TIMBERTRACKER: AN OPEN-SOURCE WEB FRAMEWORK FOR VISUALISING SUPPLY AND DEMAND IN FUTURE CONSTRUCTION TIMBER VALUE CHAINS

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ABSTRACT: The future development of Australia's built environment must tackle two key challenges: improving access to affordable housing and transitioning to net-zero in construction. Given that the majority of Australian housing is built using timber framing, a key barrier to addressing these challenges is the growing gap between the escalating market demand and the limited supply of sustainably-sourced structural sawn timber. This paper presents an open-source, interactive web framework, termed 'TimberTracker", developed to communicate and visualise this resource gap. The website integrates open data sources available for timber supply, building design, and urban planning information ecosystems, to enable better understanding of the timber resources required for Australia's current and future housing ambitions. Analysis of timber consumption data considers demand-side factors contributing to Australia's growing need for structural timber. Analysis of timber production data considers supply-side factors affecting domestic timber availability. Evaluated information is reported through an interactive geospatial map, for timber resource supply and demand requirements for Australian Local Government Areas up to 2050.

KEYWORDS: timber value chain; geospatial data analysis; timber-framed construction; material flow analysis

1 – INTRODUCTION

Timber is a versatile and structurally sound material that has shaped building practices for centuries. Importantly, timber is also one of the few carbon-negative building materials we have to hand. Common alternatives including steel, concrete, and aluminium are well-known carbon emitters, with building embodied emissions making up a staggering 8.9% of Australia's total greenhouse gas emissions [1]. Whilst most detached houses in Australia are built using timber frames, multi-story buildings are still primarily constructed using concrete and steel. These building classes are of high interest for future urban planning scenarios, as increasing urban density is necessary to reduce urban sprawl and lower transportation emissions.

Using more sustainably sourced timber in construction is also one of our best solutions to fight climate change, with timber building solutions for multi-story construction are emerging both in Australia and worldwide. Australia, however, is already a net importer of timber building products; our current softwood plantation estate is insufficient to meet historical peak demand during housing construction cycles, or future housing supply targets set to improve housing affordability. Trees also take a long time to grow, with softwood plantation trees requiring 30 years before they can be harvested for structural timber [2]. Relying on imported timber to fill this gap poses risks, as countries are expected to cut exports to satisfy their own construction demands and achieve net-zero emissions targets [3].

This paper presents the first implementation of a novel, web-based framework for visualisation of material flow and resource utilisation data in the timber construction value chain. This allows for direct interrogation of the interactions between proposed targets for urban development models, projected resource supply and demand, and potential supply shortfalls. This study will also document the challenges and assumptions encountered in connecting available open data across timber supply, building design, and urban planning information ecosystems.

