ForestNavigator

D5.4 Macro-economic assessment of wood demand scenarios

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Abstract

This deliverable employs the MAGNET model to simulate the socio-economic outcomes and impact on the forest sector (forestry, wood products, and paper & pulp) by implementing the market scenarios created in the ForestNavigator project (D5.1). In addition to showcasing the socio-economic indicators that can be evaluated in this macro-economic model, this work highlights the developments of the forest sector in terms of value-added, employment, and international trade under high wood demand scenarios.

As such, it presents impact assessments by contrasting a Business-as-Usual Scenario, i.e., the baseline, with four high forest production scenarios. These scenarios simulate the increase in demand for wood used in construction, wood-based fibres for textile production, and biomass for bioenergy production. The results show that increasing the demand of forest-based sectors can foster the generation of green jobs and positive environmental externalities, while not hindering the expectations of macroeconomic growth by mid-century.

Moreover, it also prepares scenario work employing the integrated policy modelling toolbox for WP6 and WP7, showcasing the preparatory work that will lead to the implementation of a connection between the GLOBIOM and PRIMES models.

Keywords

MAGNET, socio-economic, modelling, bio-based economy, forestry, forest sector, carbon neutrality

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Nature of the deliverable *	**R**

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Abbreviations

CGE	Computable General Equilibrium
ESA-CCI	European Space Agency Climate Change Initiative
EU	European Union
FAWS	Forest Available for Wood Supply
FMQR	Forest Materials Quantities by Region
GTAP	Global Trade Analysis Project
ISIC	International Standard Industrial Classification
MAGNET	Modular Applied GeNeral Equilibrium Tool
NACE	Nomenclature statistique des activités économiques dans la Communauté européenne
OECD	Organisation for Economic Co-operation and Development
PEM	Policy Evaluation Model (PEM)
WP	Work Package
SSP	Shared Socio-Economic Pathways
CET	Constant Elasticity of Transformation
CES	Constant Elasticity of Substitution

Executive summary

This deliverable focuses on the macro-economic assessment and the role of the forest sector in the future European economy. The study evaluates the socio-economic outcomes and impacts on the forest-based sector under different scenarios of increasing wood demand, highlighting the potential for green growth and green job creation.

The primary objective is to estimate the contribution of the forest sector to green growth, measured in terms of value added, employment, GDP, and bilateral trade flows. To achieve this, we used a combination of methods with the MAGNET model at its core. MAGNET is a multi-regional, multisector dynamic equilibrium model based on the Global Trade Analysis Project model and database. To enable MAGNET to track the implications of the scenarios for a detailed list of forest-based materials, we established a close link between MAGNET and the GLOBIOM model, enhancing the forest sector representation in MAGNET within the ForestNavigator project. In this module, each material represented in GLOBIOM was related to the economic flow between the producing sectors represented in MAGNET. For example, the economic flow from primary forestry to direct private household consumption is considered to represent fuelwood.

For wood demand scenarios, this deliverable builds on the findings of Deliverable 5.1 and implements four "high-demanding" scenarios. These scenarios evaluate an increase in the reliance on a specific forest-based sector and its implications against the business-as-usual, standard assumption of growth (Shared Socio-economic Pathway 2 – SSP2). In particular, the scenarios evaluate an increase in wood used for construction (High Construction), an increase in wood-based fibres for textile production (High Textiles), and an increase in biomass use for bioenergy production (High Bioenergy), as well as a combination of all three (High Bioeconomy).

The results in this deliverable show that scenarios with high wood demand have a significant impact on the forest-related sectors, though their overall influence on the total EU27 economy is relatively mild. In a business-as-usual scenario, the workforce in the forest-related sectors is expected to decline due to productivity improvements and industry intensification. However, in high wood demand scenarios, this decline is partially offset by increased employment forestry and wood product sectors. Overall, timber harvesting is projected to increase, and additional roundwood volume needed in the high wood demand scenarios is mainly achieved by investing in capital and labour, as there is little room to expand forestry land.

