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Wood flows and Exploration of Sustainable Forest-based Bioeconomy Strategies in Italy

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Partenariato Esteso Finanziato dal PNRR - Missione 4, Componente 2, Investimento 1.3

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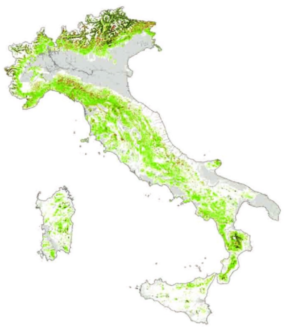
Background: forest resources and wood sector in Italy

Forest coverage: **40%** of national land area
Forest area **tripled** in the **last 70 years**
INFC, 2015



Net removals of about **14%** of national **CO_2 emissions** (+ other benefits)
National Inventory Document, Ispra (2025)

Italy: **leading European producer of furniture and wood-furnishing products** Federlegno-Arredo, 2023

Long-lived wood products (furniture, construction, etc.) and the **substitution of fossil raw materials = removal/avoided CO_2 emissions**
(UE CRCF, 2024)

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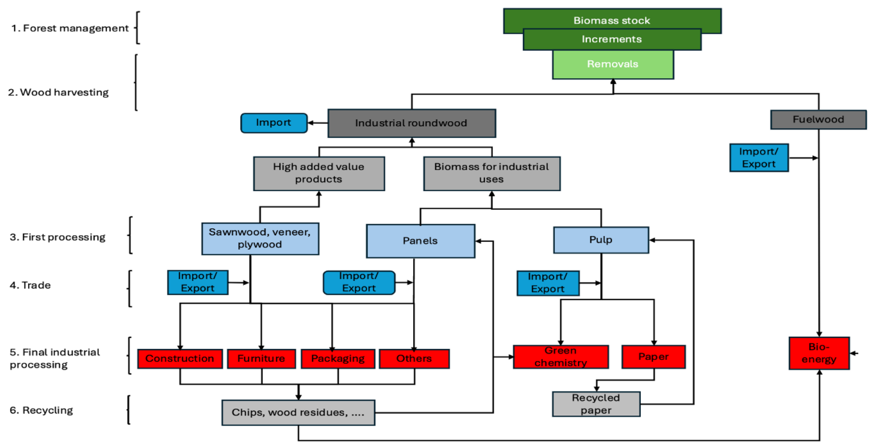
A complex set of value chains without data that allows the different flows to be described.

→ no data on the final consumption of wood, net trade or carbon sinks → no forecasting or simulation is possible.



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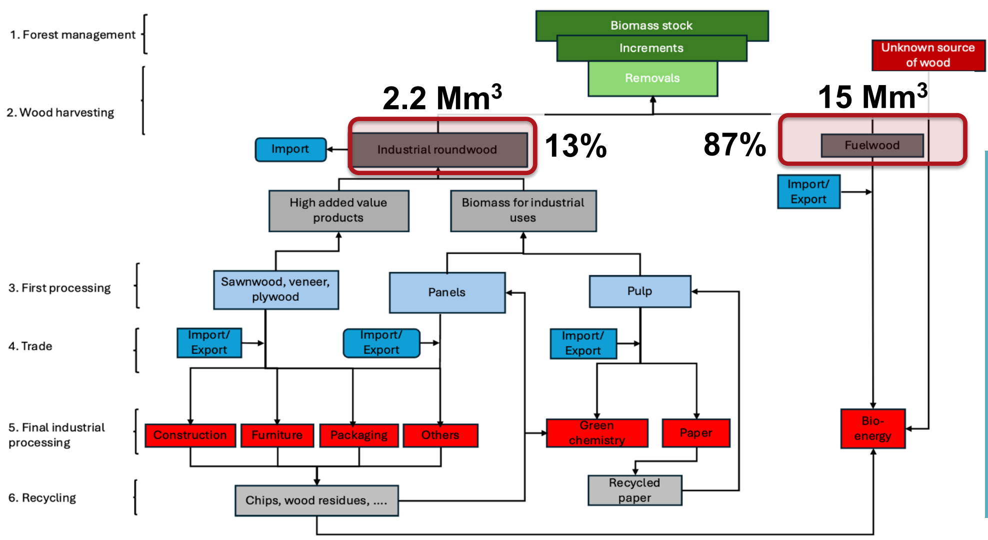
Domestic forest removals and roundwood imports



