays at a level of **A**) (Figure 21.2). With the operational mean annual increment level for south-western China nowdays (level **B**), almost half of the wood has to be transported from regions other than the two nearest prefectures, or from abroad. After some years of operation, say, around 2015, the pulp mill would, however, get most of its wood from the expected self-controlled plantations nearby. It is obvious that Stora Enso cannot fulfil all the wood demand of its planned pulp mill with a plantation estate of only 120 000 ha.

The company's own target for growth rate is set extremely high (**D**), and is aimed at guaranteeing a full supply of wood from self-managed or con-

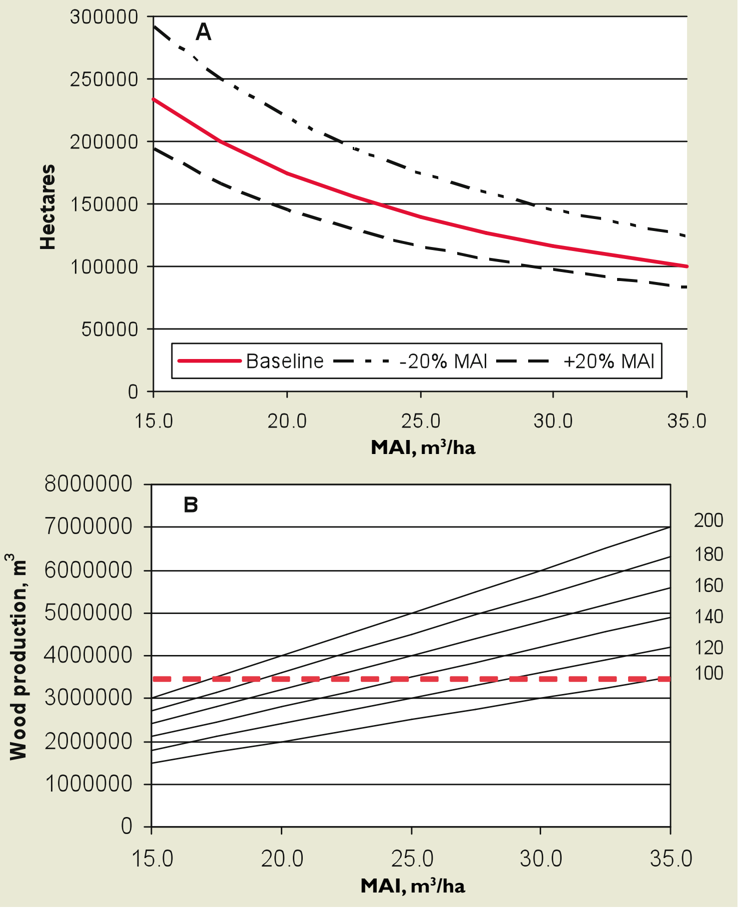

Figure 21.3 a) Plantation area needed to produce 3.5 million m^3/year with 20% reduction or increase in mean annual increment (MAI) compared with baseline. b) Total production with varying MAI (m^3/ha) and plantation areas (1000 ha). Dashed line indicates 3.5 million m^3/year production.

trolled plantations. Actually, under circumstances of the most steady wood supply from 120 000 ha, an average MAI of 29 m^3/ha underbark is needed to satisfy the annual wood demand of 3.5 million m^3. The history of forestry shows that such a broad scale high growth rate can be sustainably achieved only after many years of local experience and overcoming many impediments.

21.3.3 Relationship between Plantation Productivity and Area Needed

The scenario results above demonstrate the relationship between the growth rates of the plantation itself and the total area needed to produce a certain amount of wood. They also demonstrate how to manage risks involved in achieving long-term sustainability of operations.

There is a nonlinear relationship between the area needed and the productivity level of a plantation (Figure 21.3a). At the MAI of 35 m^3/ha, 100 000 ha are needed to produce 3.5 million m^3 of wood per year. When the growth rate is lower, more area is needed. The same relationship applies to the uncertainties involved. If we assume the MAI to be 25 m^3/ha, 140 000 ha are needed to produce 3.5 million m^3 of wood per year. However, if for some reason the MAI is 20% more, or 30 m^3/ha, the area needed is only 117 000 ha; if it is 20% less, or 20 m^3/ha, the area needed is 175 000 ha. It is critical to recognise that at the scale of the case under discussion, every 10% change in MAI for any reason is equivalent to about 5000 to 40 000 ha of land, depending on the average MAI in question. Such changes in MAI are common in many forestry estates in the world.

An easy way to estimate the total area needed to supply a pulp mill is to use a diagram similar to that in Figure 21.3b, which presents the linear relationship between the total volume produced and the MAI at varying plantation areas. Thus, for instance, to produce 3.5 million m^3 of wood per year, the company would need to operate anywhere between 100 000 and 200 000 ha if the MAI varies between 17.5 and 35 m^3/ha.

