Title	Understanding the production and use of timber in the South African construction industry to identify and reduce its negative environmental and socio-economic impacts
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SUMMARY

Timber is often regarded as a sustainable building material because of its relatively low embodied energy and the fact that it is a renewable resource. However, the production and use of timber products does have complex environmental and socio-economic impacts, and these impacts are not the same for all timbers and timber products. In order to use timber as sustainably as possible it is important to know what the environmental impacts of these products are, and to be able to differentiate between various products that perform the same function. Information of this sort would allow specifiers to make more informed choices, encourage the public to demand more sustainable products and highlight the need for the introduction and standard use of better production methods.

This research develops an understanding of how timber is grown, processed and used, which enables one to identify the environmental and socio-economic impacts of forestry and the production and use of timber in the building industry. The key factors that determine the sustainability of a timber product are shown to be forest management, waste production and management, seasoning of sawn timber, timber preservation, the use of glues, resins, coatings and sealants in the manufacture of timber products, and judicious design and specification. A number of options exist to improve the sustainable production and use of timber, however few are broadly applied in the South African context. This article makes the case for increasing the sustainability of timber products and illustrates the need for more research in this field.

UNDERSTANDING THE PRODUCTION AND USE OF TIMBER IN THE SOUTH AFRICAN CONSTRUCTION INDUSTRY TO IDENTIFY AND REDUCE ITS NEGATIVE ENVIRONMENTAL AND SOCIO-ECONOMIC IMPACTS

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1 Introduction

The built environment consumes 40% of all materials and 30% of all energy produced globally (Rees, 1999). The production of goods and services consumes raw materials and produces waste, heat, chemicals and pollution as by-products. The environment acts as both source and sink for sustaining our activities. As the negative environmental and human health impacts become more known to us, it becomes necessary to re-examine the sustainability of materials and energy usage in the built environment.

Architects, designers and consumers in South Africa select materials based on their built performance characteristics, durability, maintenance and availability. Timber is a natural and renewable resource hence it is perceived as “environmentally friendly”, but this does not necessarily mean that its use is sustainable. More importantly, timber is not just a resource for human consumption; forests provide many services that are crucial to the health of the environment.

1.1 Drivers of sustainability

1.1.1 Business

Modern economies are profit driven and free-market oriented. Environmental costs are not often built into the cost of production. These externalised costs of production are born by the environment, the workforce and the more marginalised groupings in society. As awareness about resource depletion, pollution and human health considerations grows, there is a greater need for the economic system to begin valuing environmental services and costing environmental damage.

Whereas the South African forestry and timber industry may be regarded as relatively progressive by global standards, the features that make it so are problematic from a sustainability point of view. These relate to export driven ecolabelling considerations, importation practices, monocrop production systems and technologies employed.

South Africa produces a surplus of timber and timber products which earn a significant amount of revenue through exports (see figures 1-3). Plantations, which are managed as cash crops, support this export market but place additional burdens on the environment. What implications does this have on long-term sustainability in a land where forestry has seemingly low ecological potential, and are the full costs of water, land, labour, biodiversity loss, land remediation and subsidies factored in?

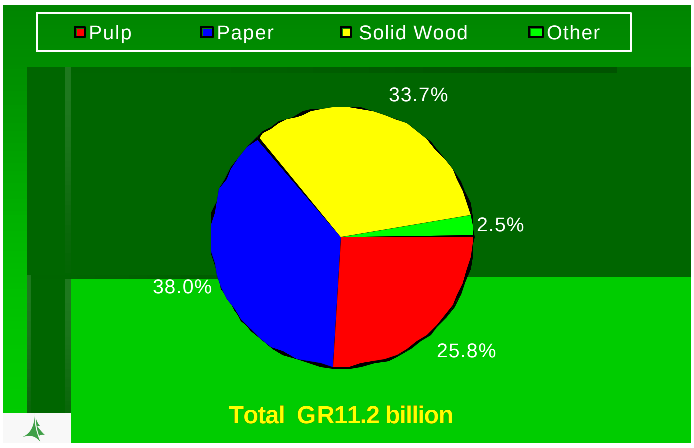

Figure 1: Forest Products Exports 2002
Source: FSA (2003)

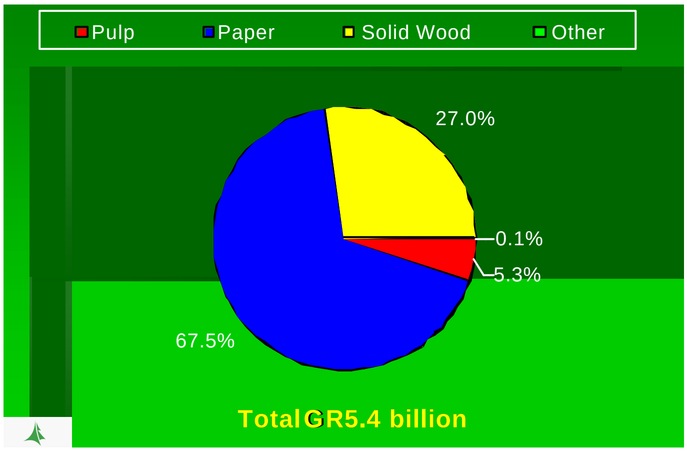

Figure 2: Forest Products Imports 2002
Source: FSA (2003)

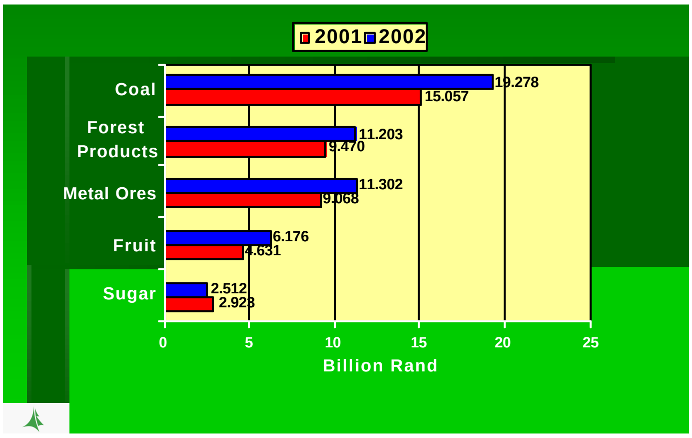

Figure 3: Comparison of Exports by Commodity: 2001 & 2002
Source: FSA (2003)

Business drives the unsustainable use of timber by importing timber from poorly managed sources. Imported timber include the following species:

- Tropical African timbers: Okoume, Obeche, Iroko, Sapele, Afrormosia, African Mahogany, Padauk, Panga Panga and Bubenga.
- Subtropical African timbers: Zambezi (Rhodesian) Teak, Kiaat and African Rosewood.
- Australian timbers: Jarrah and Karri
- South East Asian timbers: Meranti, Balau, Merbau, Jelutong and Keruing
- European timbers: Beech and Siberian Larch
- North American Timbers: Red and White Oak, Maple, Walnut, Cherry, Ash, Poplar and Oregon Pine
- South American Timbers: Imbuia, Pau Marfim, Brazilian Rosewood and Mahogany

.

Questions raised by this research include:

- Do these imported timbers come from sustainably managed forests and is our demand for them matched by equivalent regeneration?
- Are they products of fair trade?
- Are these precious products processed and used optimally and judiciously?

Trees that are farmed locally include a suite of species that make up SA Pine, Saligna, Blackwood and in small quantities Karri, Cypress and Canary pine. Valuable South African timbers available to the construction industry include Kiaat and yellowwood. Considering that we depend heavily on imported timbers to meet the demand for high quality and durable timber products, can South Africa or the sub region sustainably produce more of these valuable timbers to reduce the demand for timbers imported from other continents and tropical Africa?

1.1.2 Regulatory frameworks

Legislation, eco-labels and procurement policies are means by which the timber industry can be driven towards the more sustainable use of wood. Our legislation and regulatory standards need review with ecological sustainability as a key criterion. This becomes crucial in the context of greater privatisation of the forestry sector.