Italy among the **main European importers of industrial-use wood** and the **world's leading importer of firewood**

FAOSTAT, 2025

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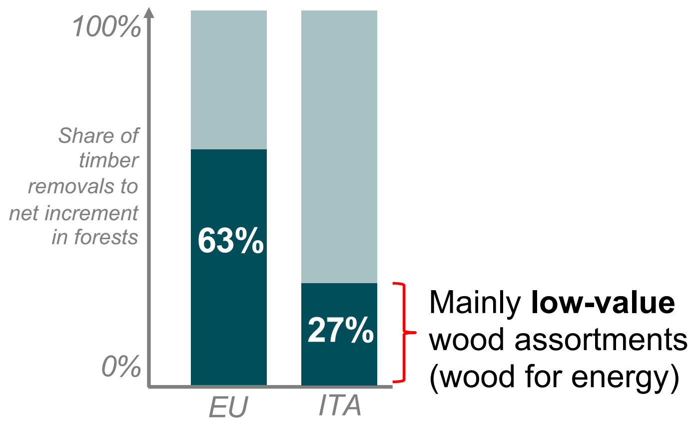
Background: forest resources and wood sector in Italy

One of the **lowest timber harvesting rates in Europe**

Eurostat, 2023; Sinfor, 2023



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The research consist of two main blocks:

1. Literature review on *Material Flow Analysis* (MFA)

Open Access | Review

Material Flow Analysis of the Wood-Based Value Chains in a Rapidly Changing Bioeconomy: A Literature Review

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(This article belongs to the Section Forest Economics, Policy, and Social Science)

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2. Modelling of the forest-wood supply chain in Italy

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Research objectives

- Analysing the state-of-the-art of the **wood value chains in Italy**
- Developing a comprehensive **forestry sector model** accounting for material flows for Italy
- Modeling forest and timber supply chain dynamics under **current and future scenarios** analyzing changes in **material flows and C-stock**

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Data sources

Phases	Production Data Sources	Trade Data Sources
1 Forest data	National Inventory of Forests and forest Carbon pools (in Italian, Inventario Nazionale delle Foreste e dei serbatoi forestali di Carbonio, INFC)	-
2 Wood Harvesting	Food and Agriculture Organization Statistical databases (FAOSTAT) for roundwood	FAOSTAT
3. Wood use for energy	Associazione Italiana Energie Agroforestali (AIEL) for bioenergy (+FIPER (Federazione Italiana Produttori di Energia da Fonti Rinnovabili) for district heating +MASAF (Minister of Agriculture, Food and Forests) large power producers)	FAOSTAT
4 First processing	FAOSTAT, Assocarta	FAOSTAT, Assocarta
5 Trade	FAOSTAT, Assocarta	FAOSTAT, Assocarta
6 Final Processing	Semi-finished product data and their sectoral distribution (Building, furniture, etc); Assocarta (final paper production, cross checked with FAOSTAT)	Comtrade (Import and Export of final sector products), Assocarta
7 Recycling	Empirical method, validated with Rilegno; Assocarta (paper, cross-checked with FAOSTAT)	FAOSTAT

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Modelling of the forest-wood supply chain in Italy

- Material flows modelled via ***System Dynamic modeling*** (Vensim)
- **Conversion coefficients** from literature:
  - **Semi-finished** and **finished** products → ***Wood Fiber Equivalent*** (m^3) (Weimar, 2009)
  - ***Wood Fiber Equivalent*** → **Wood in the rough** (*Roundwood Equivalent*, RWE, m^3) (FAO, 2020)

THÜNEN

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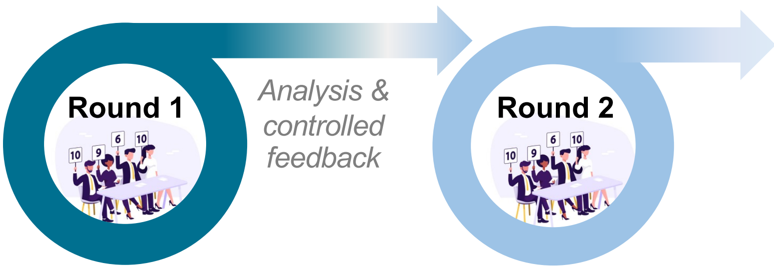
Modelling of the forest-wood supply chain in Italy

- **Expert-based** review and validation: **Delphi Method** (Niederberger & Renn, 2023)

