Chapter

A Review of Traceability Systems in the Timber Industry

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Abstract

The Australian timber industry generated $23.1b in revenue in 2019–2020, contributing $7.2b to Australia's gross domestic product. Total Australian timber export in 2019–2020 was estimated at over $3b, with log exports of approximately $650 m. Major export destinations are China, Japan, and New Zealand, with China importing over $1.6b of Australian timber products. An effective two-way tracing system will help secure product export to these major trading partners by eliminating product rejections due to a lack of certification, treatment, and pest management traceability, and enhancing the certification of product performance and compliance of imported structural and non-structural products. An opportunity exists to promote the development of proposed tracing systems to major import trading partners as a means of proving product integrity and maintaining market share as Australia continues to eliminate practices that facilitate illegal logging processes. This review aims to highlight the need for a national product tracing system in place for the Australian timber industry. This review aims to present information about current and potential future technologies that the timber industry can use across the supply chain to trace and monitor product quality and origin.

Keywords: timber products, traceability systems, illegal logging, non-certified timber

1. Introduction

The Australian timber industry generated $23.1b in revenue in 2019–2020, contributing $7.2b to Australia's gross domestic product [1]. Total Australian timber export in 2019–2020 was estimated at over $3b, with log exports of approximately $650 m. Major export destinations are China, Japan, and New Zealand, with China importing over $1.6b of Australian timber products. An effective two-way tracing system will help secure product export to these major trading partners by eliminating product rejections due to a lack of certification, treatment, and pest management traceability, and enhancing the certification of product performance and compliance of imported structural and non-structural products. This review aims to present information about current and potential future technologies that the timber industry can use across the supply chain to trace and monitor product quality and origin.

The development of an effective tracing system will enhance the reputation of Australia's timber products as legal, traceable, clean, and sustainable commodities.

Additionally, Australia currently imports timber products worth approximately $4.4b annually. Reportedly, $400 m of this total import value is considered to be illegally logged timber, resulting in an estimated $23 m per year in social and environmental costs (including negative impact on Australian businesses) to the Australian economy [2]. An opportunity exists to promote the development of proposed tracing systems to major import trading partners as a means of proving product integrity and maintaining market share as Australia continues to eliminate practices that facilitate illegal logging processes. This will lead to a value-added process that will be beneficial to both Australian timber exports and imports and position Australian timber products as a reputable and legally manufactured commodity through all supply chain stages.

2. Importance to industry

This section of the report aims to represent the industry skeleton by reviewing the main stakeholders and their role in the supply chain from the resource type point of view. Once the major industry stakeholders were identified, the benefits arising from an advanced traceability system and a standardized chain of custody were analyzed. The areas of importance to the industry comprise; Consumers, Illegal Logging, Accountability, Certification and Legislations/Regulations, Economics, Information Accessibility, and Independent Verification.

Table 1 shows that privately-owned plantations constitute 75.5% (1,459,900 hectares) of Australia's forest plantation estate. Publicly owned plantations comprise 20.8%, with the remaining 3.7% jointly owned. Jointly owned plantations are partnerships between private companies and state forest agencies.

Table 2 shows a steady increase in plantation ownership by institutional investors and private owners and a steady decrease in ownership by the government, MIS (managed investment scheme), and timber industry companies over the last decade. However, when looking at the two most recent figures, the ownership percentages have remained essentially unchanged.

State/Territory	Unit	Private	Public	Joint	Total
New South Wales	'000 ha	123.6	261.8	7.9	393.2
Victoria	'000 ha	415.9	2.5	0.1	418.5
Queensland	'000 ha	230.4	0.1	0.0	230.5
South Australia	'000 ha	150.6	16.2	0.0	166.8
Western Australia	'000 ha	233.5	79.5	46.9	359.9
Tasmania	'000 ha	258.4	35.1	16.2	309.7
Northern Territory	'000 ha	47.4	0.00	0.0	47.4
Australian Capital Territory	'000 ha	0.00	7.4	0.0	7.4
Total	'000 ha	1459.9	402.6	71.0	1933.4
Proportion of ownership	%	75.5	20.8	3.7	100

Table 1.
Plantation area, by state/territory and ownership, 2018–2019 [3].

Plantation owner.	2008–2009	2013–2014	2017–2018	2018–2019
Unit	(%)	(%)	(%)	(%)
Institutional investors	13	40	49	49
Governments	34	19	21	21
Farm foresters and other private owners	10	8	21	21
Managed investment scheme	36	20	5	5
Timber industry companies	7	13	4	4

Table 2.
Plantation ownership, selected years [3].

The tables provide an insight into the current ownership of timber plantations within Australia in terms of size and proportion and identify which industry groups would benefit most from the incorporation of a traceability system.

2.1 Forest ownership

2.1.1 Forest managers

Operating an efficient and profitable forest as well as maintaining a sustainable and legal forest is the major focus of forest managers and forest owners. However, illegal logging can threaten any sustainable forest management system and affect the environment, wildlife, and ecosystem [4, 5]. One of the major benefits of having an effective tracing system in place is the possibility of providing timely and accurate feedback to various sections of the industry, including the forest managers allowing them to adjust harvest, planting, and other goals and activities in the long and short term. The tracing system will enable access to data about the variation in quantities, grading, dimensions, the scale of products for specific market supply, and species removed from each specific site within the forest. This data can be then used as a practical map for any internal or external R&D and predictive efficiency models by providing an accurate comparison between anticipated and actual results during growth and at the harvest. This research and model creation can be then used to adjust the harvesting plans based on market demand, location, density, and quality, providing pathways to increase the revenue from the forest.

2.1.2 Government agencies

State Governments own approximately 21% of the total forest plantation area within Australia, making them a major stakeholder in the industry (**Table 2**). Throughout most states and territories, the plantation land is predominantly owned by private companies and investors. However, in New South Wales and the Australian Capital Territory, 60–100% of the forest plantations are publicly owned. Although private plantations exceed those owned by the government can be considered the top sole organization in terms of plantation area within Australia. Given this majority ownership by governments, they have a responsibility to the public and taxpayers to ensure that plantations under their control and ownership are being utilized to their maximum potential with regard to growth and revenue. As well, the government agencies also have to enforce laws and regulations within each publicly owned forest estate. A two-way tracing system that gathers information about timber products produced in Australia and imported timber products can address any issues with regard to illegal logging at various stages along the supply chain. This means ensuring any log brought into this country is sourced from sustainable forests and any log exported is taxed/regulated appropriately. Some countries such as PNG and Russia apply taxes and tariffs to the export of timber grown on private plantations on a per ton basis in an attempt to promote local manufacturing [6]. Empowering local manufacturing by ensuring resource availability, and eliminating non-compliant and low-quality products from the market is another advantage for an efficient tracing system in the longer term. It should also be noted that in some developing countries, a poor or complete lack of any chain-of-custody or traceability system and failure in compliance and capturing of tax has led to potential export revenue going into the pockets of illegal loggers or corrupt officials as opposed to the government reserves [7]. An example of this is seen in Section 7.1.1 in which PNG was struggling with this exact issue and employed the services of SGS Ltd. to implement a forestry and export management system. Russia also applies tariffs and export duties to unprocessed softwood logs in an attempt to reduce the amount of product exported and improve the prospects of the local timber industry [8].

2.1.3 Timber product developers

The timber industry worldwide continues to advance and innovate through research and product development undertaken by the companies themselves and by external R&D facilities. Product developers and researchers rely heavily on consistent and correct information about the products available in the marketplace [9]. This information is also a key part of any potential design of new products or building systems as the specifications need to account for all possible variations in quality, size, and physical properties to decide if a particular timber product is suitable for a specific application. A traceability system that records and details comprehensive and significant amounts of data will allow these research, design, and manufacturing facilities to produce new products and processes based on real-time and accurate data about the origin of a product, variations, and types of resources available from both domestic and international markets. The timber industry will benefit significantly by increasing both efficiency and output of new products.

2.1.4 Timber suppliers, Mills, and companies

An inefficient product inventory and transport system can have major impacts on the companies selling the timber resource and all other sections of the supply chain. Australian timber companies and timber mills must adhere to Australian and International standards for the quality and sustainability of their products. A linked traceability system protects them from any penalties and provides a great market opportunity for their product as opposed to imported products with potential issues regarding quality compliance and origin. Timber companies could be liable for recovering costs/fines if they sell any illegally logged/sourced products from imported or domestic supplies. Having a tracing system in place (funded through increased transport, production, and inventory costs, or litigation) will enable the timber suppliers to protect their rights [9].

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2.1.5 Timber importers and exporters

Timber importers must follow the laws of their country that have been put in place to benefit both the environment and other industries along the supply chain. In Australia, this means they must be certain that the timber they import has been sourced legally based on the criteria provided in the Illegal Logging Prohibition Regulation 2012. The full extent of this regulation is outlined in Section 7 Standards and Legislations [10]. All timber exported from Australia is subject to the Export Control Act 2020 and Export Control (Wood and Woodchips) Rules 2021. Failure to comply with any of these rules and regulations could result in significant financial and licensing penalties and legal consequences. Importers and exporters have several options to ensure they are acting legally. These include: conducting their own internal audits, purchasing only from certified forests, and purchasing only from companies with a certified chain of custody. However, certified forests at present only comprise a small portion of the international forestry market. Another option is to purchase timber from organizations that have been certified either by the appropriate government body within their jurisdiction or as is becoming more popular a third-party auditing organization such as Program for the Endorsement of Forest Certification (PEFC), Engineered Wood Product of Australasia (EWPAA), etc.

2.1.6 Consumers

Consumers of structural and non-structural timber products are vital for the continued growth of any timber industry. The average consumer has become more aware of the detrimental effect that illegal logging has on the environment. An ever-increasing number of consumers want to know the origin of products they are purchasing to ensure they have been sustainably sourced [11]. End product costs can increase dramatically if parts of the supply chain are inefficient. Currently, manufacturers have two options to prove to a customer that the product they are supplying is certified sustainable. One is to attach a certificate from a trusted verification body/organization such as PEFC, EWPAA, or operate an entire store that only distributes sustainably sourced products, reducing the need for labels or certificates.