All in all, this deliverable highlights the potential of increasing the reliance on forest-based production to acquire more green jobs and contribute to the abatement targets set up by the most recent climate policies without hindering regional macro-economic growth.

1. Introduction

1.1. Background

The ForestNavigator project aims to evaluate the climate change mitigation potential of the forest-based sector in the EU. In the pursuit of a comprehensive assessment, Work Package 5 (WP 5) assumes an important role by delving into the demand side of this sector, as the outlook for the forest-based sector is pivotal in assessing the state of forests and the ecosystem services they provide. Specifically, this report presents the implementation of a baseline and scenarios of high wood demand in the MAGNET macro-economic model, following the developments in Deliverable 5.1 (D5.1). The scenarios in this report, although somewhat stylized versions of the elaborate market scenarios from D5.1, showcase impacts on the forest sector under scenarios fostering forest-based bioeconomy and present an overview of the socio-economic indicators available for the policy scenarios that will follow in future work.

This work thus focuses on embedding the outlooks of the European forest sector within the EU economy, but in the context of a global economic model where the bilateral trade database, which is the core of the model, sheds light on the relative status of the forest sector. By linking the MAGNET state-of-the-art global Computable General Equilibrium (CGE) model to a more detailed representation of forest sector products, this enables the most detailed forest sector analysis within a global model setting. Here, global developments on macro-economic drivers, labour productivity, and land availability set the context for diving into details of the forest sector's development.

1.2. Objectives

The overall objective of this deliverable is to estimate the contribution of forestry to green growth as (monetary-based) value added, employment, GDP, and bilateral trade flows by employing the MAGNET macro-economic model. The implementation of high wood product demand in MAGNET for construction, wood-based textiles, and bioenergy serves as a comparison to a baseline, allowing for the review of various socioeconomic indicators within the context of a growing EU bioeconomy versus baseline developments. Furthermore, the outcomes focus on the implications of land use and the necessary intensification to increase harvest levels. By highlighting this wide range of indicators, this work also prepares for scenario work employing the integrated policy modelling toolbox for WP6 and WP7 through the implementation of connecting with the GLOBIOM and PRIMES models via a closer connection using MAGNET lookup tables.

Accordingly, section 2 of the report illustrates the methodology applied to achieve the assessment, including a general description of the model, its representation of land supply and forest sectors, the newly developed features and the linkages with other models that allowed their development. Section 3 describes the results providing a detailed analysis of the impacts of the high forest scenarios on GDP and value added, production and trade, factors of production (e.g., employment)

and environmental trade-offs (e.g., emissions). Finally, section 4 summarises the main results and conclusions, and describes next steps within the ForestNavigator project.

2. Methodology

2.1. MAGNET

This report employs the global CGE model MAGNET (Modular Applied GeNeral Equilibrium Tool[i]) for the assessment of forest sector-related scenarios. MAGNET is a multi-regional, multi-sector recursive dynamic equilibrium model built on neo-classical macroeconomic theory (Woltjer, 2014). The core of the MAGNET model is the Global Trade Analysis Project model (GTAP), v7 (Corong et al., 2017) and the GTAPv11c database, with base year 2017 (Aguiar et al., 2022). The extensions of MAGNET with respect to the GTAP standard version mainly concern the domain of agriculture and the bioeconomy (Van Meijl et al., 2018; Woltjer, 2014). These additions are used in various studies focusing on topics like biodiversity (Leclère et al., 2020), food security (van Meijl et al., 2020), climate mitigation (Doelman et al., 2020; Frank et al., 2019) or a combination (Hasegawa et al., 2018). As with all CGE models, MAGNET explicitly represents the economic linkages across the sectors of each regional economy. This feature is crucial when analysing the effects of policies in sectors that can vertically influence each other, such as land, agriculture, and forestry. Furthermore, MAGNET includes modular extensions to improve the representation of the agricultural, forestry and land, as well as their related policies. Compared to similar global CGE economic models, MAGNET provides a higher sectorial detail concerning the land-use sectors. The MAGNET database includes 130 sectors, including both agricultural and non-agricultural sectors. These include eighteen primary agricultural sectors, as well as connected processed food sectors, and several forestry-related sectors, such as primary forestry, wood production, and the paper & pulp sector. A detailed list of commodities represented can be found in Table 9 in the annex.