Expert panel
N= 13
Research/academia + private sector: spanning different wood-based products



Validated & calibrated coefficients to feed the model

- **Dynamic MFA** and **scenario assesment** (Aiphoria, Open-source Python)

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Scenario Modelling for the forest-wood supply chain in Italy

Name of the scenario	Description	Timeline	Some implications
Baseline (BaU)	Business-as-usual scenario, assuming linear growth or decline of the key variables. Trend based on 2000-2023 data	2024-2050	Scenario that can be used as a reference for other different scenarios
Cascade Utilization focus	Forest removals are assumed to increase linearly up to 2050, reaching the EU average level (66% of the annual increment). The additional removals are assumed to be allocated to the building sector.	2024-2050	This scenario represents a cascade-use strategy, emphasizing value retention through successive material uses before energy recovery
Sustainable Industrial Expansion via Poplar Plantation	Gradual expansion of poplar plantations to increase industrial roundwood supply for high value uses such as furniture	2024-2050	A higher utilization of timber (from poplar) in the furniture sector would enhance carbon storage across the entire value chain

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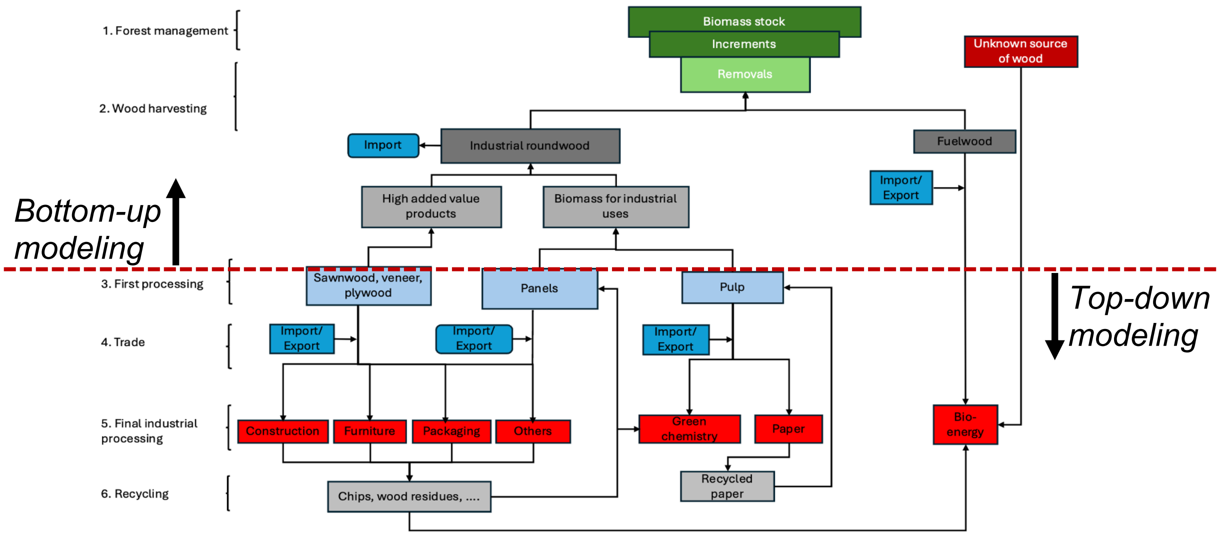
Wood material flow model for Italy (Structure)