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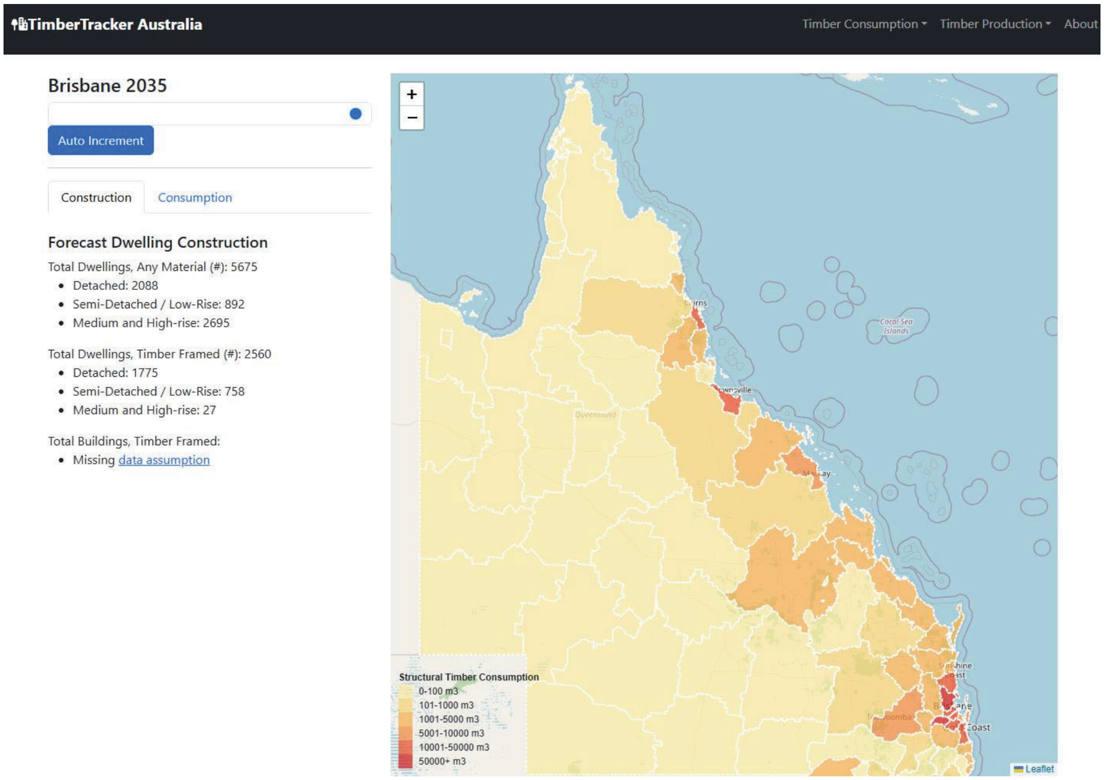

Figure 1. Timber Tracker website, available at: https://timbertracker.uqcloud.net/ .

2 – PROJECT DESCRIPTION

The project outcome is an interactive web framework that utilised embedded material flow analysis (MFA) [4] models to estimate future demand for structural timber in Australian Local Government Area (LGAs), Figure 1. The model is developed in two halves: a timber supply MFA model captures forest-to-wood product process data and a timber demand model captures product-to-building process data. Data analysis tools are developed in Excel/Python and the data reporting website is built with JavaScript React and Leaflet.

Timber supply and demand models are described in Sections 3 and 4, respectively. The model is focused on structural sawn softwood only, which in Australia is primarily sourced from plantation softwood species. This paper reports model data for Queensland as a preliminary case study region; ongoing development work is being undertaken to expand the framework to other Australian localities.

3 – SUPPLY MODEL

Data sources and assumptions used in the supply model are summarised under the following stages.

Plantation Area and Log Availability

Australian plantation statistics and log availability data are collated and published by the Australian Bureau of Agricultural and Resource Economics and Sciences (ABARES) [5,6]. Availability data is categorised by log type (species, softwood/hardwood, sawlog/pulp log) and Forestry Hub Region. Further detail for state-specific plantation forestry estates is available in contemporaneous government reports [7] and average annual harvest volumes and log type yields are published on a species-specific basis by plantation growers [8,9]. Collectively, this gives average annual log availability by species and log type, Table 1.

Table 1:Queensland log availability, by species and log type [m3 pa]

	Species		
Log Type	**Southern Pines**	**Hoop Pine**	**Other Pine**
Saw Log	1,530,000	467,000	-
Ply Log	-	22,000	-
Pulp Log / Residues	80,000	54,000	65,000
Total	1,610,000	543,000	65,000

Mill Inputs (Primary Wood Products)

The National Wood Processing survey [10] lists the number and average input volumes for Australian timber mills, categorised by mill type (saw/pole/ply mills) and State. This model adopts a more detailed classification of mill types than that used in the National Survey, with the following mill classification based on manufactured product categories:

- Sawmill (Struct.): Sawmills with structural grading capacity, producing structural and non-structural building products.
- Sawmill (Non-Struct.): Sawmills with no structural grading capacity, producing appearance-grade and/or non-structural building products and non-building products.
- Sawmill (Dunnage): Sawmills producing non-building products (dunnage, pallets).
- Pole Mill: Mills producing post, pole, and round timber products.
- Ply Mill: Mills producing veneer and plywood products.