Eco-labelling has been used around the world to support the use and production of sustainable products that range from appliances, to health and cleaning products and timber. In some cases legislation requires that products are assessed and labelled. In other cases, as for timber, the process is voluntary. Timber eco-labelling schemes are driven by public demand for timber sourced from well-managed forests where forestry operations do not cause human rights abuses and extraction does not compromise biodiversity or the forests ability to provide environmental services. Timber certification is discussed in more detail elsewhere in the document.

Procurement policies in South Africa support affirmative action and are being used through tendering to support black economic empowerment. This principle could also be applied to the environment: procurement by large institutions could grow the demand for more sustainable products.

1.1.3 Awareness

Top down legislation complimented and inspired by bottom up pressure from NGOs and an informed public drives developed countries' responses to unsustainable resource consumption and the negative environmental and human health implications thereof. South African public awareness of environmental issues is lower than that of many developed countries. As such there is not enough demand for better environmental practice, which would drive policy, legislation and business practices that support more sustainable production.

We need to be aware of the following issues. Forestry potential in South Africa is very limited due to low average rainfall, poor soil indices, and limited arable land. Deforestation and plantations contribute to global climate change and diminished freshwater availability. Imported timber is largely uncertified and a large portion of which comes from poorly managed sources. Increased demand for timber will compound these issues.

1.2 Materials Assessment

Materials assessment draws attention to the locations where the impact is created and felt, to what or who created the impact, to how damaging it is and for how long it will last. These create an understanding of how building impacts the environment and provides a basis from which improvements can be sought.

Materials assessment starts with the definition of the service provided by a product and an examination of alternative products and ways of providing this service. A comparison of the impacts of various products is made using life cycle analysis (LCA).

LCA is the analysis of the impacts of the sourcing, production, use and disposal of material, products and systems.

Material assessment involves defining criteria and then applying a methodology to collect data that is verified and tested against these criteria. Key criteria considered in material assessment are human health, environmental health, resource depletion, fair trade and human resource justice, and user acceptability. Information from such research is presented in various user-friendly formats such points scoring, best practice and environmental preferencing.

A number of methodologies are used in the developed world where such research is well advanced. These often have contextual bias that gives greater importance to certain criteria of evaluation. The various assessment methods do have commonalities, but the conclusions drawn from such assessments are not always directly comparable or universally applicable. This is due to differences in both the methodology and contextual differences between the place where studies are carried out and the place where the data is being applied.

1.3 The approach and aims of this research

This research used the principles of life cycle assessment in that it examined all stages of the timber value added chain for timber production in South Africa. A review of international literature in the field allowed us to develop an understanding of the issues surrounding the timber industry. A review of South African literature and interviews allowed us to identify how timber is produced, sourced, processed and supplied in South Africa, which allowed us to contextualise the use and production of timber in South Africa and highlight the most applicable impacts and issues. Throughout the research examples of how to reduce the impacts of timber were found. Some of these already exist in South Africa, while others are only practiced overseas.

Through this research we hope to increase awareness about impacts caused by the production and use of timber in construction and motivate more sustainable practice. The target audience of this information includes specifiers, clients, institutional procurement departments and ultimately producers, suppliers and manufacturers of timber and timber products.

This research has raised many questions regarding the sustainable production and use of timber in construction. Many of these questions remain unanswered and we hope that this research stimulates both debate and further investigation in this field.

2 Impacts

This section identifies the processes used in the production of timber products and links these to the environmental and socio-economic impacts caused at each stage in the value added chain.

2.1 Supply chain

Table 1 lists six stages in the production of timber and notes the processes that occur at each stage. Impacts are ascribed to these processes and opportunities to reduce these impacts are identified. Figure 4 is a more detailed look at the production of board products and illustrates the production stages. Impacts on a combination of soil, water, and atmosphere occur at each stage. These ultimately affect human, environmental and eco-system wellbeing and are cumulative in effect. Pollutants are both stationery and travel in water or air; persist in the product and off gas throughout the in-use life of the product; and ultimately are released into landfill or the atmosphere if burnt or incinerated. Problems arising from these impacts are described in more detail below.

Table 1: The Timber Value Added Chain.			
STAGE	**PROCESSES**	**IMPACTS**	**BETTER PRACTICE/ OPPORTUNITIES**
1. Procurement			
	▪ Growing trees ▪ Logging ▪ Hauling	▪ **Land** use change ▪ **Biodiversity** loss ▪ **Contamination** of land and water by **chemicals** (fertilizers, herbicides & pesticides). ▪ **Water** - consumption - stream flow reduction - reduced ground water replenishment ▪ **Soil** - compaction by roads - erosion by runoff ▪ **Aesthetic/recreational value** change ▪ **Secondary products**/livelihoods ▪ **Labour** practice ▪ **Energy** consumption ▪ **Greenhouse gas** production	▪ Certification ▪ Agro forestry ▪ Land remediation ▪ Selective logging ▪ Carbon sequestration ▪ Facilitating supported land reform ▪ Secondary forest products ▪ Aesthetic/recreational/tourism value ▪ Landscaping products ▪ Thinnings for furniture, board and board products & composting
2. Processing			
Paper & pulp (not addressed here)			
Rough sawn timber	▪ Milling ▪ Seasoning ▪ Preserving	▪ **Energy** consumption ▪ **Greenhouse gas** production ▪ **Water** consumption and pollution ▪ **Contamination** of land, water and air by process **chemicals** ▪ **Sawdust** and **chemicals** affect **human health** ▪ **Waste** production	▪ Solar kilns ▪ Radial sawing ▪ No additional adhesives ▪ Less toxic adhesives, preservatives & coatings ▪ Waste recycling: pellets/fuel, board and boards products, landscaping products

Boards & board products and veneers	▪ Chipping/peeling ▪ Soaking ▪ Gluing ▪ Pressing ▪ Heat ▪ Drying	▪ **Labour** practice	▪ Fibre substitutes (bamboo etc) ▪ Smart products ▪ Plastic wood
Manufacturing	▪ Assembly ▪ Finishing ▪ Sealing & coating		
3. Commissioning			
Assembly Installation Finishing	▪ Transport ▪ Cutting ▪ Joining ▪ Gluing ▪ Sanding ▪ Sealing & coating	▪ **Energy** consumption ▪ **Waste** production ▪ **Chemicals** that affect human health ▪ **Metal fixings** from non-renewable resources ▪ **Labour** practice	▪ Re-use old wood ▪ Standardised sizes ▪ Design for disassembly & durability ▪ Lower grades and smaller sections ▪ Rational use of valuable timber ▪ Waste management ▪ Natural or less toxic adhesives, coatings and sealants ▪ Mechanical fixing
4. Operation & maintenance			
Cleaning Repair & maintenance Replacement	▪ Washing ▪ Stripping, sanding ▪ Joining, cutting ▪ Re-coating	▪ **Chemicals** that **contaminate** water and affect **human health** ▪ **Water** consumption ▪ **Waste** production ▪ **Sawdust** affects **human health** ▪ **Labour** practices	▪ Less harmful chemicals
5. De-commissioning			
	▪ Disassembly ▪ Break out ▪ Disposal ▪ Re-commissioning ▪ Transport	▪ **Waste** production ▪ **Energy** consumption ▪ **Labour** practices	▪ Recycling and reuse ▪ Jobs in disassembly ▪ Reduced landfill
6. Re-commissioning			