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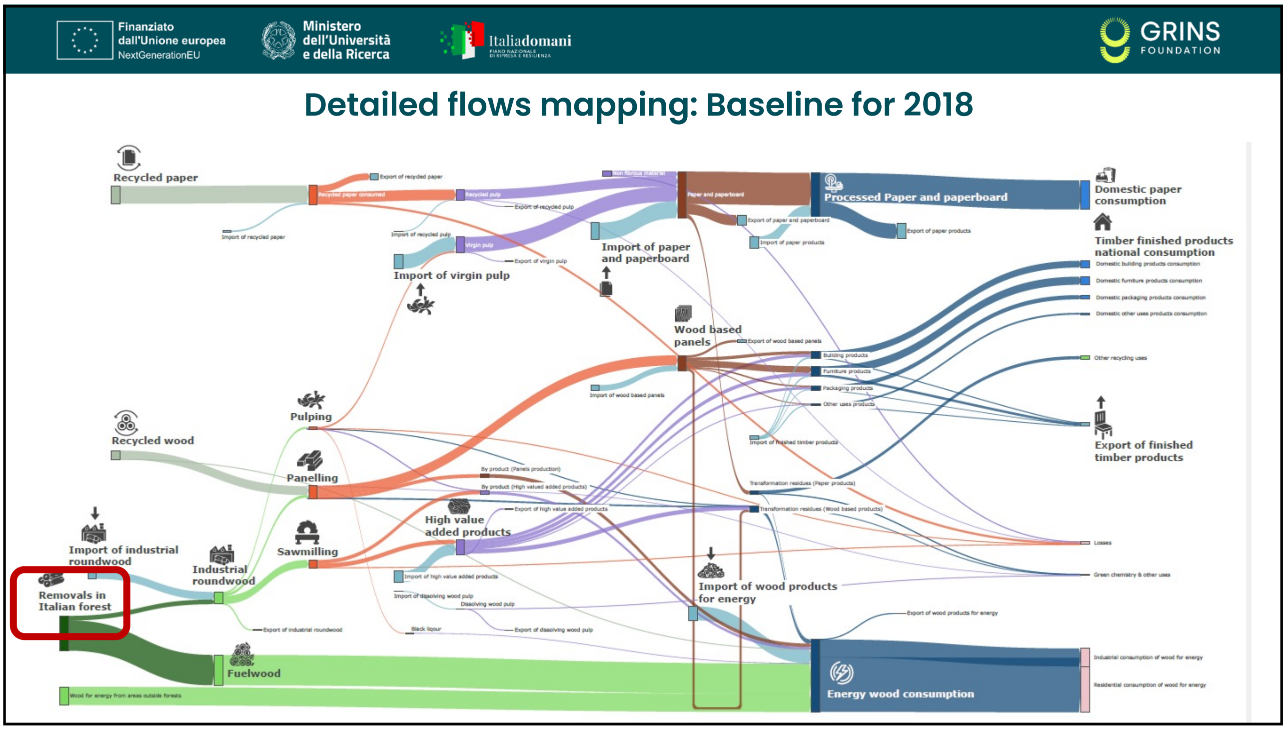
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Detailed flows mapping: Baseline for 2018
Recycled paper
Import of virgin pulp
Import of paper and paperboard
Processed Paper and paperboard
Domestic paper consumption
Timber finished products national consumption
Wood based panels
Recycled wood
Pulping
Panelling
Sawmilling
High value added products
Import of industrial roundwood
Industrial roundwood
Removals in Italian forest
Fuelwood
Export of finished timber products
Import of wood products for energy
Energy wood consumption

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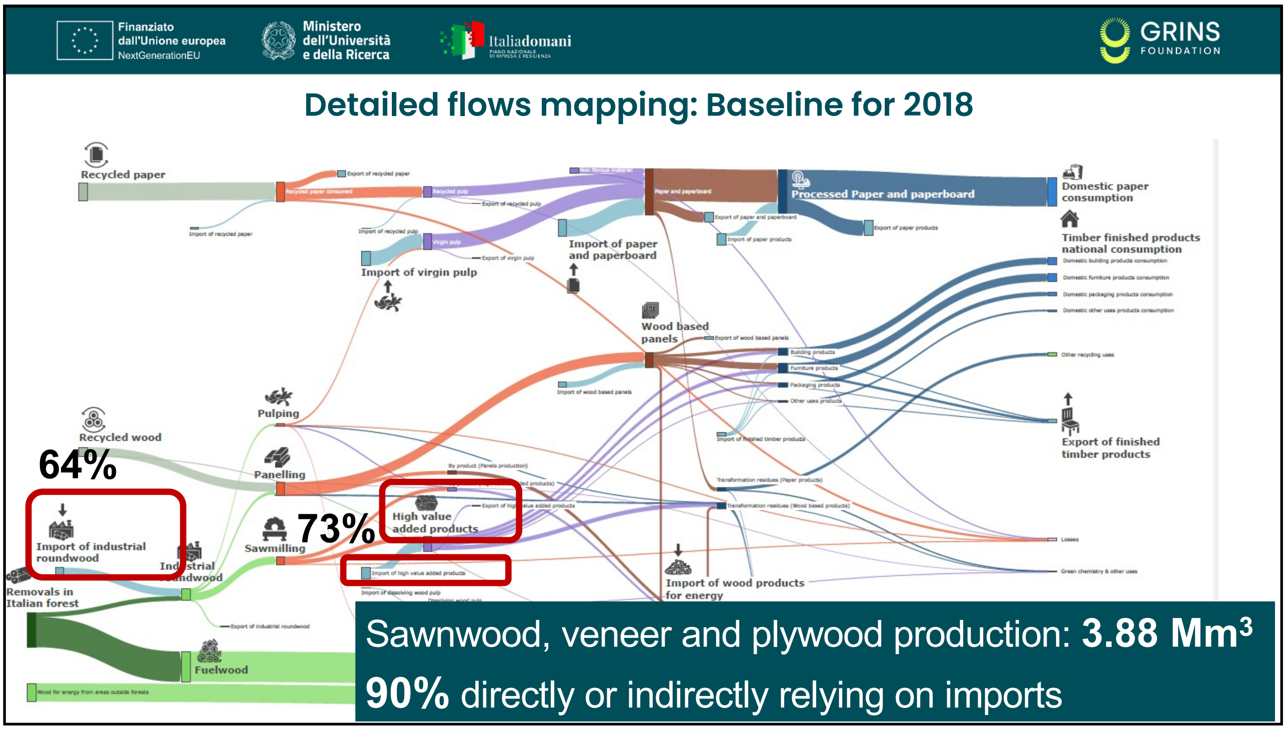
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Detailed flows mapping: Baseline for 2018
Recycled paper
Import of virgin pulp
Import of paper and paperboard
Processed Paper and paperboard
Domestic paper consumption
Timber finished products national consumption
Wood based panels
Recycled wood
Pulping
Panelling
64%
Import of industrial roundwood
73%
Sawmilling
High value added products
Industrial roundwood
Removals in Italian forest
Fuelwood
Export of finished timber products
Import of wood products for energy
Sawnwood, veneer and plywood production: 3.88 Mm³
90% directly or indirectly relying on imports