The volume of input sawlog for each mill type is inferred from [10] and publicly reported mill locations and feedstock species. This is converted to an estimated proportion of available Queensland log supply, Table 2. Queensland Southern Pine sawlogs are found to be fully utilised by existing mills, meaning some supply may be filled from interstate imports. However, this finding has not been verified. There is an under-utilisation of Hoop Pine sawlogs, consistent with findings reported in [11] and total Queensland mill inputs reported in [10].

Table 2: Estimated proportional input, by species and mill type, for Queensland timber mills.

	Feedstock		
Mill Type	**SP Saw Log**	**HP Saw Log**	**HP Ply Log**
Sawmill (Struct.)	88%	-	-
Sawmill (Non-Struct.)	8%	55%	-
Sawmill (Dunnage)	2%	14%	-
Pole Mill	8%	-	-
Ply Mill	-	-	100%
Total	106%	69%	100%

Mill Outputs (Primary Wood Products)

Average sawmill mill outputs relative to processed inputs are reported in the National Wood Processing survey [10] as board recovery rates. Board recovery rates are the relative volume of manufactured product outputs to mill log inputs. State-specific recovery rates are only reported for sawmills and exclude species consideration. Pole and ply mill recovery rates are reported as a national average.

Each mill type produces a different range of products. This model adopts mill-specific product recovery rates as shown in Table 3, which are assumed to give a similar overall product recovery rate product classification to that reported in National Wood Processing Survey [7].

Table 3: Estimated mill-specific product recovery rates for Queensland timber mills.

Product Type	**Mill Type**		
	Sawmill (Struct.)	**Sawmill (Non-Struct.)**	**Sawmill (Dunnage)**
Green - Structural	10%	1.6%	-
Green - Other	6.7%	17.7%	48.5%
Dry - Structural	31.6%	-	-
Dry - Appearance	-	17.4%	-
Dry - Other	8.6%	11.2%	-
Residues	52%	52.1%	51.5%
	Mill Type		
	Ply Mill	**Pole Mill**	
Plywood	80%	-	
Posts and Poles	-	80.5%	
Residues	20%	19.5%	

Mill Input and Outputs (Secondary Wood Products)

Laminated timber products can be made from structural (Dry-Structural) and non-structural timber (Dry-Other) materials. Queensland has laminated timber facilities for Glulam production. CLT production facilities are located interstate; to allow for its representation in the current model, CLT production is included as proportional to Queensland population at 20% of national production. Feedstock volumes are calculated assuming a 20% planage/shrinkage loss and a 75%:25% structural:non-structural feedstock material type. Feedstock volumes are converted to a relative percentage of available feedstock as summarised in Table 4. Production volumes are

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converted to a relative percentage of input feedstock as summarised in Table 5.

Engineered wood panels are manufactured at panel plants using reconstituted wood fibre. Queensland hosts two major panel production facilities for medium-density fibreboard (MDF) and particleboard. These products are made from a combination of mill residues and pulp logs. Feedstock volumes are calculated at 147% and 126% of reported maximum production volume for MDF and particleboard, respectively, due to the higher density of engineered panels compared to raw wood. Feedstock composition is assumed as 60%:40% mill residues:pulplog for MDF and 40%:60% for particleboard. Feedstock and production volumes are summarised a relative percentage in Table 4 and 5.

Table 4: Estimated proportional input, by feedstock type, for Queensland structural secondary timber production.

Mill Type	**Feedstock**	
	Dry - Structural	**Dry - Other**
Mass Timber	2.5%	2.5%
	Residues	**Pulp Log**
Panel Mill	29.5%	70%

Table 5: Estimated product recovery rates for Queensland secondary structural timber products.

Product Type	**Mill Type**	
	Mass Timber	**Panel Mill**
Glulam	70%	-
CLT	30%	-
MDF	-	53%
Particleboard	-	17%

Imports and Exports

Queensland softwood product import and export volumes for structural timber products are summarised in Table 6, from estimated volumes described in [11] and publicly reported wood fibre export volumes [12]. Wood-based residue product (wood chips, pellets) and pulp log exports are volatile. Log exports which have steeply declined since 2020 and wood pellet production and export have been significantly restructured to remain operational, since time of publication of [11].