Structural timber products are required to be compliant with specific structural standard requirements. This is another element of traceability for those products. The issue of compliance was recently highlighted in the EWPAA's submission [12] to parliament regarding non-conforming structural timber products. The alarming statistic from this report was that 28% of imported timber products were found not to meet Australian standards. This could have serious implications for end-users such as builders responsible for ensuring the materials they are using as fit for purpose. Changes in sustainability and compliance laws internationally could affect the sale of products that are not sourced from sustainable forests or do not comply with the relevant standard. An example of this is that product compliance requirements in the EU and USA could impact Australian products in the future.

2.1.7 Product failures and insurance

Insurance companies play a key role in determining who is at fault when products fail through internal investigations linked with the governing body of that industry, for example, National Construction Code (NCC), etc. An improved and transparent traceability system would provide significant benefits for end-users and property owners and product manufacturers, and importers by reducing the time and cost of insurance claims and providing indisputable evidence of the origin of materials and their suitability for a particular building application.

2.1.8 Illegal logging

Illegal logging results in social, economic, and environmental challenges in different parts of the world [13]. The cost of illegal logging, fishing, and wildlife to global natural resources is estimated at $1–2 trillion annually [14]. In Australia, up to 10% or $800 million of imported products comes from high-risk resources with evidence of high rates of illegal logging [15, 16].

In Victoria, it was reported that 1 in every 20 trees logged was harvested from areas that were not allowed access for harvesting in 2004. Illegal logging in Australia can risk vulnerable native species and ecosystems [5]. The news reported by ABC in 2018 listed areas of East Gippsland that were illegally harvested affected the population of a range of native animal species causing some deaths. [5]. Images shown in **Figure 1** are satellite images showing the areas where illegal harvesting was undertaken in Victoria in 2004 [5].

2.2 Accountability

When a consignment of timber products is found to be not fit for purpose, there needs to be a means of tracing back to the original supplier or manufacturer, whether it be pre-construction or at any point in the product's service life. Unsuitable or faulty materials can seriously affect construction timelines and financial outcomes for major projects. Being able to quickly identify the origin of faulty products will assist in reducing undesirable outcomes. This will also ensure that the supplier of the product does not avoid responsibility as a genuine product supplier. Another complication with major projects is that material is sourced from multiple companies, often over long periods of time, and tracing each piece of timber back through the supply chain requires a highly efficient traceability system. Such a system could rapidly identify other products that may be related to a failed member and avoid future issues postconstruction.

Under the Building Services Act 2011, there is a 6-year structural guarantee on building elements [17]; however, when it comes to structural timber elements, depending on product condition and environmental factors, any changes in performance or failure can occur long after the product is installed in a building. Timber

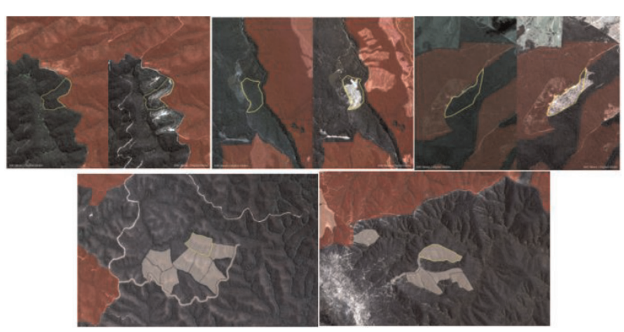

Figure 1.
Images of sections illegally logged in Victoria (red section shown is where harvesting was allowed and yellow lined sections were harvested illegally) [5].

failure can occur for various reasons, including design issues, environmental conditions, natural changes in timber dimension, lack of effective treatment and maintenance protocols, etc. [18–20]. A two-way tracing system that encompasses both domestic and imported product information could provide better clarity on the service requirements of the product in short and long time frames.

2.3 Certification, legislation, and regulation

Currently, In Australia, there are no mandatory standards or regulations in place for traceability or chain of custody specifically. However, with illegal logging still of major concern in other countries, it may become a mandatory system (at present many are voluntary). So, it is best for timber companies to design and implement a chain of custody based on current voluntary practices to future-proof their business. Also of consideration are importation laws that other countries have in place to ensure they are meeting their desired standard. Despite there being no mandatory chain of custody standards in Australia, the Illegal Logging Act 2012 places restrictions on what timber products can be imported.

Australia could be the preferred destination for importing timber products from other parts of the world due to our export certification processes being reliable, robust, and able to meet any import standard set out by a specific country. For example, China and Australia have entered much free trades and other trade agreements since 1970, and this relationship would not have continued if Australia were producing sub-standard products [21]. A tracing system that can provide detailed information about Australian products' practices, processes, and performance specifications could provide better market access and future pathways for our products compared with countries with a high rate of illegally logged and non-compliant products.

2.4 Economic

Table 3 details the economic value of Australia's timber exports. As discussed in Section 2.4, even though a high percentage of Australian forest and timber products are sustainably sourced and are compliant with Australian and International standards, a lack of an effective national tracing system could cause issues with exported [22] and imported products.

Product	Exported Value ($m)
Woodchips	1300
Aper/paperboard	963
Roundwood (logs)	644
Miscellaneous	137
Secondary Wood Products	456
Total	3500

Source: ABARES [16].

Table 3.
Value of timber products exported from Australia in 2019.

2.5 Information accessibility

When referring to an effective tracing system, it is important to highlight the significance of information accessibility by different users at every stage of the supply chain. Various tracing processes (mainly paper-based and internal documents used within companies) at different stages of the supply chain (through the chain of custody) limit the ability to retrieve information quickly and efficiently. With improved accessibility, critical pieces of information can be located and relayed to the relevant body in a timely and effective way. Organizations and companies have different permissions and security levels for their internal systems. By compiling this into a single nationwide and standardized system, all supply chain members will have better access to the information. The ability to update and add relevant product information to the system is also enhanced. This will provide information on product recalls, illegal logging, warranty/accountability issues, and certification. The transparency and standardization of the system will reinforce Australia's ability to track and guarantee the quality of its products to international importers.

2.6 Independent verification

Currently, the origin of a piece of timber can be determined through communication with the supplier of the product. However, this process can be time-consuming, information may be inaccurate and the process costly depending on the age of the product. With a more standardized traceability system, there will be independent audits of organizations to verify the information provided by each level of the supply chain linked to the previous levels/operations. This system also clarifies each stage of production and fills the gaps in the potential information flow, reducing any chance of fraud or misinformation. As reported from the Australian chain of custody certifying companies e.g. EWPAA, PEFC), conducting regular audits within the companies and certification authorities by themselves and by third parties is crucial to maintaining a high level of trust in the certification provided [23].

3. Standards, legislations and compliance

3.1 Australian standards

The Australian Standard (AS 4707:2014 Amd. 2:2018)determines the chain of custody for forest products [24]. The sustainability of timber resources is encapsulated in this standard. This standard ensures that timber products are compliant with the sustainable forestry management standard (AS4708:2013) [25] from forest grower to the end-user. Although these are the only standards provided by Standards Australia, other organizations such as the Australian Forestry Standard Ltd. (AFS) have formulated similar standards and schemes. The chain of custody for forest products standard was developed and based on the PEFC (Program for Endorsement of Forest Certification) standard (PEFC ST 2002:2020) [26] and then modified to suit Australian procedures and processes.

Currently, the standard is not compulsory for any organization within the chain of custody, however, implementing the standard in the business will ensure customers are buying a certified and legal product. It is also possible that in the future and based on national and international requirements, Australia will introduce a similar compulsory standard therefore future-proofing the system. The chain of custody standard is reviewed every 5 years which allows for any changes to operational and technical knowledge and national and international community expectations to be implemented.

In addition, from the standards above which are not formulated by government organizations, the Australian government introduced an illegal-logging due-diligence test as of November 2014. This test was developed from AS and PEFC standards and as a result, any product certified under either AS 4707:2014 or PEFC ST 2002:2013 has passed the due diligence test. The test acts as a basic level of liability for businesses to verify that their products come from legally logged forests.

Any business that is responsible for manufacturing, processing, converting, or repackaging wood can be certified under the Australian Standard for chain of custody [27]. This enables all companies along the supply chain to be completely transparent in demonstrating their use of only sustainable timber. This enables Australia to continue to be a preferred supplier for international importers as they can assure their own government that the timber is legally sourced.

Although most Australian timber manufacturing facilities use only local timbers some will use imported species if they need to suit a certain application (e.g., Indian rosewood for musical instruments). These imported materials require close consideration of the Illegal Logging Prohibition Regulation 2012 which was procured under the Illegal Logging Prohibition Act 2012. This act has proven to be extremely successful and should stand as the basis for future acts, rules and laws in the timber industry. As mentioned above in Section 3.1.5 *Export Control Act 2020, Export Control (Wood and Woodchips) Rules 2021* also introduces some considerations [28].

3.2 Compliance

Currently, the laws and compliance standards surrounding imported and domestically produced engineered wood products (EWPs) are outlined under documents such as the National Construction Code (NCC), The National Building Code (NBC), and The Competition and Consumer Act (2010) within Australia. However, a submission to the *Inquiry into Non-Conforming Building Products* in the 44th parliament by the EWPAA highlighted some key issues and flaws with the relevant government bodies policing and enforcement of these codes and acts [12]. In 2018–2019 64% of the EWPs imported to Australia came from Asia, followed by Europe and Oceania with 20% and 5%, respectively (EWPAA reported [1]).

Between January 2013 and August 2015, the EWPAA conducted almost 25,000 tests on both certified and non-certified engineered wood products. The tests found that 28% of engineered wood products imported to Australia did not meet Australian standards, whereas only 1.5% of locally manufactured EWPs did not meet the standards. A majority of this 28% of non-compliant product was claimed to meet Australian standards by the overseas exporter. Australia imported $210 million of plywood, $2.1 billion in paper, and $468.5 million of sawn wood in 2013–2014 [29]. In 2015, Australia imported timber products from China, Indonesia, Malaysia, the US, the UK and New Zealand [30], and in 2016–2017, 60% of the imported products came from China [31]. **Table 4** represents the reported ratio of non-certified timber products manufactured by various countries in 2002 [7].