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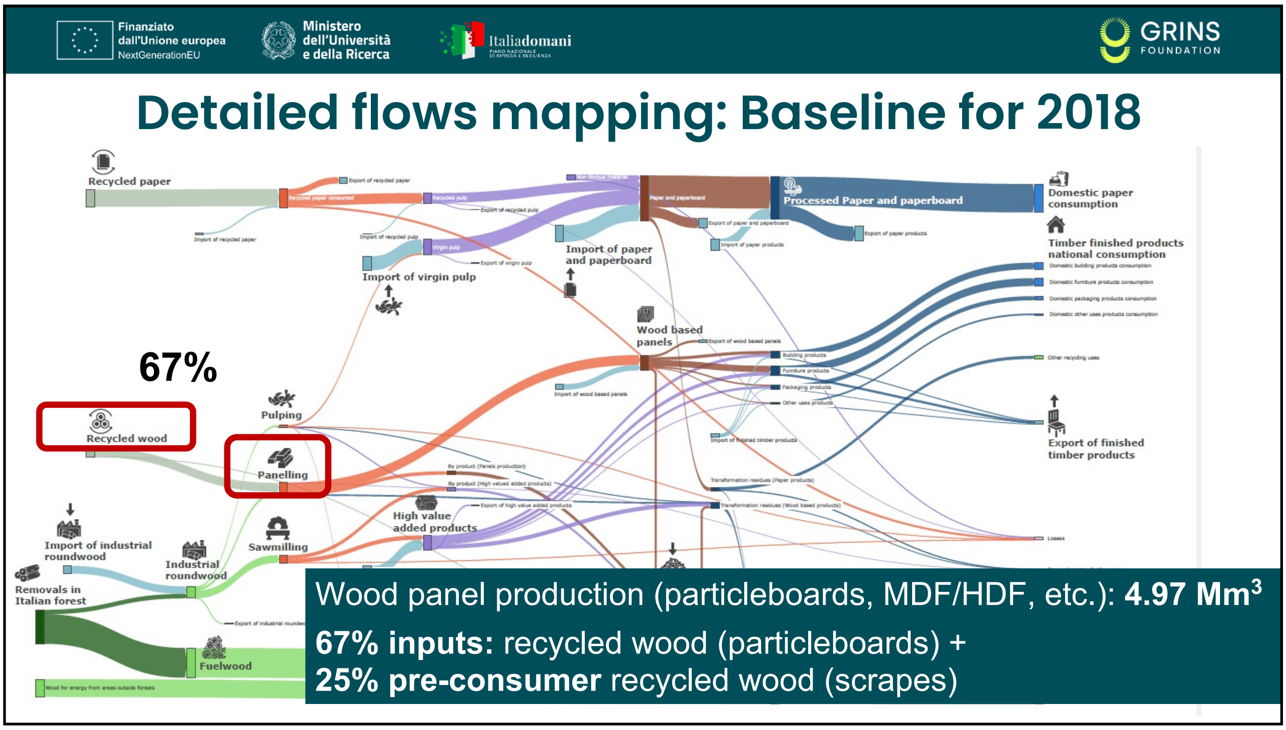
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Detailed flows mapping: Baseline for 2018
Recycled paper
Import of virgin pulp
Import of paper and paperboard
Processed Paper and paperboard
Domestic paper consumption
Timber finished products national consumption
Wood based panels
67%
Recycled wood
Pulping
Panelling
High value added products
Export of finished timber products
Import of industrial roundwood
Industrial roundwood
Sawmilling
Removals in Italian forest
Fuelwood
Wood panel production (particleboards, MDF/HDF, etc.): **4.97 Mm³**
67% inputs: recycled wood (particleboards) +
25% pre-consumer recycled wood (scrapes)