21.4 Discussion

21.4.1 Increased and Sustained Production of Wood

A new pulp mill on a new land base leads to large impacts on the economical, environmental, social, and even cultural conditions on at least a regional level of the country in question. Therefore, it is extremely important that all the effects that investment has on the surrounding environment and society are properly studied and discussed. The central issues then are long-term sustainability of wood supply, with environmental care, for the pulp mill, and security of land rental to be able to manage the plantation estate.

The growth rate of plantations varies according to tree species used, site, initial stocking, silvicultural operations (site preparation, fertilisation, weed control, etc.), and genetic origin (Tomé 2001). Many biotic and abiotic factors like pests, pathogens, fungal diseases, drought, fires, and storms (Turnbull 1999) are risks that can reduce the productivity and cause dramatic, even sudden, slowdown in wood supply. Changes in soil water level and soil fertility have an effect on growth rate, too (Nambiar and Brown 1997). According to Gonçalves et al. (2004), productivity relates to different environmental factors in order of importance as follows: water deficit, nutrient deficiency, soil depth and strength. Quite often, however, at least in experiments, the subsequent generation has a higher growth rate than the previous one (Evans 2001, Libby 2002, Binkley and Stape 2004, Evans 2005, Nambiar 2008).

MAIs given in the literature (see Table 21.1, Figure 21.1) come mostly from experimental plots. Such plots usually represent better management and even the best part of a stand. In Finland in planted conifer forests, it was found that growth rate in stands was 12–20% lower than on experimental plots used for growth modelling purposes (Oikarinen 1978). In Mexico, the growth of tropical pines was about 50% or less than that of the experimental plots (Acevedo Herrera et al. 1994).

Based on the above review of the literature, the MAI needed to suffice one million tonnes of pulp mill wood demand at an actual plantation area seems to be high when plantations are established and managed on an operational level. In Guangxi project, where no exact MAI was given, a MAI of 29 m^3/ha underbark (34 m^3/ha overbark) would suffice to supply annually 3.5 million m^3 from 120 000 ha. Such level has not yet been reached, or at least not reported, even on the experimental level in the region, except for in one proceedings paper (Hongwei et al. 2006). If the plantation area would reach 160 000 ha, an average MAI of 22 m^3/ha underbark would fulfil the wood demand. It is possible to achieve, but is still at risk from of typhoons, insects and other damage. Nambiar and Brown (1997) point out that the many uncertainties in growth rates are greater in tropical and subtropical plantations than in temperate ones, and "trees can grow fast in the tropics only if soil and environmental conditions are conducive to rapid growth and the quality of management is high."

21.4.2 Merchantable Volume for Pulp

Figures found in the literature about growth rates of plantations compared with the total wood demand of a pulp mill are often confusing or not well documented. There exist at least three points to be discussed: the amount of bark, the effect of upper end diameter used for volume estimation, and wastewood.

In forest inventories, tree dimensions are measured and volumes usually expressed as overbark values. Pulp mills, however, do not use bark, and the wood demand is expressed as wood without bark (underbark). This means, in eucalypt species, a possibility for misinterpretation of about 15% or even more (FAO 1979).

All stemwood is not used in pulping and usually a certain limit for upper diameter is given. In FAO (1979), examples are given of the amount of wastewood for different minimum top diameters and heights of *E. grandis*. Underbark utilisable volume varied from 75% (diameter at breast height (dbh) = 15 cm, top diameter = 10 cm, height = 15 m) through 90% (dbh = 20 cm, d_{top} = 10 cm, h = 20 cm), to more than 95% (dbh = 25 cm, d_{top} = 10 cm, h = 25 m) of underbark volumes.

Slash, or wastewood, that is, unusable or rotten wood, or wood lost between plantation and mill gate, must also be taken into account. The values of MAI in Figure 21.1 contain all the stemwood. Barr and Cossalter (2004a) made a reduction of 20% for non-commercial harvested volume to get realistic figures for plantation area needed to supply pulp mills. Stora Enso has announced it will use a reduction of 18–20% for bark and wood losses between plantation and mill gate (Göran Storck, personal communication).

21.4.3 Wood Use Efficiency

Wood use efficiency in pulping also has an effect on wood demand. According to Ikemori et al. (1994, cited in Campinhos 1999), the consumption of eucalypt wood to produce 1 tonne of pulp has decreased from 4.9 m^3 to 4.1 m^3 wood overbark as a result of efficient tree breeding and clonal plantation programs in Aracruz, Brazil. Barr and Cossalter (2004a), however, assumed that 4.15 m^3 underbark is needed for 1 tonne of pulp in their calculations for south-western China.