This further highlights the need for a quality control point either conducted by the importer or by a government body. With the volume of imported building products increasing rapidly throughout Australia this is becoming a major source of concern. The

Manufacturing country	Product type	% Non-certified
Indonesia	Plywood	55
	Lumber	65
	Roundwood	58
Malaysia	Plywood	11.8
	Lumber	11.8
	Roundwood	11.8
Russia	Plywood	15
	Lumber	20
	Roundwood	17
China	Plywood	30.6
	Lumber	30.6
	Roundwood	30.6

Table 4.
Percentage of non-certified timber products from the different international manufacturers [7].

report by EWPAA indicated that any further delay in Australia could mean a significant failure event such as the Dockland Cladding Fire [12, 32] to improve its enforcement of building compliance and regulations on imported engineered wood products.

The reason for the increase in use of imported engineered wood products is a cost factor. Australian companies simply cannot compete with the imported non-compliant products being produced internationally. Wood products manufactured in Australia must meet the requirements outlined by the following codes, all of which increase production costs:

- Building Code of Australia (BCA) & Australian Standards
    - Meet strength and durability properties required to ensure safe construction and acceptable structural integrity of buildings in major high load events such as storms, cyclones, fires and occupant activities.
- National Construction Code (NCC)
    - Air quality (with respect to carcinogen off-gassing).
- Department of Health National Industrial Chemicals Notification and Assessment Scheme (NICNAS).
    - Maximum emission class of E1 to ensure worker safety during manufacture of cabinetry and furnishings.

For example, the Australian standard for compliance testing for plywood can be either a 72-h boil test at 100°C or a 6-h boil test at 200Kpa of steam pressure which simulates 50 years of full weather exposure. These tests are mandatory which results in a manufacturing cost increase for Australian manufacturers. Currently, international manufacturers are not held to these standards, and they can sell their products cheaper than in Australia.

Currently, the Competition and Consumer Act 2010 does address brands and manufacturers using misleading product information and falsely presenting the quality of a product. However, as seen by the alarming rate of non-compliance in imported EWPs, it is required to establish a more clear and more effective tracing system that could provide details of product origin and compliance with Australian standards. Importers are willing to take the risk of supplying non-compliant products in Australia as the benefits far outweigh the penalties.

The major problems brought forward by the EWPAA in their submission were related to lack of surveillance and prosecution. Identifying non-compliant wood products is not possible given the lack of inspection. Importers are predominantly small companies. These companies have limited resources in terms of assets and capital which means if a significant failure of their products did occur the legal fees and penalties could be substantial. This means customers and creditors could be left with very little, if any, compensation.

Environments where non-compliance is common, are often generated by circumstances such as poor surveillance, lack of enforcement, and low disincentives and penalties for failing to comply with the governing laws. This can put public safety at risk.

3.2.1 Challenges and solutions

The major challenge with non-compliant timber products is the potential structural failures which could lead to serious injury or even death and flow on costs of failure [33]. As a direct solution to avoid the performance issues outlined above the EWPAA proposed establishing an organization that undertakes surveillance, enforces policies, and applies significant penalties in the case of non-compliance. A two-way traceability system that is managed and monitored by that organization provides the details of products manufactured nationally and imported by international suppliers. It details the testing completed on them, chemical treatments and standards they comply with that will enforce the required structural and durability specifications.

3.2.1.1 Identification of non-compliant products

When identifying non-compliant products, the process must be clear, stage by stage defined and non-discriminate meaning it will apply to all engineered wood products manufactured both domestically and internationally. The proposed Independent Compliance Body (ICB) [12] must investigate all complaints of non-compliance using independent testing facilities that are National Association of Testing Authorities (NATA) certified to ensure impartiality.

3.2.1.2 Enforcing penalties for use of non-compliant product

As has been seen in the plumbing and electrical sectors mandatory certification is not always effective in reducing the amount of non-compliant product [34]. This can be due to the international manufacturers supplying fraudulent certification and documentation even though they sometimes do not even possess the equipment required to carry out the testing. This means we are not able to verify if the testing has actually taken place. Therefore, a product can have the appropriate certification documentation and label but not actually be compliant.

This is a serious problem as quite often due diligence tests that construction site managers are required to perform only include inspecting product for documentation and labeling meaning the products will pass this test and therefore endanger the health and safety of everyone on the site. A mandatory government and third-party testing and investigations into all EWPs that are imported into Australia were proposed by an EWPAA submission [12]. Along with mandatory testing, a significant increase in penalties is also required which will directly influence both categories below:

a. *"Sell non-compliant or misrepresented product"*

b. *"Use non-compliant or misrepresented product where it is directly imported by the first user."*

Some major building supplies companies only refer to their sustainable resource policy for timber products which is a general short-length document. There is no clearly defined policy for compliance with structural EWPs. This issue was also highlighted by the EWPAA in their submission regarding compliance [12, 34].

Australia has the 'S' marking which is very similar to the European 'CE' marking (see **Figure 2**) [35] and given this system is already in place it should present very few problems if compliance is to be added into the chain of custody certification standard in Australia.

As of July 1, 2013, all structural engineered wood products that are to be permanently incorporated into constructions in Europe must have the CE marking stamped on them which means they have been identified as fit for purpose by a 'notified body' [12, 35]. In addition to the CE marking any manufacturer of structural timber components must supply a Declaration of Performance (DoP) which contains additional information that is not displayed on the individual products. This DoP is to be made available throughout the supply chain to all users via a printed document and also a digital copy. The DoP is also matched to a unique identification code that is labeled on the product and this code can be used to obtain the DoP through the original supplier if the physical copy of the DoP is lost [36]. This requirement only applies to importing 'finished components' (LVL etc.) not raw material but if this raw material is used in a 'component' then it will be certified anyway by the manufacturer in Europe. If a product being supplied by a manufacturer or seller fails to produce the CE Marking and all supporting documents the product can be withdrawn from the market and the trader can be prosecuted. The CE marking does not require samples of the product to be tested at specific intervals (one product from every batch or one product every hour etc.) because it assumes serial production. Serial production means that every product is manufactured using the same process and materials and therefore any product from that process is compliant if one is. Details of this system can be found in CE marking/certification section of CSTB webpage (https://evaluation.cstb.fr/en/ce-marking/) [12].

Figure 2.
CE marking introduced in Europe compulsory from 2013.

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4. Chain of custody

This section includes information about the Chain of Custody (CoC) and its application in the timber industry as well as its standing as a reliable certification method.

4.1 What is the chain of custody?

A chain of custody ensures each stage of the manufacturing and distribution life cycle of timber as both a resource and a product are documented and recorded by the certified parties. This system ideally is composed of a central database that gives access to information for all users via a simple login or similar system. Within this system, the information stored should be clear and extensive with respect to both sustainability and compliance. Compliance is not currently integrated into any chain of custody standard or certification within Australia. This compliance aspect added to the CoC will be solely for structural wood products. The addition of compliance to the CoC will increase accountability and ease of information checking which will result in decreased response time when critical information is needed (giving open access to information at any stage of the timber supply chain). At any stage of the supply chain, prospective consumers of the product should be able to view relevant information about a specific sample/batch of timber in relation to both sustainability and compliance. Other countries such as Europe are beginning to introduce or have introduced mandatory legislation for traceability and that could potentially limit Australia's access to export markets. The impacts of a voluntary CoC restrict companies that intend on being certified by the Australian standard but do not have parties in their supply chain certified (supplier of raw products etc.) This may result in a loss of revenue or business for the company if the buyer prefers to purchase from only certified producers.

4.2 Critical control points in CoC

4.2.1 Identification

Identify the product using a physical brand e.g. paint, hammer brand, or plastic. The label needs to be able to withstand all processes the timber may be subjected to e.g. chemical treatment. If one type of label is not suitable, then multiple types need to be used throughout the timbers manufacturing process. Labels can be fraudulent when systems are not cross-checked with documentation at all stages of the supply chain.

4.2.2 Quantities

Quantity is a very rudimentary form of tracking and controlling inventory within an industry. Quantities can be in terms of weight, cost, total pieces, volume, or value. Using quantities ensures the predicted amount of product is removed or retained at each individual stage in the CoC. For example, if 100 logs were felled on a certain day and you receive 120 logs from transport there has been an error made or there has been an attempt to launder logs. Given the digitalisation of most modern inventory systems, this is something that should be able to be tracked with relative ease.

4.2.3 Segregation

The next key critical control point is the segregation of the certified timber from the non-certified timber. Quite often in mill and log yards timber and logs are separated by characteristics such as size, shape, quality, and species. Systems like this can remain in place but need to be done within groups of certified and non-certified timber to avoid any accidental mixing of the two. The other option for timber facilities is to reject any non-certified products which will remove the need for segregation.

4.2.4 Personnel

As much as the systems and technologies of a CoC play a significant role in its success, the personnel responsible for applying these systems play a critical role. Personnel can influence the performance of a CoC system through errors and fraudulent behavior. Training and upskilling personnel are required as the CoC is applied especially to new products or suppliers.

4.2.5 Errors

Often personnel makes errors due to a lack of training or application to the job. [37]. It is important to provide adequate training as the new CoC may be far more advanced than the previous system. This training is key to ensuring the employee can successfully implement the CoC.

4.2.6 Fraudulent behavior

Fraud is not considered a particular problem within the Australian domestic timber industry; however, some countries that Australia imports products from are known for fraudulent and corrupt practices. Fraudulent activity is conducted to directly benefit the individual employee or the organization. The most effective way to reduce fraud within a CoC is to develop a system that makes fraud difficult to conduct without detection. Another step is to increase remuneration because quite often in developing countries the salary of workers is way below a basic wage. This makes employees more susceptible to bribery and fraud, given the increased financial incentive. As well as increasing the incentives authorities can increase the severity and frequency of penalties for fraud and corruption as this will likely act as a deterrent. Conducting random audits is another efficient way to expose fraud and corruption within a CoC.

4.3 Design and implementation

A CoC must consider the following key criteria:

1. Stage Specific Needs—Multiple technologies can be used within the CoC as long as they can all carry the same set of information and be easily transferred at each stage.

2. Standards—The CoC must conform to Australian standards such as AS4707:2014 and AS4708:2013 and acts/regulations such as the Illegal Logging Act 2012.

3. Cost—The cost of the technology must be proportionate to the value of the timber species it is being applied to. The cost of implementation (training, equipment, etc.) must also be considered as some small manufacturers may not be able to meet this cost.