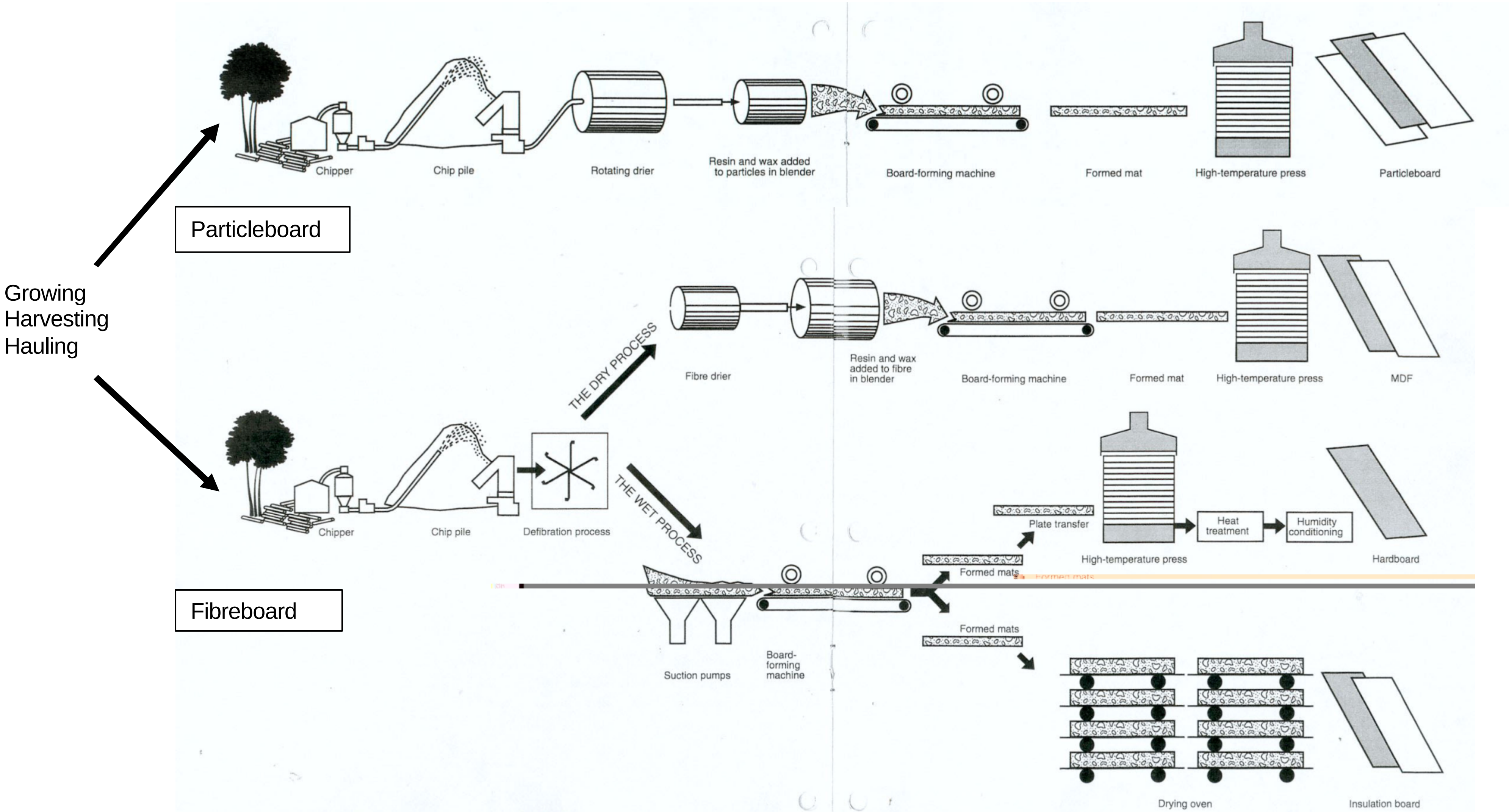

Figure 4: Board Products Manufacturing Processes.
Source: Adapted from SALMA – b (undated)

2.2 Areas of Key Impacts

2.2.1 Ecological and eco-system impacts

To understand the impacts of timber use, one needs a broad understanding of the importance of trees. Forests contribute to climatic control since they play important roles in both the carbon and hydrological cycles. The carbon cycle is the exchange of carbon between the atmosphere, oceans, waterways, land and living organisms. A natural balance is normally maintained between these components. Deforestation and burning fossil fuels change this balance and results in a shift towards higher carbon dioxide concentrations in the atmosphere, which is the primary cause of global warming. Trees cycle water between the land and atmosphere by intercepting precipitation thereby slowing its path to the ground, enabling the ground to more slowly absorb and hold water. Without trees, precipitation would compact soils, wash away topsoil and run very quickly into streams rather than replenishing ground water. Trees also play a vital role in releasing water into the atmosphere by transpiration (evaporation through leaves). This affects the greater hydrological cycle as well as local climatic patterns by influencing temperature and rainfall. Other important ecological benefits of trees include nutrient recycling, holding the soil together and harbouring biodiversity.

While plantations do produce the benefits described above, these are far less than that of natural forests and are not a net benefit when plantations replace natural forest. Plantations on previously degraded land could, however, provide net environmental and ecological benefits provided that there is adequate water available.

Before beginning our discussion on the ecological impacts of plantations, we would like to place the use of construction timber into the perspective of the broader plantation industry.

The majority of plantation timber in South Africa is used to produce pulp (see Table 2). From this table one can infer that the value of pulp is higher than that of sawn timber since less land is used and less volume is needed to create greater revenue than for sawlogs. Additionally the plantation forestry industry exported products to the value of 11.3 billion Rand in 2002 (refer back to Fig. 1). Paper and pulp together formed 63.8% of the value of exported timber products, whereas solid wood products formed only 33.7%. Pulp plays a dominant role in the forestry industry, and is thus responsible for a larger proportion of the ecological impacts of plantations. This raises the question as to whether good use is being made of what is a limited resource in South Africa. Should a low value, short life product such as paper be made from slow growing resources such as trees when alternative fibre crops such as hemp, kenaf or bamboo could be used to produce paper? Should we not look at ways to reduce paper use and recycle more?

Table 2: Percentage timber production in South Africa by product according to land management objective, production volume and value of products.
Source: Data adapted from FSA (2003)

	Pulp	Sawlogs	Mining	Other
Management Objective	56%	37%	3.8%	3.1%
Roundwood volume	63.7%	26.5%	4.3%	5.6%
Rand Value	73.5%	21.5%	1.9%	3.1%

More specific to the investigation of timber in the construction industry is the fact that 30.6% of softwood plantations (pines species) is managed for pulp production rather than sawlog production (FSA, 2003). The questions that arise from this are:

1. Should softwoods be used for paper production when they could be used for construction?
2. Can Eucalyptus trees be used more in construction? At present the majority of Eucalypts are converted to pulp (80,2%), while only a small proportion are used to produce sawlogs (3,9%) and poles (5.3%; FSA, 2003).

2.2.1.1 Impacts of Plantation Timber

South Africa does not have extensive, natural timber resources. Natural forest only accounts for 0.2% (327 600 ha) of South Africa's land area (DWAF, 1998). Thus most timber used in South Africa is plantation grown. Plantations cover 1,1% (1,351 million ha) of the country (FSA, 2003).

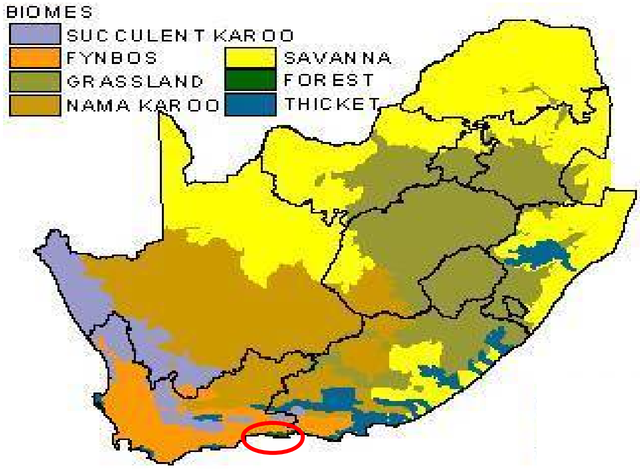

Figure 5: The Biomes of South Africa

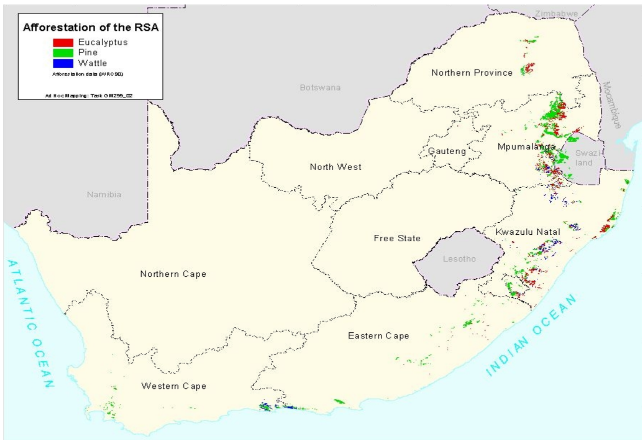

Figure 6: Plantations in South Africa
Source: FSA (2003)

The most important ecological problems arising from plantation grown timber are habitat destruction, biodiversity loss and impacts on water resources.