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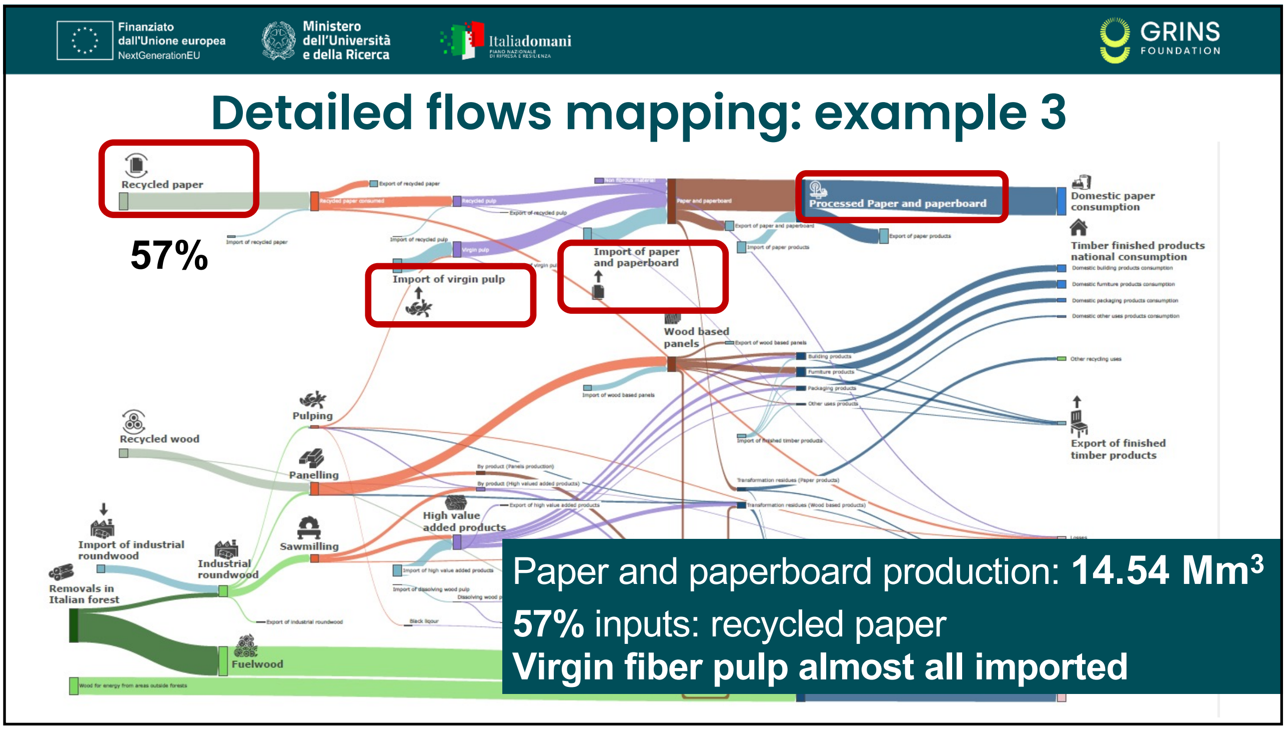
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Detailed flows mapping: example 3
Recycled paper
57%
Import of virgin pulp
Import of paper and paperboard
Processed Paper and paperboard
Domestic paper consumption
Timber finished products national consumption
Wood based panels
Pulping
Recycled wood
Panelling
High value added products
Export of finished timber products
Import of industrial roundwood
Industrial roundwood
Sawmilling
Removals in Italian forest
Fuelwood
Paper and paperboard production: **14.54 Mm³**
57% inputs: recycled paper
Virgin fiber pulp almost all imported