4. Feasibility/applicability—The technology and systems must be applicable to the stage in which it is being implemented. Some technology/equipment is not suitable for use within a forest or mill due to the high sensitivity of equipment to environmental factors (dust, temperature, and humidity changes) or other requirements (such as regular updates and calibrations).

5. Species—Some species are generally not the target of illegal logging due to their low market value and may not require a CoC.

Implementation of a CoC is just as important as the design because key aspects and steps of the system can be missed or performed incorrectly when not implemented properly. To reduce this each stage of the CoC should be analyzed to identify which systems need to be incorporated. Certifiers such as the EWPAA and PEFC outline how they certify a CoC within a timber company. A summary of the key steps is detailed below:

1. Applicants are required to identify and address any deficiencies found when comparing their current CoC with the standard CoC. Once this is completed, the mill must implement these procedures across all sites. As certification is not free, ensuring the business is ready for certification before the audit will reduce costs.

2. Identify, brief, and provide training to all staff with CoC duties.

3. Implement Due Diligence Systems for all suppliers to ensure sourced material is certified.

4. Implement physical separation or inventory control systems to monitor the certification status of timber.

A short time after the CoC is considered implemented; the certifying organization will perform an audit and issue a certificate if satisfied. Audits will be performed annually. Internal and third-party audits should also be conducted frequently to avoid loss of certification.

4.4 Key stages in supply chain

There are several key stages to the supply chain of wood products, both structural and non-structural, and each of these stages has its requirements when it comes to the systems being put in place. These systems include traceability technology, CoC documentation, and compliance. As a result of this, the overall CoC developed will have multiple technologies and systems within it depending on the applicability of each system.

4.4.1 Forest

The forest is the first of the critical points in the supply chain and is susceptible to illegal logging. Logs are laundered by mixing illegally and legally harvested logs at a stage where they may be indistinguishable. Labeling technology should be applied immediately to both the logs and the stumps after the trees are felled. Quantities and other data (size, species, diameter distributions) must be inventoried and tracked at this stage i.e. If 100 were harvested from a section and 150 logs were transported to a mill, then illegal logging may be a consequence. This should be rectified immediately through clear communication between the forest manager and the next stage in the supply chain. Given the remoteness of many forests and logging camps, this can be the most problematic stage of the CoC as complex/bulky/sensitive technology may not be accessible directly in the field. The lack of access to information at the forest level re-enforces the need for a traceability system that has been developed to suit all stages of the CoC. Complex tracing technologies may not be able to be implemented until the next stage in the CoC, which is perfectly acceptable, providing the level and quantity of information are maintained.

4.4.2 Forest to mill

Transporting the felled logs from the forest to the mill is the next critical point in the chain of custody. This is usually the stage where the timber, depending on the region, travels long distances through remote areas less regulated by government officials. Most trucking companies and national authorities require the weight of a truck to be recorded at the beginning of a journey to ensure they are within the vehicle limits [38]. Depending on the laws and regulations of the area, trucks are also required to be inspected at any weighbridges/points along major highways and transport routes. This information should vary little from leaving the forest to arriving at the mill and therefore is a good system to verify no logs have been switched or added. When timber arrives at the mill, all the initial data collected such as quantities, species and size should all be recorded and cross-checked/verified with the information from the forest. A labeling technology and data recording system are required to be efficient as any lengthy time delays caused by this process will impact the reputation of the industry supply chain.

4.4.3 Shipping between countries (importing/exporting)

Most illegal logging occurs in developing countries which tend to have less regulation and enforcement, making it easier for timber to be laundered or rebranded as legal. Once the timber moves between countries, it is difficult to prove if something that has been labeled legal was illegally sourced if the systems are not linked. This is where due diligence tests are crucial. Due diligence tests involve using the previous chain of custody documentation (from forest and mill) included in shipping documentation from the exporting country to decide if the timber is legal. Independent auditing and inspection at ports were adapted by countries like Papua New Guinea (PNG) to ensure revenue was not being lost from State-owned forests as well as to halt the illegal logging trade.

As noted in Section 3.2, the non-compliance of imported EWPs in Australia was high. Because of this, compliance needs to be added to the CoC with regard to imported products. Importers of EWPs must comply with Australian requirements and international standards for different product types, considering the potential level of fraudulent certification within products manufactured overseas.

4.4.4 Processing Facility

Timber from both local and overseas sustainable forests can arrive at the processing facility, meaning the mill will need to be familiar with CoC procedures from multiple countries. The easiest way for a processing facility to reduce time and cost for their part of the chain of custody is only to purchase already verified, sustainably sourced timber. Timber that has been certified from a sustainable and legal source must be kept separate from any timber that is in question or awaiting verification. Therefore, a segregation system needs to be in place to ensure they are not mixed together, which could see a product lose its certification or be incorrectly certified.

The processing facility is the first stage within the supply chain where compliance will need to be integrated as this is the stage when structural products will be manufactured. As outlined in Section 7.2, the compliance of EWPs is very closely linked to sustainable sourcing and illegal logging issues and as such, it is recommended that compliance become part of the CoC system. This has been implemented in other regions such as Europe, and this process was also outlined in Section 7.2. The compliance aspect of the CoC will only need to be mandatory for structural timber and wood products, and all relevant information with regard to compliance must be accessible by the builder and/or consumer.

4.4.5 Transport

The next stage involves moving products/materials between primary and secondary manufacturing processors. Secondary processors often have the least onus on them in terms of checking multiple levels of the CoC to verify the timber is legally sourced. Secondary manufacturers often rely on information solely from the primary processor, including transport documents, customs declarations, and sales documents. If an item has been verified as certified at all CoC points before the secondary processor, it is highly unlikely that any error will be picked up at this point.

Secondary processors manufacture things like furniture and small wood products that are usually non-structural, and as a result of this, it is not likely compliance will be a part of the chain of custody design for this stage. However, the biosecurity and pest and disease issues that could arise from this category need to be considered.

5. Current technologies/systems

5.1 Information systems

Traceability information systems consist of processes to maintain records that expose the trace of a particular input from suppliers to final customers. Traceability means the capability to track any product throughout all phases of production, processing, and distribution. Some of the important aspects of a traceability system include protocols to identify the batch or item, details of product processing stages such as dates, records of steps etc. the step-by-step movement of products throughout the supply chain and also a global managing system that link all data available for each batch or product [39].

The key to an effective tracing system is an information system capable of reading and compiling all the information and data collected about the product. This system should be accessible at any stage of the CoC to verify the origin of a product. The tracing technology is irrelevant if the data stored is not able to be gathered and easily accessible. Some mandatory functions of the information system are:

- Central database
- Accessibility
- All critical data stored—sample name, region, dimensions, quantities, quality, species, batch number, plantation, transport documentation, etc.
- Ease of use

An example of this data storing system is the Russian program "Uniform State Automated Information System (EGAIS)". EGAIS and its many variants are used not only in the timber industry but also in alcohol and prescription drug industries in Russia. This software system is designed as a national database for storing all data and documentation relating to a product. It can be used on any computer with an internet connection and has the ability to be operated with ordinary barcode readers which gives retailer ease of use. The consumer can then also verify the information of the product via a QR code on the label of the final product. The type of national database designed provides a reliable access way to ensure complete transparency and reliability for the traceability of products at any stage of the chain.

5.2 Traceability technologies

Traceability means the ability to track any product throughout all stages of harvest, production, processing and distribution. This tracking system can refer to recording information through various means such as barcodes, radio frequency identification (RFID) tags, and other tracking methods. Timber resources can be imported as round wood and exported as different product types, including structural (beams, etc.) and non-structural (paper, etc.). The relevant information about the source of the raw product, where the wood was grown, what processing operation was used to produce any of the products and any chemical treatment applied needs to be clearly defined and recorded for the product to be certified sustainable and compliant with required standards and regulations. An effective traceability system is required to record and manage different types of information collected at each stage of the supply chain and provide accessible data to the users, product developers, and end-users interested in sustainability aspects and performance compliance of products. Various technologies are available for tracking and identifying products such as timber; however, a continuously managed system from forest to the consumer is yet to be developed in Australia. This section aims to summarize potential technologies available and their advantages and limitations to be used in the timber industry.

5.3 Forensic technologies

5.3.1 Wood anatomy

The wood's cellular arrangement including macroscopic and microscopic formation can be used in identification and tracing of species and products [40–42]. The larger specifications depending on species and product type could include the timber color, cell arrangement, and growth rings. The smaller scale cellular combinations including the cell type, ray shape and size, and frequency can be checked under microscope. Some of these properties can be used in developing tracing systems and protocols. These characteristics could be used as a unique image/logo to record specifications and information about the product/resource. However, the detailed smart software system needs to be then designed to relate the images and information to the product. This could be limited to stages that have clear images and large enough faces to allow an image to be taken. In plywood manufacturing, for example, currently, smart systems are used to take images of each veneer face and the image collected from face could potentially be used in a trial program to turn into a fingerprint for tracing that piece of product further in the supply chain [43–45]. Similarly in other stages of the supply chain, there is information collected for quality, the pattern of cut, grading/sorting, and storing of products. This information could be used in a traceability trial.

5.3.2 Mass spectrometry

The wood chemistry and composition can be identified and used to trace the product back to its origin and growing environment/habitat. The wood species genetics and geological origin can be used to determine species specifications and types.

Mass spectroscopy uses the application of a stream of helium ions heated to 350°C to the surface of the timber. The ionized chemicals in a mass spectrometer that are used to generate a chemical profile for the sample and used to compare with known reference profiles. The data generated can be used to develop potential chemical fingerprints for species and products.

More recently, ambient atmospheric ionization techniques have been developed that minimize sample preparation steps and provide very fast results; specifically the "Direct Analysis in Real Time, Time of Flight Mass Spectrometer" (DART TOFMS) [46, 47] has shown great promise when used for timber identification [48].

The chemical fingerprints developed for species can be developed for unknown samples and species by comparing them to reference groups.. However, it is important to note that models used for clasifiying samples are only valid for taxa included in the reference dataset. The suitability of these systems could be influenced by the cost, training requirements, and maintenance and upgrades, making them less suitable for earlier stages of the supply chain.

5.3.3 Staple isotopes

Stable isotopes are variants of the same atomic element that are stable and have the same amount of protons but with different numbers of neutrons.