Plantations have replaced natural vegetation such as grasslands, indigenous forests and fynbos, which are either small and/or particularly sensitive biomes. Biodiversity is at particular risk in these biomes due to the high degree of endemism they exhibit. The fynbos is a case in point being the smallest of the world's six floral kingdoms and the only one that is contained within a single country.

Plantations are monocultures that support far fewer species than indigenous forests or other natural ecosystems. The replacement of natural vegetation by plantations causes a loss of biodiversity. Herbicides and pesticides used in commercial forestry further contribute to biodiversity loss.

Many of South Africa's plantations are found in high rainfall areas that are important water catchments. Plantations species include pines, eucalypts and to a small extend wattles. These trees are alien species and use more water than indigenous vegetation (Davies & Day, 1998: 338). Plantation forestry uses about 1.2 billion cubic metres of water that would otherwise contribute to stream flow and other uses. This is about 30% of urban and industrial water use in South Africa (DWAF, 1998). Water is in short supply in South Africa. Average annual rainfall is 452mm compared to the global average of 860mm (Davies & Day, 1998: 315).

Other ecological impacts of plantation forestry include acidification of soils, loss of soil fertility, eutrophication[1] of waterways by fertilizers, contamination of soil and water resources by pesticides and herbicides, and the compaction of soils by vehicles and machinery (Berge, 2001: 166; DWAF, 1998).

2.2.1.2 Timber from natural forests and woodlands

While plantations supply the bulk of South Africa's timber requirements, they do not produce naturally durable timber nor timber of a high aesthetic quality. Some such timbers are found in the Knysna forests and woodlands in various parts of the country but supply is extremely limited. Ultimately, South Africa is heavily dependant on imported timbers to supply the demand for durable and high-class timbers.

South Africa imports the majority of its hardwood timber (mainly meranti) from the tropical rainforests of Malaysia. Careful management of natural forests is necessary to ensure that natural timber re-growth matches extraction. The failure of many countries to do so has led to wide scale deforestation. Average worldwide deforestation through the 1990s was 14.6 million hectares per annum (the Kruger National Park is nearly 2 million hectares in extent), most of which occurred in tropical rainforests. World forest cover was 3866 million ha in 2000, of which 47% was tropical rainforest (FAO, 2001). Rainforests provide more ecosystem services per unit area than temperate forests.

The causes of deforestation are varied and logging for construction timber does not cause all deforestation. However logging has an indirect effect in that it opens up areas to other forms of exploitations such as agriculture.

2.2.2 Energy consumption

The majority of South Africa's electricity is derived from coal fired powered stations that produce carbon dioxide thereby contributing to global warming. Additionally, these power plants cause air pollution, which in the case of nitrous oxides and sulphur dioxide cause acid rain. Nuclear power has inherent risks and radioactive waste disposal is an unresolved problem. Energy produced by boilers that are fired on hydrocarbons will have the same effects as electricity production from fossil fuels. Thus the use of energy in the processing of timber has important environmental impacts.

2.2.2.1 Embodied Energy

Timber is perceived to have relatively low embodied energy. This is generally true but does depend on the product. The key factors that contribute to the embodied energy of *sawn timber* products are transport and kiln drying.

Transport occurs at all stages in the timber processing chain. Transport energy is a more important component of the embodied energy of imported timber than local ones. Nationally, regional distribution of timber resources relative to demand also determines the embodied transport energy of a product. Mills in the Western Cape have experienced supply shortages in the past and at times depended on timber brought in from other parts of the country. This region may experience shortages in the future since many of MTO's[2] plantations may not be replanted after the timber is harvested.

Kiln drying adds dimensional stability to timber and thereby reduces timber-processing waste. However, it contributes to 75% of the energy used to produce sawn softwood. (Lawson, 1996: 22). Hardwoods must be allowed to partially air dry before they can

[1] Eutrophication is a process whereby high levels of nutrients support abnormally high levels of aquatic plant growth, which ultimately leads to a decrease in dissolved oxygen concentration and lower water quality.
[2] MTO (Mountains to the Sea) is a company that owns a large number of plantations in the Western Cape that were previously managed by SAFCOL.

enter kilns. As such hardwood products have less embodied energy than softwood products (Lawson, 1996: 24).

In South Africa, kilns are normally powered on wood waste. This is a cost effective way of dealing with this waste and generating power. However wood waste could be put to other uses if solar kilns were used to season timber. Other uses for wood waste are animal bedding, board product manufacture and pellet production for heat and power generation. Consideration would have to be given to the transport costs that would be incurred if wood waste is not dealt with on site.

A combined gas and solar kiln is available in Australia and has been reported on in a South African trade journal (Anon, 2003c). India has used solar kilns since the eighties. The authors are unaware of any commercially use solar kilns in South Africa, although one academic institution is doing experiments with solar kilns.

Table 3[3]**:** Process Energy Requirement[4] (PER) of timber and some common building materials.
Source: Lawson, 1996: 13

Product	**Embodied energy (MJ/kg)**
Timber products	
Air dried sawn hardwood	0.5
Kiln dried sawn hardwood	2
Kiln dried sawn softwood	3.4
Particleboard	8
Plywood	10.4
Glulam	11
Laminated veneer lumber	11
MDF	11.3
Hardboard	24.1
Other Materials	
Stabilised earth	0.7
Concrete block	1.4
Clay bricks	2.5
Cement	5.6
Mild steel	34
Aluminium	170

The production of *board products* and *engineered timber* is more energy intensive than the production of sawn timber as can be seen in Table 3. Energy used in the production of laminated products such as plywood includes peeling the logs, (which are soaked in hot water and hence there is an additional impact on water resources), cutting and drying the peelings, and pressing the mats (bonded layers of veneers) at high temperature and pressure. Particle and fibreboard production uses energy in chipping logs and thinnings, drying the chippings (particleboard and MDF only), and pressing the formed mats at high temperature and pressure. Soft fibreboard products (insulation board) are not pressed, but are dried in ovens. These processes were graphically illustrated in Figure 4 further back in the document.

[3] This data is from overseas sources and it must be borne in mind that it may not be directly applicable to our local conditions. Additionally it must be emphasized that embodied energy is not the only criteria against which environmental performance can be measured, and that in our context embodied water, for example, may be an equally important measure. As materials assessment methods advance, more factors are taken into account.
[4] PER is the component of embodied energy that relates directly to the manufacture of a material or component.

The energy used in the production of synthetic resins can be high and must be taken into account for products that use these binders. This is equally true for coatings and sealants that are also most commonly produced from petrochemicals in energy intensive processes.

Timber preservation methods vary in their energy use. Pressure treatments force the preservative into the wood structure. All commonly used preservatives and boron can be applied in this way. Creosote can also be applied to timbers by submerging the timber in tanks of preservative heated to 80ºC to 90ºC and then allowed to cool. Only seasoned timber (either air or kiln dried) is treated as described above, however unseasoned timber can be preserved with boron by emersion into a preservative solution (SALMA – a, undated).

We have no data for the relative amount of energy used in these processes, but it is clear that the boron emersion method is the most energy efficient. When treating with creosote the hot-cold submersion method is likely to be more efficient than that of pressure treating since the pressure treatment also requires heat. Moreover, smaller treatment plants that use firewood boilers that run off timber off-cuts usually use the hot-cold tank method.