To summarise the trade balance, Queensland is a net importer of high-value wood and engineered wood products and a net exporter of low or negative-value residue products and pulp logs.

Table 6: Estimated Queensland average annual softwood import and export volumes [m^3 pa].

Product Type	**Import**	**Export**	**Balance**
Plywood	110000	0	-110000
Dry - Structural	75000	0	-75000
Dry - Appearance	60000	0	-60000
Particleboard	10000	0	-10000
Green - Other	30000	30000	0
MDF	10000	50000	40000
Pulplog/Rounds	0	295000	295000
Pellets	0	50000	50000
Woodchip	0	50000	50000
Total	295000	475000	180000

Total Market Supply

Product supply is aggregated to three broad categories for subsequent mapping to market consumption:

- Building Material (Structural Use): Timber material sold to construction markets for structural applications. Includes Green – Structural, Dry – Structural, Plywood, 85% Particleboard, Glulam, and CLT product volumes.
- Building Material (Non-Structural Use): Timber material sold to construction markets for other applications. Includes 50% Dry – Appearance, 85% MDF product volumes.
- Non-Building Material: Timber material sold to non-construction markets, including landscape and industrial (pallets and dunnage) markets. Includes Dry – Other, 50% Dry – Appearance, Posts and Poles, 15% MDF, 15% Particleboard.

The total Queensland softwood market supply is illustrated as a mass flow diagram, Figure 2. Queensland manufactures a total of approximately 1,362,000 m^3 of wood products per year, comprising 541,500 m^3 (39.8%) of building material for structural use, 246,500 m^3 (18.1%) of building material for non-structural use, and 574,000 m^3 (42.1%) of non-building material. The total timber building material supply for Queensland per annum is 1,003,000 m^3, with 788,000 m^3 (78.6%) made in Queensland and 215,000 m^3 (21.7%) imported from overseas.

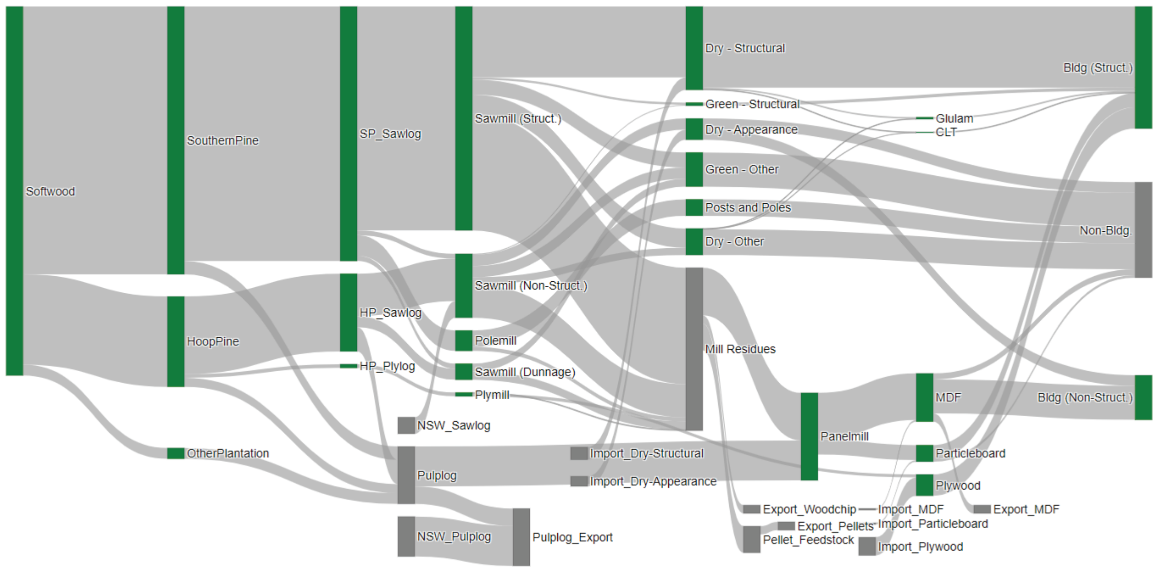

Figure 2: Queensland softwood annual mass flow diagram – supply only.