Materials such as water, air and soil are characterized by stable isotope ratios (made from known elements) are affected by the climate and origin of their geology. Considering these known parameters a tree grown in specific area and sourced from water, minerals, and carbon dioxide in the same location will have similar compositional effects on the wood generated.

By investigating the chemcial element compositions and ratios at each origin the isotopic "fingerprint" for that site can be developed. The combination of the multiple stable isotope analyses, including elements such as sulfur and strontium, an improved spatial granularity of the identified isotope can be developed into a signature. On this basis, it is possible to use stable isotopes to identify or rule out particular regions of timber provenance. The detection method is suitable to be used for identifying the geographic origin of the products however a detailed reference data set is required. This method however does not have the ability to determine the genus, species of individuals products [49–51]. The application of stable isotope in combination with analyses of trace elements can improve the prediction accuracy [13, 52]. Trace elements and stable isotopes together can be considered “Geochemistry”. Although it has not been tested, it is likely that trace element analyses could also augment other methodologies that seek to determine timber provenance, such as DNA analyses.

5.3.4 DNA analyses

Small changes in the genetic code accumulate over generations, resulting in greater differences between the DNA sequences of distantly related compared with closely related individuals. By reading the DNA sequence at particular parts of the genome, individuals can be assigned to a particular group (i.e., species, population) on the basis of similarities and differences in their DNA compared with reference data. Success can be limited by the technical challenges inherent in extracting and amplifying sufficient DNA from timber.

Genetic DNA is extracted from the wood cells by first pulverizing the wood and then using several chemicals to isolate the DNA from other cell content. Specific parts of the DNA are then read and compared with reference data to identify the species or geographic origin of the wood sample.

5.3.5 Radiocarbon

Carbon occurs naturally as the radioactive isotope 14C (“radiocarbon”) and the stable isotopes 12C and 13C. Radiocarbon decays naturally to nitrogen (14 N) [43]. By measuring the ratio of radiocarbon to the stable carbon isotopes, it is possible to calculate a “radiocarbon age” of timber. During the early 1960s, levels of 14C in the upper atmosphere were augmented through nuclear-bomb testing producing a spike in calibrations (the “bomb curve”), which can be used to date recent material. The accurate calculation requires two samples of different ages (such as different tree rings within a piece of timber). The results reveal the age of the individual tree rings tested, but this may not equate to the felling date if the outermost tree rings were not present in the sample.

5.3.6 Near-infrared spectroscopy

Near-infrared spectroscopy (NIRS) identified elements by exposing the samples to near infrared electromagnetic energy to capture the materials’ spectra absorption. The process records the information from product’ chemistry and physical structure. The collected data will be analyzed using appropriate multivariate modeling methods in order to produce useful information about the product’s chemistry and physical variations. The NIRs analysis has the capability of identifying genera, species within the same genus, and between species from various regions.

One appropriate analysis and mdoeling are completed, NIRs technology can accurately test and detect product specifications with minimum operator skills required. Current research is working on developing models and data sets to optimize the NIRs systems’ accuracy of output in predicting product properties when various variables including humidity, moisture level, and cutting direction are introduced.

Results from current existing research results in the field have shown that families and species of products can be identified using NIRs.. NIRs have been successfully used in differentiating Brazilian mahogany wood from Mexico, Honduras, Peru, and Venezuela. However the technology still requires further research and is not currently widely available to industry. There are also various limitations such as access to accurate data sets, and variabilities between species and product types that slows the development of predictive models. The required large data sets of information to develop a reliable model and variability of timber species could be some of the possible disadvantages in using the NIRs technology in timber production supply chains.

5.4 Labelling technologies

5.4.1 Conventional paint and chisel labels

The oldest methods of log labeling involve the painting or chiseling of company information and log identification information, usually on one or both ends of each log. Such labels are commonly used in conjunction with documentation to provide more detailed information about log origin, species, dimensions, and volume. A chisel also called an inscribing tool or scribe, is a specialized knife used to engrave the information into the end of the log. Although both painting and chiseling require more time than hammer branding, considerably more information can be included in the labels produced with these methods. The labels produced by painting and chiseling also are generally more legible than hammer brands.

5.4.2 Stamped codes

Coding methods have been developed in which patterns of dots or circles are stamped in the ends of the logs. These stamped codes can be applied automatically by harvesting machines [53] or by using special stamping devices [54]. They can subsequently be interpreted by handheld or machine-mounted readers. The codes can contain a significant amount of information and may also refer to additional documentation.

5.4.3 Branding hammers

A branding hammer has been used as a traditional labeling method in log processing and has a simple mechanism. The hammer used creates a unique pattern on the surface of the log that is used to identify the origin of the log. Other documentation and details can be used alongside the branding hammer to provide clearer information about the log origin than the hammer branding only.

5.4.4 Conventional labels

Conventional labels are used widely in timber industry which can be as simple as a treated paper tag or plastic label. Metal or hardened plastic staples, nails, and adhesives are usually used to attach the labels on the product surface. For more specific products such as pulpwood that are processed or "digested" during product development these lebels are not as effective. The levels can provide details of company name or log number, however, further details can be included if a barcode is added to the label. The addition of barcode will require barcode scanner throughout the product life and supply chain.

5.4.5 Nail-based labels

Nail-based labels are usually installed on the wood products or logs using hammer. These labels are generally made from metal or hardened plastic. There are nail-based labels will imprinted barcodes that increase their security and capacity to include more information however a scanner or reader is then required to read the product information throughout the supply chain.

5.4.6 Magnetic stripe cards

Paper or plastic based magnetic stripe cards contain a black magnetic strip and has capacity to store productinformation. However, the use of these cards require reader and special scanning devices to read and modify the product information. These cards are used widely in various industries such as airport transit tickets and bank cards that can provide ubiquitous technology in the financial and security sectors. The new technologies such as smart cards and two-dimensional barcodes are becoming more commonly used and easier to access. Potential advantage of these cards could be the possibility of proprietary encoding and programmability of the and there already is a specific International Organization for Standardization (ISO) standard for encoding stripe cards.

5.4.7 Smart cards

Smart cards are basically credit-card-sized plastic cards that could contain large amounts of product details and production specifications in a microchip. These cards are also called "Chip card," "integrated circuit card," and "smart card". There are two types of smart cards:

- Dumb smart card that only has memory to store product details. An example of these types of cards is the cards that are used forstoring details of a shipping manifest. Its memory a shipping manifest.

- True smart card actually has an embedded microprocessor in addition to the storage memory. The true smart card provides the possibility of storing and making changes in the data recorded. The security of information in these cards can bemaintained in various ways. This security has been touted as the main reason that smart cards will eventually replace other card technologies.

The reader requirement for the smart cards can be a potential disadvantage of them considering the supply chain type and environment. The "contactless" cards however can provide a more effective solution for timber tracing. Short-range cards operate by electrical inductive or capacitive coupling when the reader and card are brought within a millimeter or so of each other; longer-range cards communicate by radio signals.

5.4.8 Radiofrequency identification

The basis of Radio Frequency Identification (RFID) is to place tags with a micro radio transponder that allows a read and write capacity whereby small amounts of information about the product can be sent from the tag to a reader unit. The tags are actually transponders in technical terms and include a minute computer chip with an inbuilt antenna. The data transmit between tags and RFID units using radio waves, which commonly involves a time and date stamp reading at specific locations in a defined process. This identifies where the object is at a given point in time [55]. There are two types of RFID tags, passive and active. Passive tags are powered by the incoming electromagnetic waves generated by the RFID readers, with a signal captured by the tag's antenna. This allows passive tags to be simplified and small, but with limited capabilities of signal propagation, data storage and processing. Active tags contain their own internal power source (a battery). This enables the tags to emit a signal to the RFID reader with an increased propagation range. A range of sensors and modules (e.g. sensors and/or GPS) can also be supported by the tag with the increased power.

Table 5 provides a comparison of the two tag technologies.

Passive RFID technology is more suitable for supply chain tracking applications. This technology is compatible with the forestry industry, especially with product certification. The placement of these tags at the cutting and loading time ensures that the origin of the timber is from well-managed forests and not from illegal harvesting. RFID systems in the shape of a nail are more resistant to shocks, vibrations, and humidity, which could be suitable for earlier stages of the timber industry while cost needs to be always considered. In the industry's product manufacturing and treatment section, the technology could have less applicability due to its sensitivity and time consumption for installation.

RFID tags were used in a pilot project for tracking the process of cutting down trees and transporting logs to a processing plant in Germany in 2006 [56]. About 500 tags were used in the test in a forest near Munich. None of the tags were damaged during the process of felling and stacking logs, while approximately 5% were lost during transportation from forest to processing plant. The application cost was estimated to be approximately $6 per cubic meter of harvested wood at the time.

5.4.9 Microtaggants

Microtaggants are microscopic, color-coded plastic particles that are specifically designed to positively identify a wide variety of substances or objects. These unique

Characteristics	Active	Passive
Power	Battery	No internal power
Required signal strength	Low	High
Communication range	30–100 + metres	Near contact—25 metres
Data storage range	128 kb	128b
Per tag cost	US$25–US$50	US$0.09–US$20
Tag size	Varies depending on application	Sticker to credit card size
Fixed infrastructure costs	Lower—cheaper interrogators	Higher—particularly fixed readers
Beat area of use	High volume assets moving within designated areas in random and dynamic systems	High volume assets moving through fixed choke points in definable, uniform systems

Table 5.
Comparison of the active and passive RFID technologies.

identification particles are composed of distinct layers whose colors and sequences can be changed, making several million codes available. Layers of fluorescent or magnetic material can be added to the particles so they can be found easily. Fluorescent layers are detected by viewing under long-wave ultraviolet light, and particles with magnetic layers can be recovered from loose-flowing or bulk materials by using a magnet. The color codes can be read using a pocket microscope of at least 100× magnification.

Another type of microtaggants is NanoTags, which can be made from various materials such as nickel, octagon-shaped, 6–10 microns thin and 0.3–0.5 mm wide. The Security Identification Code (SIC) is etched physically through the body of the nickel tag. NanoTags can be mixed with adhesives or embedded into the body of plastics. Once the mixture of tags and adhesives (or plastics) becomes dry and solid, the encased NanoTags become resistant to water, most chemicals, and environments.