2.1.1. Land supply

The MAGNET model employs a specific land supply curve that enables a dynamic representation of the relationship between land price and its supply, allowing for the dynamic accounting of pressures on the limit of available land per country or region (potentially up to the NUTS2 level). This allows the endogenous calculation of the land demand per sector based on land prices. As such, the demand curve is built to allow land prices to increase as land use gets closer to the maximum available land in the country or region due to land scarcity. Moreover, the total country or region land supply is not exogenous in the standard GTAP model but specified according to the relationship between land supply and land rental rate in each region (Eickhout et al., 2008; van Meijl et al., 2006). Figure 1 provides a representation of the idea behind the land supply curve. When a type of land use approaches the maximum potential land use, land users necessarily start to use additional land, which is potentially less productive and has higher production costs. Therefore, in

[i] www.magnet-model.org

land-abundant regions, e.g. South America, an increase in demand from D1 to D1* (left side of Figure 1) results in a large increase in land use (from l1 to l2) and a relatively modest increase in rental rates (from r1 to r2). On the other hand, an increase in land demand in land-scarce regions such as the European Union (EU) will necessarily lead to a relatively small increase in land use and a large increase in the rental rate (right-hand side of Figure 1; shift from D2 to D2*). The maximum potential land (or 'asymptote') is obtained by analysis of land suitability from the IMAGE model (Doelman et al., 2018).

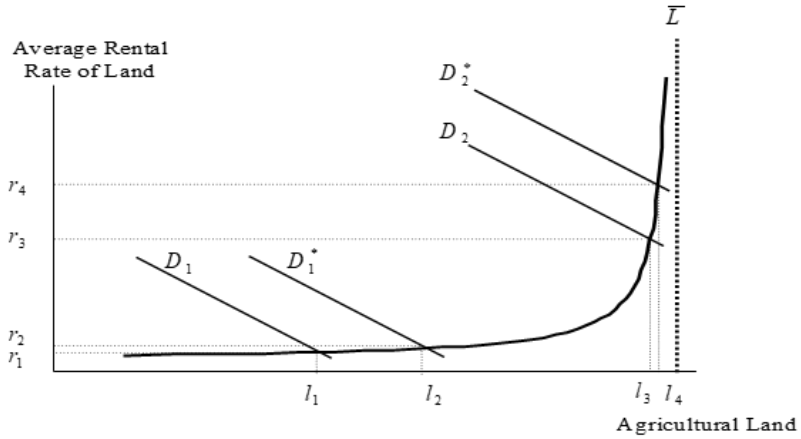

Figure 1: Land Supply Curve in MAGNET

Forest area that is economically active in the MAGNET model is defined as managed forest area in data provided by the IMAGE model. This data uses the ESA-CCI forest class as a starting point, which is split into managed and unmanaged forests based on the global forest management layer produced by (Lesiv et al., 2022). The categories naturally regenerating with signs of management, planted forests and plantation forests are assumed to be managed, while naturally regenerating without signs of management is assumed to be natural. For each grid cell, the shares of managed/natural from Lesiv are multiplied with the forest area from ESA-CCI, thereby maintaining ESA-CCI forest cover but including management information from (Lesiv et al., 2022). This results in 122 Mha managed forest in EU27, which is a little lower than the EU28 138 Mha reported as Forest Available for Wood Supply (FAWS) in state of Europe's forests 2020 report.