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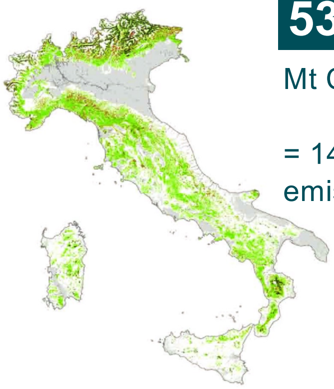
Carbon stock potential under current management from forests and HWPs (year 2023)



53.6

Mt CO_2eq

= 14% of national CO_2 emissions

Net CO_2eq removals by Italian forests

National Inventory Document, Ispra (2025)

Building	2.9
Furniture	4.3
Packaging	2.0
Other	0.9
Paper	20.9

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Mt CO_2eq

~60% of total forest removals

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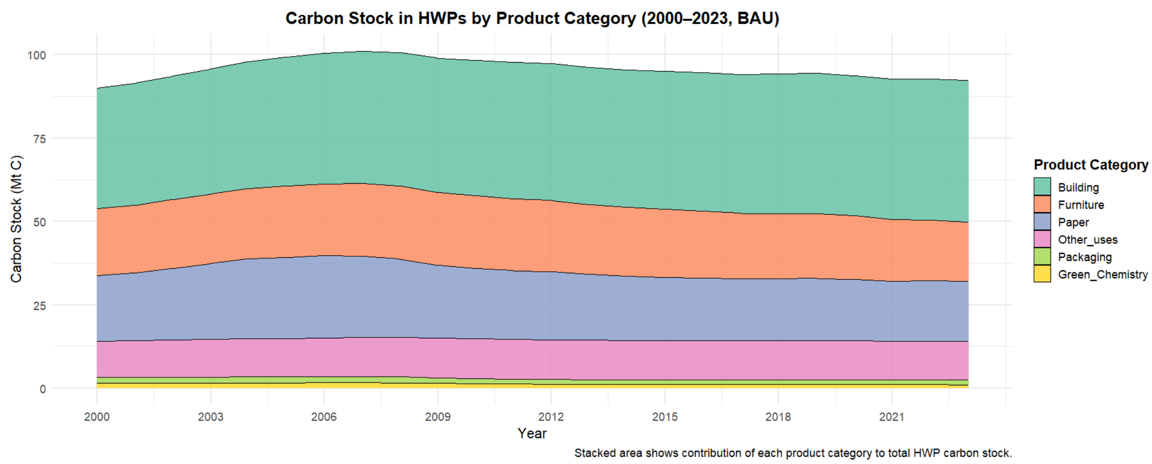
Carbon stock potential under Businesss-as-usual (BaU)



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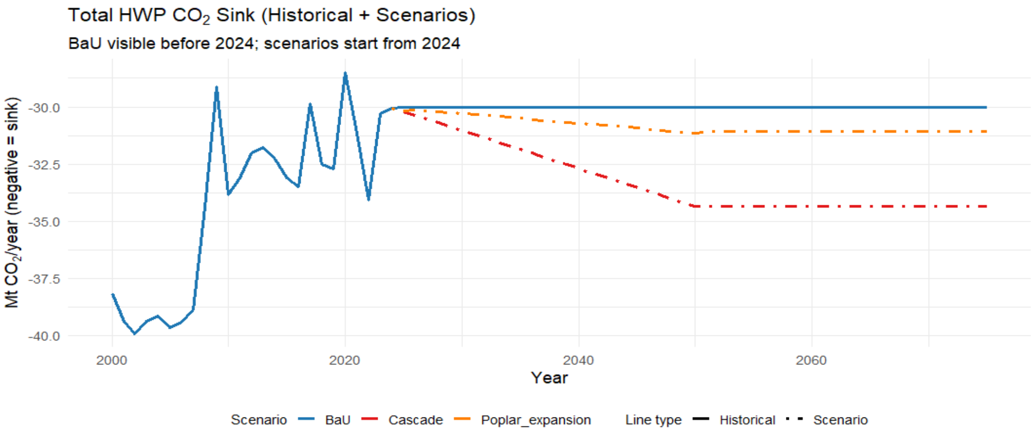
Projected CO_2 sink from harvested wood products (HWP)