The microtaggants with plastic substrates are vulnerable to rapid deterioration at high temperatures, which starts at temperatures above 150°C, and then leads to gradual loss of all information and completely burning at 350°C, while the NanoTags remain intact. This technology could have potential applications for various stages of the timber industry; however, its suitability needs to be checked against the conditions before and after product manufacturing, storage, and in-use life of products. The accessibility of reading/detecting particles and their variations also need to be investigated to provide a robust and secure system for the industry to use.

5.4.10 Nanotechnology

Optical markers at the nanoparticle level are used to mark timber at various processing points. The markers can be embedded in a clear or color spray and applied to live trees or cut logs and other timber products. A hand detector can help to detect the presence of nanoparticles. This technology is currently under development and not available for wide application.

5.5 Other technologies

5.5.1 Automated macroscopic wood anatomical identification

Recent development in the field of wood anatomy is the automated recognition of species (machine vision) and biometric log traceability, making use of image reference collections. "Machine vision" technology is currently being developed for automated macroscopic wood anatomical identification and has potential for use as a handheld timber identification device. The system captures images under conditions of strict light control through its camera, and it uses signal processing approaches to extract information and then analyze it in a way that establishes a classification scheme. A prototype device has been developed, which has been utilized in two field situations to test multiple specimens in real-time. The potential accuracy of this method is excellent—as good, if not sometimes better than that which can be achieved by a trained expert, due in part to the increased sensitivity to light of the optical receptors employed in the system when compared to the human eye. The skill level required to operate a functional system at the front line to obtain an identification is minimal and comparable to that required to take macroscopic photographs suitable for off-site expert identification. However, the technology is at the prototype stage and has been tested on a limited number of species, so it is not widely available at present.

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5.5.2 Blockchain technology

Blockchain connects multiple time-stamped records—or 'blocks'—together using cryptography to form a linked, linear chain; these blocks cannot be altered retroactively, making such systems highly secure and resistant to manipulation. Each block is connected to the preceding block, validates the transactions, and distributes information throughout a network of users in the form of a decentralized ledger system.

The application of blockchain technology in timber traceability is at the development stage. In the preliminary studies, blockchain technology has been introduced to electronically trace timber as it travels from the forest to the final product, using an information tracing system based on open source and Radio Frequency Identification (RFID) technology [57].

PEFC International has funded the "Wood-chain project", which will test and stimulate the application of blockchain technology as an innovative IT solution for forestry and wood applications. Blockchain technology may allow transparent and complete supervision of wood and timber products traceability, fully compatible with PEFC Chain of Custody certification.

6. Comparison of technologies

Details of technologies compared, and their advantages and disadvantages are listed in the following parts of this section in a tabulated format. Details of each technology including type, strength, and weaknesses are presented in **Tables 6** and 7.

6.1 Advantages and disadvantages, forensic technologies

List of advantages and disadvantages of technologies used for tracing products is presented in **Tables 6** and 7.

6.2 Advantages and disadvantages, labelling technologies

6.3 Suitability of labelling technologies at different stages of supply chain

This section reviews the applicability and effectiveness of the techniques from application, security, labor required, accuracy, and effectiveness point of view. Further comparison and discussion are required if any of the techniques were selected for any of the production stages, including the scale, price, and number used for the product batch. **Table 8** represents a list of labeling types and briefly details their suitability for the timber industry.

6.4 Security characteristics of labelling technologies

A list of security characteristics of labelling technologies is presented in **Table 9**.

6.5 Costs and lead times

The summary of cost estimates and required time for each type of technology is listed in **Table 10**.

Technology type	Strengths	Weaknesses
Microscopic wood anatomy	Microscopic analyses are relatively quick and inexpensive to conduct and can provide an indication of the species group involved. It could potentially be designed based on images already being taken in industry operations for grading and sorting products.	It can rarely provide confirmation of an exact species and is not an indication of the geographic region of origin beyond the species group's natural range. It's also more suitable for raw materials than later stages in the supply chain. The development of a smart system to detect specific species or products can be time-consuming and costly.
Automated machine vision	Faster than traditional microscopy technique and if abundant reference images exist, can be more accurate.	Limited reference image database for species at present can be costly to set up and would require upgrades and further modifications. Requires further calibration and modification for adding species and product types.
Mass spectrometry (e.g. Direct Analysis in Real Time, Time of Flight Mass Spectrometer (DART TOFMS)	This method requires nearly no sample preparation, is non-destructive (a sliver of wood is sufficient) and is fast. Promising for its ease of use and once developed fully can be low cost.	The application of DART-TOF Mass Spectrometry in wood forensics is currently at an early stage of development. Faces the same constraints as other technologies in regard to reference data. Potentially require training, calibration and maintenance, could be too sensitive to be used in all supply chain stages.
Stable isotopes	It has the potential to possibly identify origin and species (depending on how unique species take up chemicals differently and reference database) down to the concession level.	Cannot identify species. The widespread application requires the collection of great numbers of geo-referenced samples to provide reference data.
DNA barcoding	It can be used to identify both species and origin with great accuracy and precision. It can tie an individual log (or the products derived from it) to the stump it came from (genetic fingerprinting).	The success rate for the extraction of usable DNA sequences from wood products is currently low. DNA techniques are also limited by the number of reliable DNA barcodes sequenced for different species, the number of reliable genetic reference maps available; and their spatial resolution.
Near-infrared spectroscopy	This method is non-destructive and fast. Closely related species can be differentiated, and the technique has the capacity to discriminate between geographic provenances. An integrated approach with analysis of isotopes and trace elements can yield high levels of accuracy.	NIRS reference data are still limited. As a stand-alone method, the identification accuracy is variable. Initial large data set is required to develop a validated and reliable model. The requirement to update and calibrate the model could cause extra costs.

Table 6.
Advantages and disadvantages of technologies used for tracing various products.

Technology type	Strengths	Weaknesses
Conventional paint and chisel labels	Paint and chisel marks are easy to apply, low-cost, and require no special training. These labels can be very robust and survive road and water transport very well. They can also be integrated with forest management, logistics, and stock inventory functions.	Hand-printed labels are used in various stages of supply chain and can be used on large-size logs as well as other products. They are not as secure as some other labeling options and can be lost or damaged easily. The other disadvantage of using these labels is the amount of paperwork required to record and manage the information.
Branding hammers	The hammer branding is a cost-effective and easy-to-use method, does not require any training and can be applied on any size log. The hammer branding can be used in combination with coded serial numbers and can be used as an option in both forest management system as well as transport and stock inventory in the log yard.	Hammers can be easily replicated and widely distributed to unauthorized personnel. Hammer marks are not easily keyed to associated documentation, and thus, they cannot easily be used as part of a comprehensive chain of custody system. It can be labor intensive and not easy to follow if any part of the data is missing. Also, could be difficult to refer to imported products.
Conventional labels	Attaching the label is relatively quick. Conventional labels are inexpensive and are easier to read than other marking technologies. Large amount of data related to product location, and ownership. Size and scale and any other production specifications can be stored using this labelling option. Barcoded labels can also provide better security and possibility of including more information about the product.	Conventional labels can be easy to duplicate or counterfeit unless suitable security mechanisms are integrated into the design of the labels. Barcoded labels can easily be removed or fall off. Experience shows that 1–5% of labels fall off before the product reaches its destination. Conventional labels cannot usually be manufactured in the forest and therefore have to be pre-printed for log tracking purposes. Can be replicated and accessed by other parties throughout the chain.
Nail-based labels	The nail-based labels are more durable than paper or plastic-based labels. Their installation process is similar to the hammer brands and large amount of information can be included in them. The addition of barcode to nail-based label could provide possibility of adding more product information and the nature of these labels (difficult to reprint or change) provide better security of information throughout the supply chain.	The nail-based labels are not easy to replace, and any modification requires re-printing and needs to be done prior to their installation. The limitation associated with any change in the details and need for reprinting makes them less flexible to be used throughout the supply chain.
Magnetic stripe cards	Magnetic stripe cards are useful for attaching information to documentation rather than for labeling individual products. The information stored on these devices is relatively secure and difficult (but not impossible) to alter or counterfeit. These devices can facilitate data processing and security audits of documents. It is possible to manufacture labels at processing plants and at many storage facilities, allowing more data to be inserted into the documents.	Magnetic cards are not as effective to be used for log labelling as some other labelling options. The card readers can be expensive and not easily used in various stages of supply chain. The data recorded on the cards also has limited size and is not as flexible as information that can be stored on other options such as smart cards.

Technology type	Strengths	Weaknesses
Smart cards	The large amount of data that can be stored on smart cards with high level of security is their main advantage. They are also good replacements for paper-based labels and the large amount of paperwork required for some of the other labelling options. They provide the security of information that cannot be easily replicated or modified by non-authorized parties. These devices can significantly facilitate data capture, data processing, and security audits. It is possible to capture data at processing plants and at many storage facilities allowing more data to be inserted into the documents. These labels can enhance logistics and stock inventory functions.	The potential disadvantage would be the cost associated with their use, reading, and maintaining their information system. The cost can make them less effective for individual log purposes. Their need for readers/ scanners makes them less mobile and flexible throughout the supply chain.2
RFID labels	The RFID labels are easily and rapidly readable in various environments and remote conditions including underwater. They can store large amounts of product information and are highly secure and difficult to tamper with or modified by non-authorized parties. They provide flexible system for data management, processing, and make data reviews and audits easier. They also can be used in various stages of supply chain to enhance logistics, raw, and processed product data recording, and inventory functions.	The cost can be one of their disadvantages in comparison with other labelling options. The scanners used to read the data also can be expensive and can require a high level of technical experience to program and maintenance.
Microtaggant tracer	Microtaggants are very secure and provide an accurate level of product information. They can nt be replaced or counterfeited easily while they are inexpensive labelling options and simple to use. They can be used in various stages of supply chain and are comparable to other current labelling options used by industry (such as conventional and printed labels). They are durable and can be used on products during processing stages of supply chain.	They are not a full tracing system and are only effective when used in labelling batch products. Their application for individual products is not economically viable. They are read manually and do not provide electronic reading options. Although the microtaggants are low cost the cost of setting up the system for them is still high.
Chemical tracer paint	The tracer paint is an accurate system with high level of security that cannot be easily tampered. It is a low-cost labelling solution that can be utilized easily. The tracer paint option can provide flexibility of use throughout the supply chain. The oil-based options are more durable than the normal options and could be used during the timber processing lines.	Solvents used with oil-based tracer paints may induce allergies in some people. Requires proper accountability and secure storage facilities to prevent theft (and misuse) of the paint. Laboratory identification of the painting signature is time-consuming and expensive. More investigation into their applicability at different stages of product development (treatment, cutting, gluing, etc.) needs to be done.
Nanotechnology	Nanoparticles can be easily sprayed onto wood and detected by a hand-held device. It has the potential to be applied to timber and pulp, and paper products as a cheaper alternative to	The application can be cheap, but the technology is proprietary. The range of distinct and identifiable nanoparticles is not infinite to prevent complete

Technology type	Strengths	Weaknesses
	barcodes, radio-frequency identification (RFID), and other tracking technologies. Products marked with nanoparticles can be authenticated at any time, instantly, non-destructively, an unlimited number of times, and without cumbersome lab testing or slowing the flow of goods.	exclusivity in identification and traceability use. Further testing and large-scale trials are needed to develop practical protocols and solutions for their applications in each stage of the supply chain.