21.4.4 Other Competing Use of Wood

All the plantation-based wood is not used for pulping. There exist many competing uses for fast-growing eucalypt wood. In Guangxi, industrial wood from plantations has been used for sawnwood (annual capacity of 3.2 million m^3 of roundwood), wood panels (2.7 million m^3/year), wood chips (1.3 million m^3/year), and pulp and paper (Cossalter and Barr 2005). Wood is also used for bioenergy. Only 30% of pulp production has been wood-based. It is obvious that in Guangxi province, large investments in the pulp mill will require new strategies for the industrial use of plantation-based wood.

21.4.5 Land Competition and Other Sources of Raw Material

The competition over land for other purposes (such as food production) causes fragmentation, increases the distance of the wood raw material supply work circle, and pushes up the price of land, the cost of transport, and the cost of wood. This can seriously impact financial viability of the overall production of the pulp industry.

Potentially, it would be cheaper to grow eucalypt plantations in Northern Vietnam or Lao PDR, or even in other south-east Asian countries, where the cost of land and wood production is not so expensive as in China, and growth, yield, and productivity are acceptable.

If the wood supply from existing plantations is insufficient, other sources of raw material are needed. In Guangxi, tree residues, like wastewood, branches, and sawmill and plywood mill residues, are used in small-capacity pulp mills or in the reconstituted-panel industry (Cossalter and Barr 2005). Thus, they cannot serve as raw material for a large-scale pulp mill due to their lower quality. Furthermore, the way forest authorities have divided the area for purchasing and establishing plantations near the coast between Stora Enso and APP, is not logistically reasonable.

21.4.6 Risk Assessment

It is clear that the calculations on wood supply made by the consultant company (UNDP 2006) were based on very limited knowledge and understanding of tree growth dynamics and factors that affect growth rate and thus wood supply. Obvious biotic and abiotic risks that can reduce wood supply, though discussed, have not been quantified or taken into account in any way in the consultants' assessment. There also seems to be confusion about the interpretation of tree bark, upper-end diameter, and wastewood portions, and their effects on wood supply. Together, these account for at least 20% of the total volume or, in other words, a quantity of over 0.7 million m^3 of planned annual wood demand for a mill. Besides these elementary factors in tree growth and wood composition not analysed, the amount of plantation area available has been overestimated. In conclusion, it seems that wood supply experts have not been sufficiently involved in the feasibility and evaluation processes made by the consultant companies.

According to Stora Enso Guangxi project personnel, the company has considered a certain risk in reducing the mean target MAI overbark values by 18–20% to account for bark, harvest, and transportation losses. An operational growth of 21.3 m^3/ha/yr (net mill gate) is mentioned after first rotation (Göran Storck, personal communication). This would then mean a need of 160 000 ha of plantations (see Figure 21.3b) to fulfil the wood demand, which also has been mentioned as Stora Enso's target area (SE 2006a), but will not be reached in eight years of operation.

Though investment reward may be attractive, in addition to the wood supply issues, building a mill in China also involves high economic and political risks in terms of, for instance, transparency of financial data, normal duration, basis of financial information, auditing and corporate governance, and enforceability of indemnification (Ernst and Young 2009).

21.4.7 Corporate Governance Issues

A major part of the risk assessment made by UNDP China discusses corporate governance and environmental issues, land rental, and labour availability (UNDP 2006). Stora Enso has established a community development project through six village-based tele-centres (computer with internet connection) in project areas. It has also supported biodiversity conservation programs in the project area by payments to conserve nearby mangrove forests. However, the local villagers seem not to be satisfied with the actions made by the company and the local authorities. Stora Enso now has made some 3000 land rental agreements, yet more lands are needed to achieve the initial goals of industrial plantations and to sustain the wood supply for the huge pulp mill in the project.

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Photo 21.1 After the plantation has been firmly establish, local communities can use it for grazing cattle.

As a raw material-intensive industry, the forest products industry has a close relationship to national economic and social development. Supported by the Chinese government, the capital- and technology-intensive pulp and paper industry has rapidly become a new growth engine in China's national economy, and plays a strategically important role in sustainable development in China. Without a national macro-economic planning and management backed by a systematic, focused, and institutionalised approach to CR, the pulp and paper industry in China will inevitably be grounded in the context of unsustainable actions. Consequently, there is likelihood that the contributions of both the public sector (the Chinese government) and the private sector (Chinese companies and multinational companies like Stora Enso) could fail to achieve the desired outcomes, which include, not only economic growth, but also poverty alleviation, pollution mitigation, and increase in human capital.