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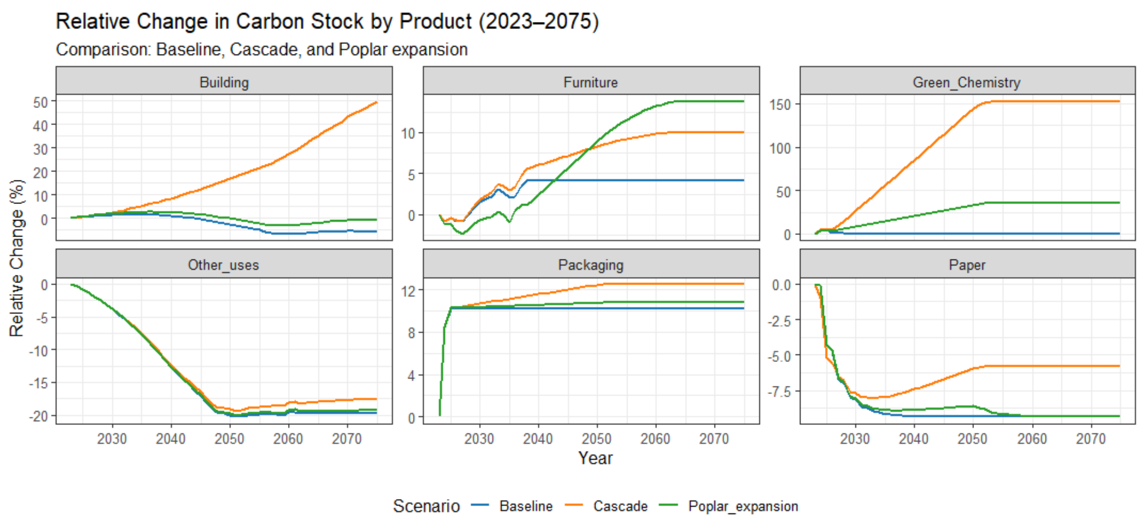
Carbon stock potential (By Product types) under future scenarios



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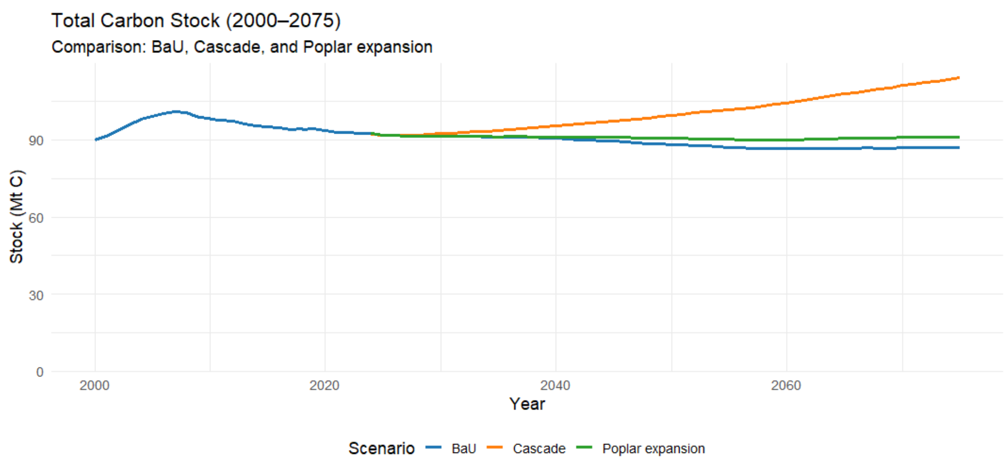
Carbon stock potential under different scenarios



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Some final considerations

- Domestic harvesting and wood industrial use **strongly decoupled**
- **Limited** domestic wood **mobilization**
- Dependence on **imports** for **sawn timber, veneers and plywood** (and for **wood pulp)**
- Central role of **recycled/recovered material** for panels (particleboard) and paper

  → **Circular bioeconomy** (EU and national Bioeconomy Strategies)
- Key role in **C-stock**: room to improve removals keeping stocking capacity

  → Cascade Use → More **long-lived products** for higher CO_2 removal
  → Poplar expansion → **Expanding plantations** to boost carbon stock in HWP

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Thanks for your attention

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