Table 7.
Advantages and disadvantages of technologies used for labeling products.

Label type	Tree label	Log labels	Processed wood labels	Transport documentation
Conventional paint and chisel labels	Suitable	Suitable	Not suitable	Not suitable
Branding hammers	Not suitable	Not suitable	Not suitable	Not suitable
Conventional labels	Suitable	Suitable	Suitable	Not suitable
Nail-based labels	Suitable	Suitable	Not suitable	Not suitable
Magnetic stripe cards	Not suitable	Not suitable	Not suitable	Suitable
Smart cards	Not suitable	Not suitable	Not suitable	Suitable
RFID labels	Suitable	Suitable	Suitable	Suitable
Microtaggant tracer	Suitable	Suitable for adding security to other labels for tracking batches of logs	Suitable for adding security to other labels for tracking batches of logs	Not suitable
Chemical tracer paint	Suitable	Suitable for adding security to other labels for tracking batches of logs	Suitable for adding security to other labels for tracking batches of logs	Not suitable
Nanotechnology	Suitable	Suitable	Suitable	Suitable

Table 8.
List of potential labelling technologies for tracing timber products.

It should be noted that the above-listed cost does not include the cost for maintenance, upgrades, and calibration.

6.6 Technology currently available/used

This section includes information about the existing and some potential technologies that can be used in tracing timber throughout the supply chain (**Table 11**). The main focus of this section has been on the specific information about each technology, their potential advantages and limitation that could have for each stage of the supply chain.

Label type	Security characteristics
Conventional paint and chisel labels; Hammer brands	These labels do not provide any advanced level of security and only represent the data included in the paper-based product management system they link to. Their accuracy and security are checked by in-field audits and cross-examining their information with the potential data management system in place. The accuracy and security of these systems is highly dependent on the data recording system developed for them and any issues and mistake in the system could cause in-accuracy and uncertainty about the product information [58] For painted labels, the security can be enhanced if the paint is used in combination with a microtaggant or some type of chemical marker.
Conventional labels	The conventional labels are more secure than the paint, chisel, or branding hammers however still can be tampered and replaced. To improve the security of these labels they can be printed on different materials such as watermarked paper or hologram-embedded plastics. The labels can also be used with microtaggant and marker chemicals. Addition of barcodes to these labels can provide higher level of security. The design of these labels to destructible can provide some level of security by deforming or disintegrating in case of any attempt of tampering, however, this can also make them less durable throughout the supply chain. The security and accuracy of information on these labels are checked by audits and filed checks. And the quality of the referenced documentation and up-to-date details affect the effectiveness of these labels [58].
Nail-based labels	• These labels are more difficult to be replaced due to their materials and the information printed on them in comparison with paper or plastic-based labels. To improve their security, they can be used in combination with microtaggants and marker chemicals. The use of encrypted barcodes on nail-based labels can also enhance accuracy and security. It is usually costly and difficult to remake the nail-based labels on-site or in-field and the change or modification of product information on the label is difficult. They provide information according to the referenced documentation and to check their accuracy audits are required. The comprehensiveness, up-to-date and accuracy of referenced documentation reflect the nail-based labels' quality and accuracy [58].
Magnetic stripe cards	• The stripe cards are secure and can be encoded to enhance the security of information they provide. Their readers can be programmed to provide better accuracy and security of information. The use of these cards with watermarked paper or hologram-embedded plastics can enhance their security. Use of marker chemicals and microtaggants is also possible to improve the level of security. And the information included on the stripe cards can be encrypted to reduce the possibility of tampering. The supporting documentation can be used with the stripe cards and auditing and field checking of source material needed to cross-check the accuracy of the referenced information.
Smart cards	• The smart cards are very secure and possibility of encoding the stored information enhances their security in comparison to other labelling systems. If they are designed properly, they automatically stop operating when they are outside the designed voltage and frequency ranges providing additional anti-tampering characteristics. The design of them can be modified to become inoperable once the programming the cards is completed so they can't be altered or modified by non-authorized parties.
RFID labels	• RFID systems are secure and can be used to process large volume of information in a short timeframe, remotely and in real-time. Their

Label type	Security characteristics
	security is as high as the smart cards with potential for encrypting information. RFID labels are covertly used due to their hidden mechanism within the product or product batch and also can be used on other labels. The existence of RFID labels can be examined easily, rapidly, remotely, and in real-time.
Microtaggant Tracer	Microtaggants are tamper-proof labelling options and can be used in combination with other labels. They are a cost-effective system to identify potential tampering and replacement of labels. However, they are only effective if they are used with a thorough surveillance operation system that is well designed and programmed.
Nanoparticles	Nanoparticles are secure as they are not easily tampered with or replaced. They provide possibility of tracing raw and processed products in various stages of the supply chain. They require a management system and referenced information if they are used on large scale however the appropriately designed management system also provides the possibility of modifying and adding information as product is processed throughout the supply chain.

Table 9.
Comparison of security characteristics of labelling systems for application in the timber industry.

Traceability techniques	The approximate cost (USD)	Minimum time required for the process
Wood anatomy (including machine vision/ dendrochronology)	<\$100*	Minutes–days
Mass spectrometry	<\$1–\$100*	Minutes–days*
Near-infrared spectroscopy	<\$1–\$100*	Minutes–days*
Stable isotopes	\$100–\$400*	Several days*
Radio-carbon	\$300–\$400*	Several days*
Genetics	\$100–\$300*	Several days*
RFID	\$0.09–\$20**	N/A
Microtaggant	\$145***	N/A
Nanotag	Can vary depending on types and material used/has been successfully used for food industry previously.	N/A
Nanoparticles (Stardust****)	Under development****	N/A

**It should be noted that these are the approximate cost range for a trained expert to complete the laboratory test of one sample and minimum lead times based on the time required to complete the laboratory test.*
***Cost range of one passive RFID tag. RFID readers can vary from around \$400 to up to \$3000 or more.*
****The cost of 236.6-milliliters bottle of Microtaggants (easily marking at least 1000 logs).*
*****Stardust is being developed and has the potential to replace barcodes, RFID, and other technologies as a cheaper alternative.*

Table 10.
Summary of technology costs and their required processing time.

Technology type	System	Supply chain stage	Product details	Advantages and limitations
Nanotechnology	Covert marking and tracing of raw materials with dust-like nanoparticles in various applications, including timber.	From forest to the consumer	Stardust www.stardustus.com Stardust has developed solutions enabling covert marking and tracing of raw materials in a range of applications, including timber, responsibly sourced goose down and leather, organic fibers, and coral.	Pros: Easy to apply, tamper-proof and cheap. It can be scanned and identified by a handheld device. Cons: Under development and proprietary.
DNA analysis	A chemical profiling technology that verifies the provenance of the product, including food and non-food.	Provenance verification	Source certain www.sourcecertain.com	Pros: Accurate and precise with identifying species and origin. Cons: Dependent on the number of reliable genetic reference maps.
Microtaggant	Metal microdot which provides the option to customize branding, for identification purpose.	From forest to the consumer	NanoTag www.nanotag.com	Pros: Easy to apply, tamper-proof, applicable to the whole supply chain. Cons: Needs to be manually read. Sometimes not easy to find and read.
Microtaggant	Microtaggant particles contain multiple color layers, which translate to a numeric code. Other materials can also be added to the Microtaggant to aid in location and authentication.	From forest to the consumer	Microtrace www.microtrace solutions.com	As previous
Information system/ Nanotechnology	An information system that promotes transparency and accountability along the supply chain ensures regulatory compliance and improves supply chain integrity.	From forest to the consumer	Ivo42 https://iov42.com/ The system provides blockchain digital identities to each of the stakeholders that are part of the supply chain (be it an individual or an organization) and represents timber as digital assets.	Pros: Accurate and can handle a large amount of information entered into the system. Cons: Can be expensive; the setup can be time-consuming and requires a holistic, systematic action.
GPS system	A GPS system unique in the European timber industry for transparent tracing of log deliveries in Romania. It	From forest to mill	TimFlow www.timflow.com	Pros: Can be used along with other GPS operating systems and is easy to use. Cons: Requires connectivity of

Technology type	System	Supply chain stage	Product details	Advantages and limitations
	seamlessly monitors the transport route from the loading place to the factory gate. The information collected includes GPS data and photos of the consignments.			information, and the scale of data requires filtering and further analysis.
Durable tags and labels	Dura-ID Solutions specializes in labels and tags which survive hostile procedures and conditions.	For timber treatment	Dura-id solutions dura-id.com	Pros; Can survive hostile procedures and conditions during timber treatment. Cons: Requires a purpose-built system to use the data; however, the data needs to be added to a system separately to be accessed and used in future.
Information system/DNA and isotope testing, and blockchain	A timber traceability platform that combines traceability, verification, and visualization.	From forest to the consumer	Nature's barcode timber traceability platform www.naturesbarcode.com The platform makes critical supply chain information from forest to consumer available to different stakeholders.	Pros: Enables compliance and procurement officers to organize huge volumes of supply chain data and due diligence evidence. Cons: On-the-ground experts are needed to check supply chain practices; DNA analysis and isotope testing are needed to verify data.
Information system/GPS, branding hammer, image analysis, and blockchain	Hammer branding combined with database and image processing. *"The OtmetkaID marking system stamps a globally unique code at the root end of each log, automatically creating the first link in a blockchain."*	From forest to mill	Otmetka otmetka.com OtmetkaID© allows verification of the geographical origin for each marked log. Currently developing automated tagging and tag reading technologies for New Zealand harvesting equipment and New Zealand supply chains.	Pros: Can be easily accessed, and information is up to date and in stage by stage. Cons: Set up is costly and time-consuming and requires regular data entry and updates.
Information system/Paper tag	A centralized repository of information about transactions between wood owners, its customers, carriers,	From forest to mill	Skogsbrukets Datacentral (SDC) in Sweden http://www.sdc.se/default.asp?id=1007&ptid An independent IT company set up by 50	Pros: Easy to access the information. Cons: Cost of setting up and keeping the information up to date.