The CCA treatment of poles uses less energy than that of sawn timber since poles are not normally kiln dried before treatment, whereas sawn timber is.

2.2.2.2 Building operation and decommissioning

Energy is consumed throughout the lifecycle of a building. In buildings of low embodied energy and in more extreme climates, operational energy becomes an important component of total energy consumption. The implication is that materials that contribute to energy efficient building operation and maintenance are desirable. Timber is one such material since it is a poor conductor of heat. Its use in applications such as flooring and cladding can contribute to improved energy performance of buildings. Timber framed windows are more thermally efficient than those made of other materials such as steel and aluminium (Wilson, 1996), the importance of which is relative to extremes of temperature experienced in an area.

Maintaining components is more energy and resource efficient than replacement (Walker-Morrison, 2003). The most important aspect of building maintenance applicable to timber components is the production and application of coatings and sealants needed to protect timber. Energy consumption in this regard can be minimised by detailing timber to protect it from weathering and by choosing natural oils or paints rather than synthetic oils and varnishes derived from petrochemicals that carry a much higher embodied energy (cited in Woolley *et al* 1997: 138). This, however must be balanced by the higher maintenance costs often associated with natural products which may necessitate more frequent cleaning and recoating, most evident of which are applications that experience much wear and tear such as flooring.

Finally, in both the retrofitting and decommissioning of buildings, energy is consumed. Timber is interesting in this regard since it has high potential for re-use and can be used for fuel. These are however critically dependant on how timber components are made. Design for disassembly and reuse should be considered at the beginning of projects.

2.2.3 Human health

The use of timber in itself does not cause health problems, and in fact can contribute to good indoor air quality since it regulates indoor air humidity (Baggs & Baggs, 1996). However, to ensure its durability, timber is treated with preservatives and finished with coatings and sealants. The production and application of these products affect both worker and user health.

2.2.3.1 Milling

The milling and manufacturing of timber products creates wood dust that can cause allergic reactions, asthma and cancer (Bower, 2000: 291; cited in Willis & Tonkin, 1998: 46). Wood dust from oak and beech is carcinogenic (Berge, 2001: 169). On site sawing of wood has similar health implications, additional to which must be considered the toxicity of sawdust from preservative treated timber.

2.2.3.2 Preserving timber

Commonly used timber preservatives in South Africa are CCA (copper, chrome arsenic), creosote, TBTOL (Tributyltinoxide-lindane), PCP (Pentachlorophenol) and less frequently, boron salts.

CCA is a water-borne preservative that is highly toxic in its fluid form and in wet timber. It is poisonous in very small quantities and is also carcinogenic (Woolly *et al,* 1997: 108). It poses a serious health risk to treatment plant workers. It is claimed to be stable and to not leach once the timber has dried, however, studies show evidence of both leaching and toxicity, especially for children on playground equipment in the USA (Environmental Working Group, 2001).

Creosote is carcinogenic, genotoxic and an irritant (Woolley *et al,* 1997: 107). Exposure can be through both direct contact and vapour inhalation. The constituents of TBTOL, tributyltinoxide and lindane are highly toxic to humans, cause a range of illnesses and even death in the case of lindane. (Woolley *et al,* 1997:112). Boron compounds are considered to be the least toxic of all preservative treatments, but can have toxic effects if ingested or exposed to in large quantities (Woolley *et al,* 1997: 108).

PCP is a solvent born preservative that has similar applications to TBTO-L. PCP is extremely toxic and has been responsible for many deaths world wide. The impacts of PCP are so severe that it is completely banned or severely restricted in the developed world. It has been written out of South African timber preservation codes, but is still available.

The European commission has banned the use of CCA in all residential applications and initially proposed to ban it from all applications except for railway sleepers, electricity and telephone poles, and industrial cooling towers (ENDS, 2003a). The use of creosote in Europe is effectively limited to applications where skin contact is uncommon and it cannot be sold to the public (ENDS, 2003b). Lindane has been banned or severely restricted in several countries including Japan and the USA. TBTO use has also been restricted in Europe. (Woolley *et al,* 1997). None of these products are banned in South Africa and creosote can be bought by anyone.

2.2.3.3 Adhesives

Laminated timber products, particleboards and MDF use resins as binders. The resin chosen depends on the intended application of the board product as indicated in Table 4.

Table 4. Description of adhesive types appropriate for various exposure classes. Source: SALMA – b (undated)		
Exposure class and application	**Conditions of exposure**	**Type of adhesive**
Class 1 (exterior)	Exposed (constantly or intermittently to water) to open air	Phenolic formaldehyde & isocyanate
Class 2 (semi-exterior)	At infrequent intervals exposed partially or as a whole to unprotected open air conditions	Phenolic formaldehyde, isocyanate, melamine formaldehyde, and melamine-urea formaldehyde combination only
Class 3 (humid interior)	Constantly protected from water, but exposed to conditions which may cause components to attain a moisture content exceeding 170g/kg	Any type
Class 4 (dry interior)	Exposed to dry, sheltered (indoor) conditions only	Any type

Urea formaldehyde is cheaper than other resins and is thus the most commonly used resin, except for class 1 and 2 applications. Urea formaldehyde glues are the least stable of the formaldehyde based resins and off gas continuously at room temperature. Formaldehyde is carcinogenic, allergenic (Berge, 2001: 30) and mutagenic (Bower, 2000). Exposure to formaldehyde also causes skin allergies and disease, respiratory irritation and locomotive disorders (Woolley *et al,* 1997: 85). Formaldehyde off gassing is particularly problematic because formaldehyde is found in many products including carpets, vinyl plastic floor and wall tiles, plastic bags, permanent press clothing and linen; and some glues, perfumes and detergents (Baggs & Baggs, 1996: 141).

The concentration of formaldehydes can be low in well-ventilated rooms and may not cause immediate reaction in all but the most sensitive people. However regular exposure causes a cumulative effect whereby an individual becomes more sensitive. This accumulation is also responsible for diseases such as cancer, which develop over longer periods of time. People working in the manufacture of board products are the most at risk due to continued and higher levels of exposure.

Isocyanate resins are considered to be stable at room temperature and not problematic for users. They have the additional advantage of being stronger and can be used in smaller quantities (Woolley *et al*, 1997). They are however toxic to workers exposed to it during manufacture and great care must be taking in manufacturing board products.

2.2.3.4 Coatings and sealants

These products may be water or solvent based, and both classes may be made from natural or synthetic materials. All solvent based products off gas volatile organic compounds[5] (VOCs) both in their production and use. Water based products may also off gas VOC’s but in much lower quantities than solvent based ones. VOCs are known irritants and possible carcinogens (cited in Willis & Tonkin, 1998: 50).

2.2.4 Environmental Health

The most dangerous environmental impacts of timber preservatives lie in the possible contamination of land and water caused by the treatment and disposal of treated timber. The very nature of these preservatives means they will be toxic in the

[5] Volatile organic compounds are the lighter fractions of oil or hydrocarbons. They evaporate easily and thus are linked to air pollution.

environment. Severity is linked to the persistence of the toxic components. Two components of CCA, chromium and arsenic, are highly persistent. They do not biodegrade in landfill and are concentrated when treated timber is incinerated (Wilson, 1997). Similarly, lindane is an insecticide that is comparable to DDT in terms of its toxicity and high degree of persistence (ENDS, 2000).

Creosote is derived from coal tar. The environmental impacts of this industry include land contamination and air and water pollution. Creosote can migrate through the soil, but is ultimately biodegradable (cited in Woolley *et al,* 1997: 107).

Artificial resins and coatings are normally produced from petrochemicals. Nitrous oxides and sulphur dioxide are produced as waste products, both of which cause acid rain. VOCs are released during manufacture, and in the case of solvent borne paints, during use. Apart from their toxicity to humans, VOCs cause chemical and photochemical reactions in the atmosphere that lead to the formation of smog. The secondary pollutants associated with smog (for example low level ozone) damage plants, materials and human health (Woolley *et al*, 1997). The petrochemical industry as a whole releases other toxic elements such as particulates and heavy metals into the environment.