4 – DEMAND MODEL

The demand model is developed to identify the end market use of structural timber used in building construction. This includes material demand by region and by building type.

Residential Dwellings – Volume and Diversity

Building Approvals [13] data collated by the Australian Bureau of Statistics (ABS) provides information about the number of dwellings approved by Local Government Area (LGA). This includes a relatively detailed functional classification of buildings, with seven building codes related to residential dwellings. These are aggregated into detached, low-rise, mid-rise, and high-rise residential building classification. The 2021-22 financial year, with 38,000 total dwellings approved in Queensland, is representative of the approximate long-term average annual construction volume. This comprises 24300 (64%) detached, 6200 (16%) low-rise, 3100 (8%) mid-rise and 4400 (12%) high-rise dwellings. Construction volume per LGA is illustrated in Figure 3 and is highly concentrated in South-East Queensland, particularly for mid-rise and high-rise dwellings.

Residential Buildings – Size and Demand

Victoria is the only Australian State to publish building permit data with information on building size (number of dwellings; number of storeys; and gross floor area per approved building project) and material use (building frame, floor, roof, and wall material) [14, 15]. This allows the relative market share of different construction systems to be estimated with high reliability and with high visibility on how this is shaped by local construction practice. For all other Australian regions, including Queensland, construction gross floor area (GFA) and material market share is only reported as estimated values, based on aggregated reporting from relatively less reliable industry and market surveys. For the present model, total GFA per building class in other States is calculated by scaling Victorian data by the relative total dwelling number. For Queensland, the scaled Victorian data has relative dwelling construction per building classification within ±3% of actual values.

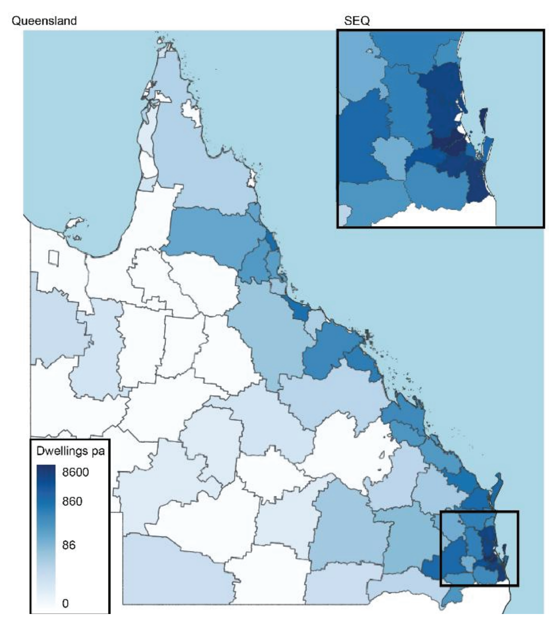

Figure 3: Queensland residential dwelling construction per LGA.

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Timber demand for residential dwelling construction is estimated from calculated GFAs using material intensity factors, which list mass of material used per square meter of usable floor area. No material intensity data was found for Queensland building construction. This report adopts material intensity factors for timber listed in [16, 17], based on analysis of building stock in a single suburb in Canberra. Timber weight is converted to softwood volume assuming an 85% softwood product composition and a 450-550 kg/m3 dry wood density. Calculated timber demand is summarised in Table 7 and Figure 1.

Table 7: Queensland Residential Construction – Floor Area and Timber Volume.