Technology type	System	Supply chain stage	Product details	Advantages and limitations
	sawmill factories, and independent organizations that carry out measurement and determination of wood quality.		timber companies in Sweden that ensure record-keeping of agreements on timber, its measurement, and transportation.	

Table 11.
Summary of labelling technologies and their product details and advantages and limitations.

7. Case studies (Australia & International)

7.1 Illegal logging

7.1.1 Papua New Guinea (PNG)

7.1.1.1 Issue

Illegal logging in PNG was recorded as high as 70% of the total logged timber in 2006 causing major concerns for the PNG authorities [59].

7.1.1.2 System introduced

The PNG government has used a full-time third-party auditor to check the product information throughout the supply chain for many years. The product details audited include species, volume, and quality of raw products harvested and exported. The auditing system and process are outsourced to SGS PNG Limited are present in the country's exporting docks and actively track products leaving the port. The auditor uses barcode labels and portable data terminals to enhance the accuracy of data checked. The system also is designed with a backup offline and manual system in case there are issues with the labeling technology. The system in place has provided various benefits in identifying illegal logs and reducing the associated issues by:

Providing accurate information about the details and scale of products being exported from PNG. The increased profits have compensated for the cost associated with third-party auditing.

Providing better understanding of the industry stages and the influential factors in production and export stages. This has led to better communication between the PNG government agencies and forest industry.

Created historical accurate information about the country's production rate and exported log.

Transparency and clarity of supply chain and providing a verifiable audit history that can be used by industry stockholders.

Providing better information for training program development for forest industry and future industry planning.

7.1.2 Russia

7.1.2.1 Issue

Mass illegal and unregulated logging of Russian forests pushed the Amur tiger to the brink of extinction. Most of Russia's exported timber goes to China to supply its furniture and flooring industry.

7.1.2.2 System Introduced

In 2013, the Russian Federation introduced "The Development of Forestry 2013–2020", an 8-year plan to reduce illegal logging and increase profits from the timber sector which was underutilized. To ensure the plan was immediately implemented the criminal code was also updated in 2014 to include stricter penalties for illegal logging, transport, and sale.

Timber labeling, traceability, and monitoring system requirements were updated in the "Federal Law on Amendments to the Forest Code of the Russian Federation 2013" as part of The Development of Forestry 2013–2020. In 2015 the Russian government launched a new electronic system for recording timber-related information i.e. the Uniform State Automated Information System (EGAIS). All forest and timber organizations are required to submit information on the volume of logs harvested, labels used, and timber sold. Although all forests in Russia are State-owned, they are operated by private companies and organizations that are licensed. Valuable forest species are determined by the Russian Federation and the list is updated regularly. Below is a summary of the amendments made in 2013 tEWPs original document from 2006:

- The wood of valuable forest species, for example, oak, beech, and ash, is subject to mandatory marking and labeling by legal entities with procedure/specifics of markings yet to be developed.

- The information must be submitted to Uniform State Automated Information System (EGAIS) no later than one day before export. Similar systems for alcohol, chemicals, and medicines exist.

- Documentation accompanying the logs during transport should include the following information: exporter, consignee, carrier, species, volume, and assortment.

- All exported logs should also be accompanied by a transaction declaration that can be found within the EGAIS. The form should contain the following information: exporter, volume, species, assortment (such as sawn log grade, pulpwood grade, or firewood grade), information on the lease agreement, and information on the log purchase contract.

7.1.2.3 Benefits

Illegal logging of valuable forest species decreased by 37% during 2017–2018. However, species that are not labeled as valuable are not covered under EGAIS, which means illegal logging still exists. A proposal to introduce electronic tagging of all logs may not be economically feasible depending on the cost of the log chip. Chips are estimated to cost between USD 0.5–5 each and the least valuable logs come in at around USD10.37.

7.1.3 Austria (Schweighofer)

7.1.3.1 Issue

Austrian company Holzindustrie Schweighofer and 32 others were accused and prosecuted for running an illegal logging operation in Romania. The companies ignored laws relating to the amount of timber able to be harvested legally.

7.1.3.2 System introduced

After legal action was taken against Schweighofer they rebranded to HS Group (Holzindustrie Schweighofer Group) and worked on developing and employing an internally designed timber/log tracking system. The system developed was Timflow and allowed complete transparency and tracking of all log shipments from forest to mill. The system consisted of GPS trackers fitted to trucks and hand-held terminals (smartphones/tablets) given to the drivers. After a load of logs is placed onto the truck, the drivers use the handheld terminals to take photos from all sides of the trailer as well as a photo of the registration plates. The drivers then also register the transport data and any additional information into the software along with the photos. Once the truck begins its journey to the mill, the photos and information is uploaded to the GPS tracking route. The GPS software allows detection of even slight deviations from the approved route. Once the truck arrives at the mill, it is not allowed entry until the HS Group has verified the paperwork and information gathered by the GPS and handheld terminal. The photos taken when the truck was loaded, are then compared with the physical load on arrival to ensure the load has not been altered or disturbed in any way. HS group also verify the approved route with the GPS data from the truck to ensure no deviation has taken place. If any of these comparisons are flagged by the HS Grouptaken immediately taken aside, and further investigations take place. To ensure the driver's privacy is maintained the information is uploaded to a publicly accessible database to view 24 h later.

7.1.3.3 Benefits

The main benefit of a system like this is that the company is able to prove beyond doubt that the timber they are processing and manufacturing is sourced from a legal and sustainable forest. This is particularly important for a company like HS Group which has previously been prosecuted for illegal logging and may be under close scrutiny by authorities. Another advantage is the increased public knowledge of the efforts the company is taking to source only legally harvested logs.

7.1.4 Tokyo

7.1.4.1 Issue

The construction of several of Tokyo's Olympic stadiums used plywood boards as form wood for concrete, 87% of which were sourced from South-East Asian rainforests. It is well known that there are significant illegal logging operations in Asia but despite this, Japan's protocol for sustainability is not strict or clear. The policy has an inherent lack of due diligence by having no obligation for full traceability. As seen with inquiries in Australia, there is a probability the quality and strength of the plywood could be in question.

7.1.4.2 System introduced

In January 2019, a few months after the original report was released highlighting the use of timber that was not sustainably sourced, the Tokyo 2020 Olympic organizing committee reviewed the Wood Procurement Standards (WPS). They made two changes to the WPS, the first is that any timber products sourced from that point onward not be sourced from natural forests converted to plantations. Secondly, Japan is to collect more data on manufacturers before procuring from them and add recommendations for additional measures to reduce sustainability risk. However, because the construction of the majority of buildings had been completed before the changes to the WPS, the impact of using non-sustainable plywood may not be reversible. There was also a question about the implementation and enforcement of the new changes.

7.1.4.3 Benefits

Given the construction of the Olympic buildings was still underway when this review was conducted, no reports of the success of these changes to WPS have been reported. However, the lack of a solid sustainable timber sourcing policy has resulted in a severe critique of the Olympic organizing committee from environmental and forestry organizations worldwide. This has the potential to have a detrimental effect on public opinion and acceptance of the construction aspect of the Olympic games.

7.2 Compliance

7.2.1 Docklands Melbourne cladding fire

7.2.1.1 Issue

Noncompliant with Australian cladding combustibility regulations, cladding materials used in external of the Lacrosse Tower which was damaged severely by fire in 2014 which caused up to $40 million in damage.

7.2.1.2 Process followed

In 2017, the building owners received 5.7 million dollars in compensation for fire damage due to non-compliant fire design by the architect, failure in building permit by the certifying group, and failure of fire engineer to assess, recognize, and warn the construction company about the non-compliant cladding [32].

8. Conclusions and recommendations

The report investigates the need for a traceability system at various stages of the timber supply chain, issues related to illegal logging globally and in Australia, and compliance requirements for domestic timber products and imported products. This review focuses on potential challenges that illegal logging and non-compliant timber products could have on domestic, export, and import markets. A list of technologies and systems that have been used previously for tracing timber throughout the supply chain has been presented. Other technologies available and their potential to be used in tracing timber products were also discussed. Advantages and limitations of these technologies at different stages of the timber supply chain, including cost, was listed and compared.

Some case studies and examples of current systems used to trace timber from plantation through to the end-user around the world were also included. A list of failures and the scale of damage in cases where timber was illegally logged and non-compliant products used in the building was discussed.

Overall, from the review conducted, it can be concluded that depending on the supply, for example, stage, operation, and cost of material, different types of tracing technologies need to be implemented. This can include the use of cheaper and easier-to-implement options at the beginning of the supply chain. As the value of the product increases, the flexibility to use more advanced technologies will increase. However, a detailed and systematic global data management system is required to link all data collected through different means at each stage of the timber supply chain.

In Australia, considering that the majority of the forests operate under a sustainable protocol and follow a certifiable procedure to comply with the chain of custody, illegal logging may not be a major issue. However, the potential detrimental effects on wildlife and the environment due to illegal logging need to be investigated and considered on a case-by-case basis from both resource loss and economic points of view. The illegal logging issue will be a major challenge for imports to Australia from parts of the world where logging is not legally certified. This can be addressed by having a two-way traceability system with specific information and documentation for each category of timber product.

The compliance with national and international standards and traceability requirements for domestic products as well as imported products are additional issues and challenges that the timber industry faces. The traceability system will address this aspect by requiring details for each product at every stage of the supply chain provided by the producer, manufacturer, or supplier.

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