2.2.5 Socio-economic impacts

Forestry practice has been discussed in terms of its ecological impacts. There is a suite of socio-economic impacts that derive from forestry practices both locally and internationally.

The majority[6] (63.2%) of plantations in South Africa are privately owned (Forestry South Africa, 2003), the bulk of which are held by a few large companies. In some cases ownership extends down the value added chain from forests to mills, and right down to manufacturers and merchants.

Some forested land has been subject to land claims. Tenure in general is an issue for people short of land or whose security is threatened by the sale of state assets to private companies (DWAF, 1998). Secondary forest products from both plantations and natural woodlands and forests include firewood, saplings, medicinal plants, honey, edible plants and craft materials. These are particularly important to impoverished communities who may also require to live on the land and not just have access to its products. There has been a trend to contract out forestry operations that can negatively affect workers job security and benefits and result in poor quality of work (DWAF, 1998).

Imported timbers often come from countries that have insufficient controls over logging practices. Illegal logging is common and is often linked to corruption and human rights abuses (FAO, 2001). Indigenous people whose way of life depends on non-timber forest products are most at risk. Worker rights within the industry itself are abused, workers receive low wages and work in unsatisfactory conditions.

2.2.6 Waste Production

In many countries the construction industry accounts for 40% of the total waste stream (Macozoma, 2002). Waste occurs in all stages of a buildings life cycle. An estimated 80% of a tree is wasted from the harvesting of a tree to the manufacture of a solid wood, end product (Anon, 2003a). When one expands this to include construction, this figure is pushed up to 94% (Santana, 2002).

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[6] This proportion has grown since 2002 with the conclusion of deals to package and sell off SAFCOL's larger plantations.

Table 5. Timber wasted in building products. Source: cited in Santana (2002)	
Process stage	**Waste Rate (%)**
Sawlog	40
Transport	6
Sawmill	27
Drying	5
Retail	3
Standard sizes	5
Over specification	6
Installation	2
Total:	**94**

Excessive waste production has the following impacts. More timber needs to be grown and processed to produce a certain amount of building. Accordingly the impacts highlighted throughout this paper are exacerbated. Additionally, waste has direct implications in the use of land for landfill and the pollution of land and water resources by waste, which, as in the case of preservative treated timber, carries toxic chemicals. Finally, there is a direct financial cost of both excessive production and waste disposal and management.

3 Reducing the impacts of timber production and use

These guidelines provide broad advice to reduce the negative impacts of the use of timber. This information has been ordered to reflect the process of specifying timber rather than by impact as for the previous section since this is seen to be useful to the specifier.

3.1 Choosing timber species and grades

The selection of the species of timber to be used for a particular application must be based on several criteria including fitness for purpose, vulnerability of timber species, management of source and location of timber source.

3.1.1 Fitness for purpose

Inherent properties of timber broadly include strength, durability, dimensional stability, workability and aesthetic qualities. These must be matched to the requirements of the proposed application, taking into consideration the expected lifespan of the application and the possibility of re-use of the timber components. For, example the turnaround time for shop fittings is short and the potential to recycle such components is low. Highly durable, valuable and rare timbers are therefore not recommended. Further research will rate commonly available timbers in terms of their properties and make recommendations as to what timbers are most suitable for particular applications, taking into account the environmental impacts associated with their production and use.

3.1.2 Vulnerable timber species

Some indigenous and imported timbers are vulnerable because they are naturally rare and/or endangered. For example, big leafed mahogany (*Swietenia macrophylla*) typically occurs very sparsely, about one intermediate sized tree per hectare, in the Amazon (FoE, 1996). Unscrupulous logging has caused this and other more naturally abundant species to become endangered.

CITES (Convention for International Trade in Endangered Species) is an international convention that protects endangered plants and animals. Species threatened with extinction are listed on one of three indices based on their degree of vulnerability. A number of timber species are currently listed by CITES. Some species are listed in indices that allow a degree of trade, while others have special permits attached that allow certain countries to trade specified amounts of the timber for specified periods. Commercial trade in other species is completely banned (CITES, 2004). However due to the large amount of illegal activities in the industry, and the fact that monitoring of timber imports into South Africa is inadequate, the authors recommend that no CITES listed timber be specified. Afrormosia is the most commonly used CITES listed timber species in the South African construction industry.

Table 6: CITES listed timber species that are used in South Africa.[7]

Common Name	Other Names	Scientific Name
African Teak	Afrormosia	*Pericoptus elata* or *Afrormosia elata*
American mahogany	Cuban mahogany, West Indian Mahogany	*Swietenia mahogoni*
Brazilian rosewood	Bahia rosewood	*Dalbergia nigra*
Big leafed Mahogany	Brazilian mahogany, Honduras Mahogany	*Swietenia macrophylla*
Honduras Mahogany	Mexican Mahogany	*Swietenia humilis*

The IUCN (World Conservation Union) is an international organisation that plays various roles aimed at conserving natural resources. One of their functions is to monitor the state of the world's species by maintaining the Red Data List of endangered and threatened species. Ongoing scientific assessment provides information that allows scientists to classify species according to their degree of vulnerability. Species that are classified as Critically Endangered, Endangered and Vulnerable are included on the Red Data List (IUCN, 2004). Included in these species are a number of timbers that are used in South Africa.

[7] This data has been sourced from the CITES website by searching their lists for timbers that are commonly used in the South African construction industry. Since some less commonly used species may be encountered, and the fact that CITES lists are continually updated, specifiers should check the lists before making a decision. The CITES website is www.cites.org.

Table 7: Common timbers listed on the IUCN Red Data List.		
COMMON NAME	**SCIENTIFIC NAME**	**STATUS**
African Timbers		
Afrormosia	*Pericoptus elata or Afrormosia elata*	Endangered
Bubinga	*Copaifera salikounda*	vulnerable
Okoume	*Aucoumea klaineana*	vulnerable
Mahogany (African)	*Khaya ivorensis*	vulnerable
Sapele	*Entandrophragma cylindricum*	vulnerable
Asian Timbers		
Balau	*Shorea spp.*	Many *Shorea* species are critically endangered, endangered or vulnerable
Meranti	*Shorea spp.*	
Keruing	*Dipterocarpus spp*	vulnerable
Indian Rosewood	*Dalbergia latifolia*	vulnerable
Merbau	*Intsia bijuga*	vulnerable
Latin American Timbers		
American mahogany	*Swietenia mahogoni*	Endangered
Big leafed Mahogany	*Swietenia macrophylla*	vulnerable
Honduras Mahogany	*Swietenia humilis*	vulnerable
Brazilian rosewood	*Dalbergia nigra*	vulnerable
Imbuia	*Phoebe porosa or Ocotea porosa*	vulnerable
Pau Marfim	*Balfourodendron riedelianum*	Endangered

In South Africa, all indigenous forest species are protected and a permit is required to fell forest trees. Vulnerable indigenous woodland tree species are also protected under the National Forestry Act, which demands a licence to fell indigenous trees listed on the Department of Water Affairs and Forestry's protected species list which is in the process of being updated. Kiaat also called African Teak (*Pterocarpus angloensis*) and Chamfuta also called Pod Mahogany (*Afzelia quanzensis*) are the two most commonly used woodland timber species that will appear on this list (Golding, 2002)

The problem with this form of protection is twofold. Many of these species are found in nearby countries where they may or may not be sustainably managed, but are nevertheless harvested and imported into South Africa. Thus it is extremely difficult to determine whether a protected timber has been illegally harvested in South Africa or imported from another country. Secondly, there is limited funding and expertise in various government departments to control trade and enforce regulations. Specifiers should try to determine the source of such timbers before specifying them.

3.1.3 Management of sources

Timber certification schemes are a means of identifying timber from sustainably managed forests. Forestry practices are assessed and if certain criteria are met, the timber originating from those forests is labelled as certified. This enables customers to support the sustainable management of timber resources.

The Forestry Stewardship Council (FSC) is the most credible such scheme and operates internationally. Their evaluations are based upon both social and environmental criteria. They oversee the inspection and certification of forestry operations by independent, third party auditors. Two types of certificates are available.