Building Class	**Total**		**Per Dwelling**	
	GFA [m2]	**Timber [m3]**	**GFA [m2]**	**Timber [m3]**
Detached	5918000 (71.8%)	430000 (81.5%)	244	17.7
Low-Rise	1279000 (15.5%)	87000 (16.4%)	208	14.1
Mid-Rise	450000 (5.5%)	5000 (0.9%)	142	1.5
High-Rise	600000 (7.3%)	6000 (1.1%)	98	1.4
Total	8247000 (100%)	528000 (100%)		

Non-Residential Buildings

The GFA of Australia's current building stock is given in [16], per State and per building type, including residential and non-residential building types. The present report estimates the annual construction of non-residential buildings in Queensland as the relative scale of non-residential to residential GFA. This gives an estimated non-residential annual GFA construction of 2,860,000 m^2 per annum. This is consistent with estimated values given in [18] (Ref. Table 26) of 2,914,443 m^2 in 2020 and 2,835,913 m^2 in 2030. The utilised building classification in [16] is broader than that used in [18] and based off aerial point cloud data rather than building use data. The following simplified non-residential building classification is adopted for the present model:

- Commercial 1-3 storey: education buildings; short term accommodation buildings, warehouses; aged care buildings.
- Commercial 4-7 storey: offices, health facilities; entertainment and recreation buildings.
- Commercial 8+ storey: offices; buildings not elsewhere classified.
- Industrial: retail and wholesale trade buildings; factories and other secondary production buildings; agricultural and aquacultural buildings; transport buildings.

Timber demand in non-residential buildings is again estimated using the material intensity factors listed in [16,17]. Non-residential construction and timber demand volumes are summarised in Table 8.

Table 8: Queensland Non-Residential Construction – Floor Area and Timber Volume.

Building Class	**GFA [m2]**	**Timber [m3]**
Commercial 1-3 storey	966000 (33.8%)	27000 (48.3%)
Commercial 4-7 storey	1153000 (40.3%)	10000 (17.5%)
Commercial 8+ storey	117000 (4.1%)	1000 (1.3%)
Industrial	625000 (21.8%)	18000 (32.8%)
Total	2861000 (100%)	56000 (100%)

Total Market Demand

There is limited available data on timber volumes used in specific downstream construction sectors. An estimate of sawn timber market use is given in [18] as: 53% new residential building construction (low, medium, and high density); 14% non-residential building construction, and 33% alterations and additions. There is also a certain amount of material wastage between supply and end market use, estimated as 5-10% for offsite construction and 10-20% of on-site construction. A value of 13% wastage is adopted, calibrated to match building material market consumption to supply, for structural and non-structural product categories.

Queensland's total timber demand is estimated as approximately 1,577,000 m³ per year. New builds account for 584,000 m³ (37.0%) of consumption, with an additional 87,000 m³ (5.5%) generated as construction waste. Alterations and additions represent 331,000 m³ (21.0%) of demand. Building-related timber demand totals 1,001,000 m³ (63.5%) annually, while demand in non-building applications is 574,000 m³ (36.5%). Demand material flows are illustrated alongside simplified supply material flows in Figure 3.