Different stakeholders such as governmental agencies, investors, analysts, non-governmental organisations (NGOs), consumers, and individuals all over the world transfer pressure to companies through economic, environmental, and social interaction. While up-to-date information technology has facilitated the globalisation course, it also has inevitably led to increased exposure of companies' progress in industrial globalisation and sustainable development. The success of CR initiatives is often linked to stakeholder dialogue and stakeholder engagement in the discussion of best CR practice. Grounded neither on legal rights nor moral obligations, a stakeholder's recognition is contingent upon the business need for that recognition (Blowfield and Frynas 2005). As Lang (2007) notes, the ESIA report by UNDP China (2006) fails to recognise the environmental and social impacts on affected local communities' serious concerns about the eucalypt monoculture in Guangxi, and excludes studies by NGOs on the relevant issues. As NGOs have become more and more active in plantation issues, their influence should not be neglected.

With globalisation, forest certification will inevitably become an important indicator of sustainable forest management for the Chinese forest companies that compete in the international markets. In all southern provinces, including Guangxi, the forest estate is under collective tenure, with over 90% of its area of commercial forests on collectively owned lands, whereas more than 92% of the land possible for new plantations is owned by local communities, farmers' cooperatives, and individual households.

The role of these recognised land owners thus becomes central in the success of plantation development (Cossalter and Barr 2005). To Stora Enso, the question of how to reach small-scale forestry and promote forest certification in China, with reciprocal acceptance by major stakeholder groups, still remains challenging. In addition to the cooperation with the Chinese government, it would be strategically important for Stora Enso to engage and partner with NGOs and local forest owners through various smallholders or outgrowers schemes and local employment, in order to retain its corporate legitimacy and sustain its competitiveness where it operates.

As societal demands are changing with respect to the world's forest resources, the global forest sector is moving towards a more holistic and encompassing approach to CR and sustainability initiatives. Large forest companies understand and define CR largely based on activities related to sustainable forest management (SFM) and accountability among a number of emerging economic, environmental, and social issues in order to retain their legitimacy (see i.e. Wang 2005, Panwar et al. 2006, Vidal and Kozak 2008), engage in a broad array of CR activities, and shape their social performance strategies to fit their geographical profile (Mikkilä and Toppinen 2008).

Land availability, tenure security, and solid fibre base are key determinants for the long-term success of Stora Enso's pulp mill project in Guangxi. Ignoring the concerns raised by villagers and local communities, and the priorities of those villagers and local communities (especially the poor and marginalised) renting lands might present a threat to Stora Enso's legitimate operations and the sustainability of their land tenure and wood fibre supply. The escalation of local land ownership related conflicts in the affected areas in spring 2009 should have been taken as a signal for public critique and been used to get hands-on experience and knowledge so that the company could review their overall strategy, including risk management and communication strategies for future actions. In future studies, it would be worthwhile to follow up on the progress in sustainability of forest industry plantations, especially the corresponding social strategy, performance and impacts.

21.4.8 The Way Forward

The planned pulp mill represents modern, large-scale investments whose environmental and social impacts and connected factors are widely discussed and taken into account. The technologies to be used in the pulping processes will probably represent some of the most modern and clean processes in the world. The investment will also provide significant employment and generate revenues at local and regional levels. Our concern, however, is that adequate risk analyses of the sustainability of wood supply have not been fully conducted. More wood supply beyond Bei Hai and Qin Zhou prefectures, which is not from Stora Enso's plantations, will be needed to meet the possible wood shortage of the mill in case Stora Enso can pay more for transportation costs.

The wood supply from existing and planned plantations, and the wood demand for pulping are not yet in balance, and the long-term sustainability of these operations is open to discussion. Improved germplasm and nursery practices, careful site preparation, stand establishment, and nutrient balance, are essential for eucalypt plantation productivity, but biotic and abiotic damage may have dramatic negative influences on productivity.

It is quite likely that more new fast-growing eucalypt plantations will be needed. Special attention has to be paid to transparency in the process of acquiring plantations through land concessions or by acquiring the ownership of the land. The company has announced that it has established a network of permanent sample plots and that it regularly carries out forest inventories in eucalypt plantations. These databases will, in the course of time, guarantee accurate growth rate measurements of plantations at the operational scale.

Learning from the recently increasing protests and land disputes against plantations, there is a crucial need for the company to proactively engage in effective and direct dialogue and communication with different stakeholder groups. This is especially true for those affected villagers and local communities renting lands to Stora Enso, as well as those groups that are not considered "primary stakeholders." When aiming towards sustainable development a wide range of issues related to the spreading of plantations in China deserve attention. These issues relate to how the government and the business society can strike a balance between conflicting priorities and the bottom line, so that companies can prosper from addressing environmental and social concerns in a genuinely sustainable manner. Population pressure, increased competition for land and wood, abiotic and biotic risks, greater fragmentation of plantations, longer transportation distances, lower growth rates and yields than expected, can all increase costs and risks and, thus, threaten the viability of the investment.

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Photo 21.2 Plantation establishment and management are crucial for tree growth. These plantations were established at the same time, but appropriate management has been applied only in the right side leading to considerable differences in the growth and quality of the plantations.

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