Forest Management certificates apply to forestry management practices while Chain of Custody (CoC) certificates apply to forest products. CoC certificates provide a means of tracking timber from sustainably managed forests through the value added chain. Certified timber can be identified by either looking for the FSC stamp on the finished product, asking the supplier to show the FSC certificate or by examining the invoice which must show proof of certification.

The indigenous forests of the S. Cape and about 80% of South African plantations are FSC certified. Specifiers can thus discern between certified and non-certified local timber by requesting CoC certificates from suppliers. The FSC website (www.fscoax.org) lists all certificate holders. Criticisms of certification is that while most of South Africa's plantations are certified, there are relatively few suppliers and manufacturers that have CoC certification. This means that it may be difficult for specifiers to get hold of certified timber. Secondly, forest management certificates for plantations assess the management of the plantation, but do not go one step back in the process and consider if the plantation should be there or not. This is a particularly pertinent question in South Africa since our plantations have large impacts on our limited water resources and biodiversity.

The only imported timber that we are aware of that is FSC certified is Zambezi Teak. Only a few suppliers of Zambezi Teak originating in Zimbabwe are certified – the majority are not. Until more certified timber becomes available, the following guidelines may allow specifiers to make more informed choices.

Meranti is the timber imported into South Africa in the largest quantity and is used largely for joinery. It comes primarily from Malaysia. Malaysia has a national certification program that is structured similarly to that of the FSC. However, the timber imported into South Africa is not certified, and some may be illegally logged. Additionally there is doubt as to integrity of their certification scheme. This guideline applies to all SE Asian timbers.

Jarrah and Karri are hardwoods imported from Australia. The importers claim that the timber is from sustainably managed sources that hold an Australian Forestry Standard certification, however they do not carry a CoC certificate.

Hardwoods such as ash, beech, maple, walnut, cherry and oak are imported from United States and Beech and Larch from Europe. There are several regional and national certification schemes operating in these regions, but we do not know of anyone in South Africa who trades in timber or timber products that carry a CoC certificate from such a scheme. Europe's forested land area is on the increase (Wood for Good, 2004) as are hardwood forests in the United States (AHEC, 2004). In general the management of timber resources in these regions is good. However, unless a certificate is attached to the timber, there is no assurance that it has been sourced from a sustainably managed forest.

African timbers include Okoume, Iroko, Sapile, Zambezi Teak, Kiaat and Afrormosia. As mentioned the last two are protected species. The source of all these timbers is often not easily determined and the sustainability thereof is questionable. We are aware of one joinery company that imports at least a certain proportion of its African timber from forests that have been have been certified and the certification has been verified by Keurhout. Keurhout is a Dutch organisation that verifies certification from various national or international schemes against a set of minimum requirements determined by the Dutch government in accordance with ITTO (International Tropical Timber Organisation), FSC and UNCED (United Nations Conference on Environment and Development) Forestry Principles (Keurhout, 2002).

Timber imported from South America is not certified and like SE Asian and tropical African timbers, is sourced from tropical rainforest. Two CITES listed timbers, Brazilian Rosewood and Mahogany, come from this region and should definitely not be used.

3.1.4 Location of timber source

The more distant the source, the greater the embodied energy of the timber product will be. Locally grown timbers are most preferable in this regard. For high quality, imported timbers, those from other African countries are preferable to those that come from other continents.

Within South Africa differentiation can also be made. Most plantation timber originates from the eastern parts of the country, from Mpumalanga to the E Cape. These areas are close to the major centres of demand. The Cape Peninsula, however, is not self sufficient in timber resources, and as mentioned this situation may be aggravated in the future as designated land falls out of timber production.

3.2 Effective use of timber to reduce waste

For more general ways to reduce waste production and encourage the reuse and recycling of building materials refer to Macozoma (2002). A number of guidelines specific to the use of timber in construction are discussed below. These include strategies to both reduce waste production and to ensure that re-use and recycling are more feasible.

The specification of timber products can have upstream impacts on waste production. More waste is created in milling and manufacture of large sections of high strength and aesthetic quality grades. Specifiers should rather use smaller sections, finger jointed material and specify lower aesthetic grade internal components such as flooring and ceilings.

At the design stage, careful planning can ensure more efficient use of timber by not over specifying, and by ensuring that standard components be used to eliminate the need to cut timber on site. Less finished and untreated timber can also be detailed elegantly to exploit those particular qualities. Design for durability will also ensure that timber components need less maintenance, last longer, and are in a suitable condition for recycling. Design for disassembly makes re-use and recycling possible. Joints that are bolted or screwed rather than glued or nailed make recycling more feasible. The use of glues, synthetic coatings and toxic preservatives precludes the possibility of safe composting or using recycled timber as fuel.

Milling is the largest single contributor to waste in the timber processing chain. Conventional milling wastes approximately 60% of a log. Radial sawing is a technique that reduces waste to as little as 20% (cited in Willis & Tonkin, 1998: 42). Radial sawing cleaves the log perpendicular to the growth rings, like cutting a pie. Additionally, younger trees can be used since radially sawn timber shrinks evenly and thus bends or warps less than conventionally sawn timber when dried (Radcon, 2004). Radial sawn timber poses interesting design possibilities due to its wedge shaped profile, but can also be milled to a rectangular form. The authors do not know of any companies that sell radially sawn products in South Africa.

There will always be a certain amount of waste produced and management strategies should focus on converting this waste into useful products. Ways to use wood waste and the use of alternative sources of fibre to make wood products are discussed in the next section. Wood waste can also be used in other industries. Waste timber can be processed for use in landscaping. Waste timber can be used as fuel. Wood pellets[8] are a large and growing source of bio fuel, especially in Scandinavian countries where virtually all wood waste from mills and manufacturers is collected and pelleted (Anon, 2003a). The market for pellets has grown so much that these countries now import wood pellets. In South Africa, deforestation of indigenous forests and coppices is largely brought about by the dependence on fuel wood by low income and rural communities the latter of which forms 40% of the population.

3.3 Smart use of wood

3.3.1 Board products

Board products are cited as having a positive, remedial impact on the waste stream of the timber industry since they use thinnings and waste from sawmills as their raw material. However, what originated as an industry based on recycling waste material has become one that relies heavily on roundwood for raw material input. The use of toxic resins in processing is also a problem that needs to be addressed in this industry.

Several options exist that would reduce the impact the board products industry has on timber resources. Board products can be made from non-timber plant fibres. One such product is made of waste straw and has properties that are something between MDF and particleboard (Anon, 1999a). Timber recycled from demolition of old buildings is another source of fibre, and one Canadian company has invested in a MDF plant that uses recycled timber (Anon, 1995). Finally, there is research being conducted into the use of alien trees cleared by DWAFs Working for Water programme for the production of board products.

Another problem with wood products is the use of toxic resins. Directives exist in some countries to limit the amount of formaldehyde that can be off gassed from a product. Some manufacturers go beyond these benchmarks and have been able to produce zero formaldehyde emission wood products. This is achieved by substituting urea formaldehydes for phenol or melamine formaldehydes, which offgas less, or by using isocyanate or natural resins that do not contain formaldehyde. Natural resins can be made from soya, blood albumen, casein and animal products, but are not suitable for outdoor use. Since these products are not available in South Africa, where possible it is suggested that wood products that do not use resins such as hardboards be used instead of products such as MDF and particleboard. Plywoods generally have less resin content than boards produced from chips (Woolley *et al*, 1998: 85).

Indoor plants can reduce the threats posed by formaldehyde and other indoor air pollutants. Wolverton (1996) lists 50 indoor plants that are effective at absorbing and breaking down a range of indoor pollutants.

3.3.2 Other wood products and alternatives.

Hawken *et al* (1999: 182-184) cite a number of smart wood products. These include laminated timber beams that use smaller sections of timber that can be sourced from offcuts or younger, smaller trees. Glulam is one such product that is commonly available in South Africa. An even stronger glulam beam that incorporates carbon fibre between the wood makes for stronger yet lighter beams. Logs from younger trees can be quarter sawn and the resulting four pieces joined with the bevelled edge facing inwards to produce a hollow core square beam that is larger and stronger than a beam that could have been cut from the log using conventional methods. Wooden I-beams that consist of plywood webs between solid wood flanges are now standard in North America for applications such as floor joists.