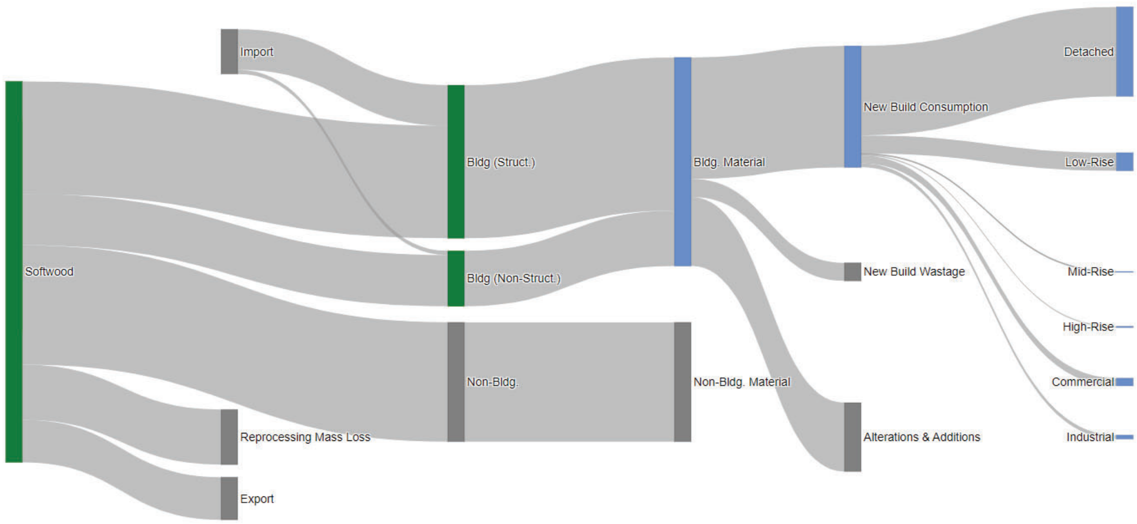

Figure 3: Queensland softwood annual mass flow diagram – supply and demand.

5 – RESULTS

The developed supply and demand models are now used to project future wood product availability, construction consumption, and supply shortfall. The projection assumes a 'business as usual' future, where key model assumptions remain unchanged over time, including for the relative proportion of wood products recovered from log processing, the density of dwelling development in each LGA, and material intensity factors for timber consumption in building construction.

Projected Log Availability

Forecast log availability data is published for 5-year harvest periods from 2020-24 to 2060-64. For Queensland, total available softwood plantation log volume is projected to increase to 2.6 million m^3 in 2046 before reducing to a longer-term average of approximately 2.4 million m^3 per year. The proportion of sawlog and pulp log is assumed as constant. No distinction is made between log availability per species, but is noted here for potential future model improvement. From Section 3, building material and non-building material product volumes are projected as 35.5% and 25.9%, respectively, of harvest log volume.

Projected supply for timber products manufactured in Queensland are shown in Figure 4 (blue line). Queensland can manufacture a maximum of 930,000 m^3 per annum of timber building product under status quo value chain conditions.

Projected Construction Volume

Projected dwelling data is published by various government levels (primarily, local and State), following various methodologies. State-level household dwelling projections [20] are developed based on demographic analysis of current dwelling figures and future population and household characteristics. These project that 843,000 new dwellings will be constructed in Queensland between 2024 and 2046, with a gradual per annum reduction from current construction rate. This paper adopts a modified projection based on the more recent Homes for Queenslanders housing plan [21] to deliver 1,000,000 new dwellings by 2046. This is modelled as a 6% increase in housing construction every 5 years from 2026 (1.17% equivalent annual increase), starting from 38,000 dwellings in 2024-25. Dwelling construction is assumed as constant after 2046.

A shift toward high-density building development model is advocated for in many local and State development plans, to reduce competition for urban space, improve housing affordability, and allow for the more sustainable provision of infrastructure and public transport services. However, a shift from historical (detached housing) development models to a higher proportion of medium and high-density residential buildings will change the supply and performance demands of future construction materials. Projected dwelling diversity sub-targets for South-East Queensland LGAs are given in [22]. This data has not been incorporated into the present projection, but is noted here for potential future model improvement.

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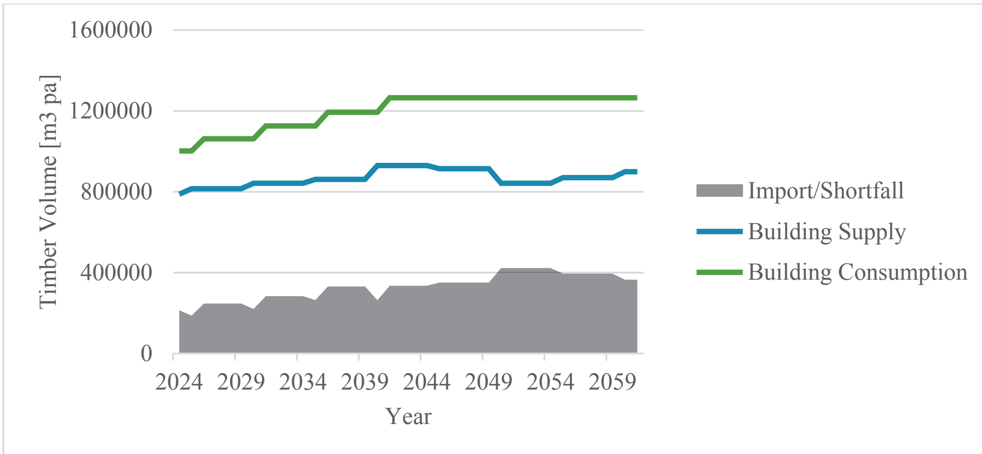

Figure 4: Projected supply and consumption of softwood timber building products in Queensland. Shaded area is projected material shortfall.