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8 Wood pellets are small cylindrical pieces of compressed sawdust, woodchips and/or wood shavings that can be used in electricity generators or as a source of fuel in the home.

Timber components and systems can be redesigned to use less wood while still providing the same level of service. For example, an Italian woodworking shop has been able to produce cabinet and full size interior panel doors that use 40% less timber than normal panel doors (Rigato, 2004). In South Africa a girder beam assembled from wooden 38x38 battens joined by a zig-zagged, galvanised steel lattice is available as a proprietary product. Its applications range from rafters, to beams, joists and vertical studs. Larger sections of timber, laminated timber, thicker lattice material and wider spacing of the top and bottom chords allow the product to be used for heavy loads, spans as large as 22m and curved roof forms (Mike Tremeer, pers. comm. 2004).

Plastic wood is a product that uses recycled plastic in combination with sawdust or other natural, waste fibres such as rice husks to produce planks that have the appearance and workability of solid wood, but are more durable, and are thus particularly suited to outdoor applications such as decking (Anon, 1998; Anon, 1999b).

Bamboo is a fast growing fibre that is stronger per unit weight than timber (Cusack & Yiping, 2002). It is widely used in Asia as a structural material and as scaffolding. Engineered bamboo products include plywood, laminated floorboards, laminated beams, particleboard and chipboard (Cusack & Yiping, 2002). Laminated tongue and groove floorboards are available in South Africa. The feasibility of bamboo in remediating degraded land needs further investigation. The use of hemp impregnated with mineral products has a longstanding tradition of building application in France.

The durability and hardness of Radiata pine can be improved by injecting a cellulose-petrochemical compound into wood cells (Anon, 2003b). As far as we know, this technology is not used in South Africa.

While all these products have the benefit of reducing the demands on wood resources, some do have the disadvantage of being more energy intensive in their production and often make use of toxic resins. Additionally since they are composite materials, their recyclability is reduced. These factors must be borne in mind when assessing each individual product.

3.4 Preservatives

Timber preservation is controlled by the SABS (South African Bureau of Standards) who classify the hazards to which timbers can be exposed and state what preservatives may be used for each hazard class. These classifications focus on the performance of the timbres rather than the impact on human health and the environment. Structural hardwood poles (gum poles) must be treated in all parts of the country, while structural softwoods (SA pine) must be treated at the coast. Hazard class 2 timbers (interior timber above ground) can be treated using any preservative. CCA is commonly used for structural timbers such as trusses, but this is not necessary. Boron could be used. However, boron treatment is not widespread and suppliers do not stock large amounts of treated timber. A greater demand of this product would make it more feasible for suppliers to stock it as a standard product.

In many parts of the country there is no need to treat non-structural timbers in hazard class 2. At the coast, preservation is recommended for softwoods but naturally resistant hardwoods do not need treatment. If treatment is applied, organic solvent borne preservatives are often used for applications that require dimensional stability (mouldings, flooring window & door frames), since the solvent quickly evaporates off while water would not, and such treatment does not discolour the wood. Alternatives to TBTO-L exist abroad and are being brought onto the market in South Africa. One such product is TBTN-permethrin which is less toxic than TBTO primarily because of the use of permethrin instead of lindane. Permethrin is both less toxic and less persistent than lindane (Woolley *et al*, 1997). A product that does not use white spirits as the solvent has been developed in Australia and in the future may be marketed in South Africa as an alternative to organic solvent borne preservatives (Anon, 2004).

Boron, due to its low toxicity, would be a preferable form of treatment to TBTO or permethrin. However, boron treatment methods used in South Africa are unsuitable for treating timber used in applications that need dimensional stability. A gas phase process using boron as the preservative that does not affect the dimensional stability of timber exists, but is not used in South Africa.

Hazard class 3, 4 and 5 timbers (exterior above ground, timber in ground contact and timber in fresh water respectively) are subject to leaching so the preservative must be fixed. Water borne boron is unsuitable in this regard and CCA or creosote is used using a pressure impregnation process. Two alternatives to CCA exist: ACQ (ammoniacal copper quaternary) and copper azole. Both these products are less toxic and less persistent than CCA, can safely be burnt and composted (Woolley *et al,* 1997; Walker Morrison, 2003). Copper azole has recently been introduced into South Africa and is being marketed as Tanalised Ecowood[9] (Anon, 2004).

Leaching of preservative from treated timber in ground contact can be prevented by using a product called the Field Liner which is a geotextile that fits over the bottom of a pole that is planted in the ground. The soil is protected from contamination and the pole last longer because the preservative does not leach and the Field Liner acts as a physical barrier to termites. Currently it is used in conjunction with CCA and creosote treated poles for H4 applications mainly in agriculture and tranmission poles. However there is scope for it to be used in conjunction with boron treated timber in the construction industry. Current building codes do not permit boron treated timber to be used for in ground applications, even if the Field Liner is used.

A number of natural preservatives that were used in the past do exist. These include a clay called Swedish Red, but is problematic since it has a high lead content. A preservative called Reseda glaze, which is derived from a plant *Reseda luteola*, is another alternative that has been used recently in Germany (Smitz-Gunther, 1999: 206).

3.5 Coatings and Sealants

Natural rather than synthetic coatings should be used. Natural products are mostly derived from renewable sources such as flax (linseed oil) and beeswax and use no or considerably less petrochemical based ingredients than synthetic coatings and sealants. Natural oil processing is less energy intensive and causes less air pollution than crude oil processing.

A secondary decision is whether to use water or organic solvent based products. Water based products emit less VOCs and are thus better for indoor air quality, worker health and contribute less to the production of photochemical smog.

However, if a synthetic product is used the differentiation between water and solvent based products is more complicated. Water based products emit less VOCs but have more complex chemistries than synthetic solvent based products. The additional chemicals added are produced from petrochemicals; other forms of environmental pollution offset gains in indoor air quality.

[9] At the time of writing, this product was being sold into the export market, but was due to be released into the South African market this year.

The performance of natural products can match that of synthetic ones, but in some cases natural products are not as durable as synthetic products such as polyurethane varnishes that harden on the surface of timber. This disadvantage is offset by the fact that reapplication of natural oils is far simpler than that of varnishes that need sanding before a new coat can be applied.

4 Conclusions

In the light of a population that is both growing and can be expected to consume more per capita as it acquires more wealth, demand for timber in South Africa will increase. This will place further pressure on South Africa's already limited potential to produce timber and timber products. Demand will also grow for imported timbers, the supply of which contributes to deforestation and climate change, and as is the case in the DRC can be linked to armed conflicts.

In order to ensure that the impacts of timber production and use do not increase with increasing demand, our use of timber must be rationalised. Consideration should be given to the following:

- Supporting the production of timber from sustainably managed sources.
- Reducing the use of timber for pulp and paper.
- Researching and creating alternative sources of timber such as urban agroforestry, establishing plantations on degraded land, and growing indigenous species that are suitable for construction and other diverse uses.
- Creating timber substitutes from timber waste and other natural fibres such as bamboo and hemp for construction.
- The use of coppices to modify local climates and water tables.
- More resource efficient production such as radial sawing and using less timber in products while still providing the same level of service, such as engineered products.
- Reducing waste throughout the value added chain.
- Recycling timber and timber production waste.
- Design to maximise the life and recyclability of timber products.
- Using less toxic chemicals in the production, processing, preserving and coating of timber.
- Using more energy efficient production methods such as solar kiln drying and reducing transport by sourcing locally.

This paper has highlighted many processes and products that have reduced environmental impacts. Many of these are not available in South Africa, or are not widely used. Legislation, public pressure, demand by specifiers, responsible action by business and creative design solutions are all needed to drive the more sustainable production and use of timber.

5 Acknowledgements

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