The average annual growth rate for Queensland non-residential construction GFA is estimated as 1.36% in [18]. This study adopts a more conservative growth rate of 1.17%, equivalent to the assumed average annual residential dwelling construction growth rate. Timber products used for non-building applications are conservatively assumed as constant over the forward projection period. Recent literature has noted that there is limited market for some of this product, particularly out-of-grade sawn timber [23], which is already sold at a loss under current market conditions.

The projected demand for timber building products in Queensland is shown in Figure 4 (green line). Timber consumption is projected to grow to 1.265 million m3 per annum by 2041, a 26% increase compared to the 1.001 million m^3 estimated consumption in 2021.

Projected Building Material Shortfall

The projected supply and demand of softwood timber building products in Queensland is shown in Figure 4 (shaded region). The shortfall of available building material is projected to grow to 422,000 m^3 by 2054, an increase of almost 100% compared to the 215,000 m^3 estimated shortfall in 2021. This shortfall is currently addressed from imported building product. Thus, there is also an increase in the proportion of imported building supply, from 21.7% to 33.3% (54% increase).

Required Additional Softwood Plantations

The disruption of import availability severely impacts construction supply, as observed during Covid-19 international supply chain disruption in 2019-2020. Reliance on imported timber also poses risks, as countries are expected to reduce net exports to satisfy their own construction demands and achieve net-zero emissions targets. The developed models can be used to estimate the additional plantation area required to mitigate the future dependency on imported timber products for building construction targets.

To estimate the required additional plantation area required in Queensland, the shortfall volume of building product is converted to an equivalent manufactured product volume (less wastage), log volume, number of trees (assuming 0.9m3 average log volume per stem), and plantation area (assuming 380 stems per hectare). Results are shown in Table 9, along with resource productivity benchmarks for detached and townhouse dwelling types. Queensland needs an additional 2,000 ha of plantation to be established per year, to reduce the import dependency to current levels after 2055 (assuming 20 years to first harvest of new plantations and current value chain conditions.). This would need to increase to 4,000 ha per annum to eliminate the import dependency after 2055.

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Table 9: Equivalent softwood plantation area for Queensland reference dwellings (detached and low-rise townhouse) and projected supply shortfalls.

	Volume [m3]			Plantation	
	Building	**Product**	**Log**	**# Trees**	**Area [ha]**
Detached House	17.7	20.3	57.3	64	0.17
Low-Rise Townhouse	14.1	16.2	45.6	51	0.13
Maintain Import Deficit	215,000	247,000	696,000	770,000	2000
Total Import Deficit	422,000	485,000	1,367,000	1,518,000	4000

6 – CONCLUSION

This study presents TimberTracker, an open-source, data-driven framework that for visualising timber supply and demand in Australia's construction sector. The tool integrates publicly available datasets across forestry, wood processing, and building activity to project future material flows for structural timber. The Queensland case study highlights the growing gap between projected construction timber demand and current domestic supply capacity, as well as additional plantation area required to offset the risks associated with increased reliance on imported timber.

While the current framework is limited by the granularity and consistency of available data, particularly for non-residential building and material intensity values, it offers a replicable and transparent methodology for visualising material flow scenarios in regions with similar softwood value chains. As urban growth accelerates and climate goals tighten, tools like TimberTracker can play a vital role in supporting evidence-based planning, sustainable forestry investment, and resilient housing policy.

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Declaration of Generative AI Use

Generative AI (OpenAI ChatGPT) was used to assist with language editing and writing refinement in this paper. All content was reviewed and verified by the authors to ensure accuracy and appropriateness.

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