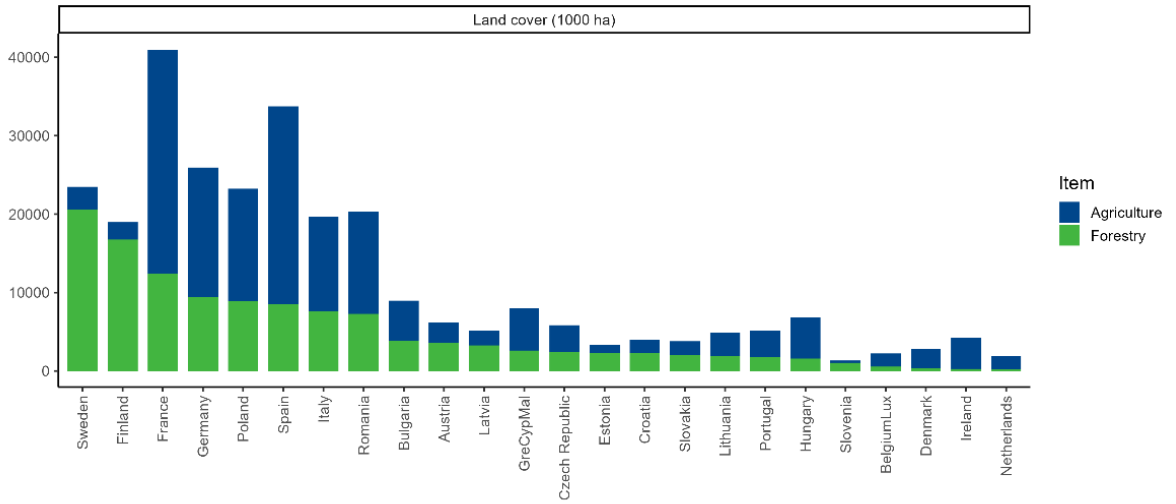

Figure 2: Relative areas of forestry and agriculture by EU member state

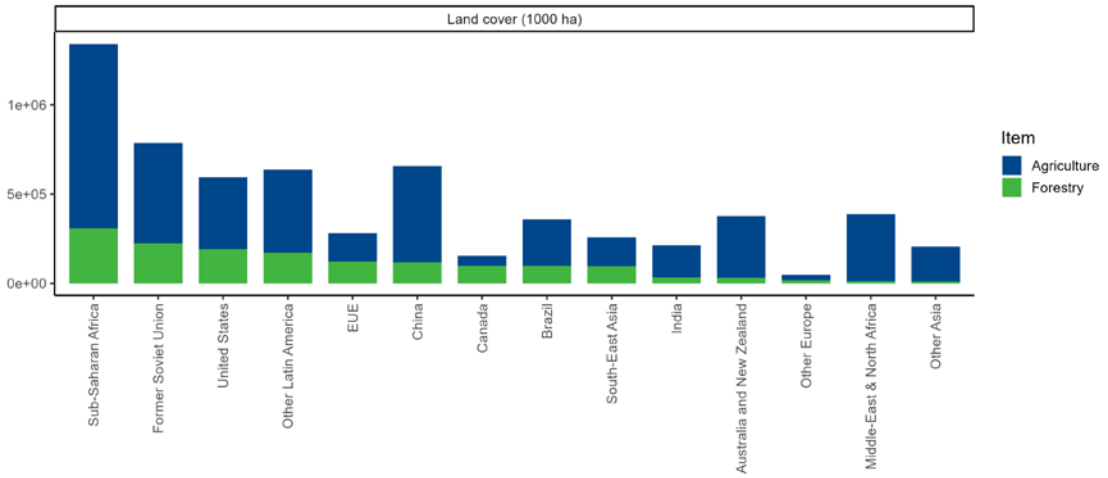

Figure 3: Relative areas of forestry by global region

MAGNET assumes a differentiated degree of substitutability between groups of land uses, though the degree of substitutability varies across but not within groups (nests). Land heterogeneity is introduced by using a Constant Elasticity of Transformation (CET) function. For crops, in particular, it uses an innovative demand structure that specifies the different degrees of substitutability between agricultural land uses according to its crops (Huang et al., 2004) (Huang et al., 2004). As such, the MAGNET structure combines the standard GTAP version with the more detailed Organisation for Economic Co-operation and Development (OECD)'s Policy Evaluation Model (PEM) structure (OECD, 2003)(Figure 4). This structure distinguishes different types of land in a nested 3-level CET structure. The model covers several types of land use with different suitability levels for various crops (i.e., cereal grains, oilseeds, sugar cane/sugar beet and other agricultural uses). This means that in the current MAGNET model setup, forest land is allowed to substitute directly with agricultural land, albeit with a lower elasticity than sectors within the current agricultural land.

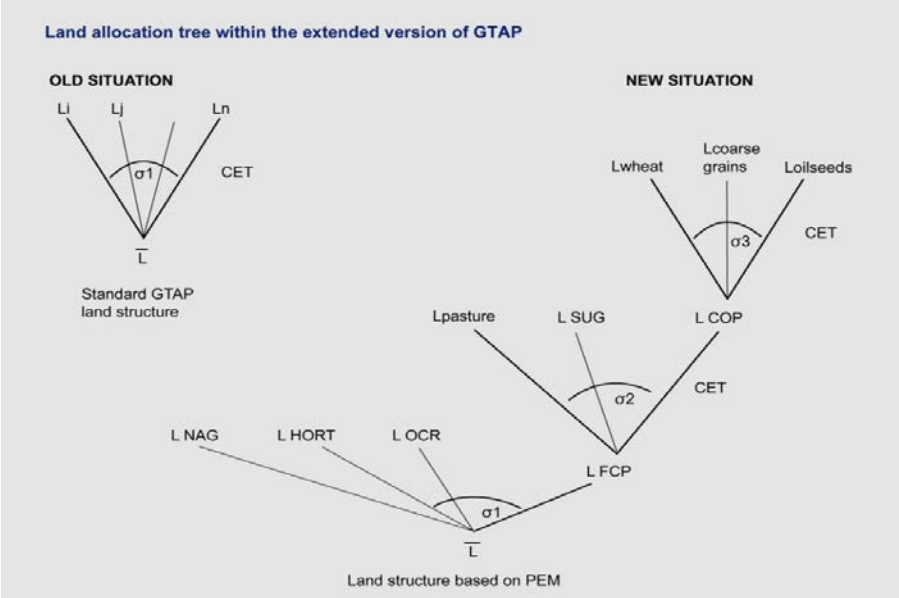

Figure 4: Old and New Land allocation trees in MAGNET following the *PEM approach (OECD, 2003)*

MAGNET employs flexible constant elasticity of substitution (CES) tree to build production structures. This allows to define specific production structure for virtually every product, providing higher detail in the production dynamics. In MAGNET there are currently twenty production structures, defining specific groups of products such as crops, livestock, and energy. The production tree of the forestry sector, specifically, describes the production structure of the primary forestry sector. This tree is based on a three-level nested structure, in which the first nest describes the relationship between intermediate and primary inputs; the second defines the relationship between land and other primary inputs, and the last tier defines the relationship between primary inputs other than land and different types of labour. A representation of the forestry CES production tree is provided in Figure 5. Here, the numbers in red constitute the substitution elasticities for each nest. For forestry, the top nest elasticity of 0 means there is no flexibility in changing the intermediate inputs, only in the land, capital and labour nest is substitution allowed. This is the default approach in GTAP sectors. It should be realized that there is only a single type of primary forestry sector in MAGNET that represents managed forests. There are no details regarding e.g., management types or tree species.

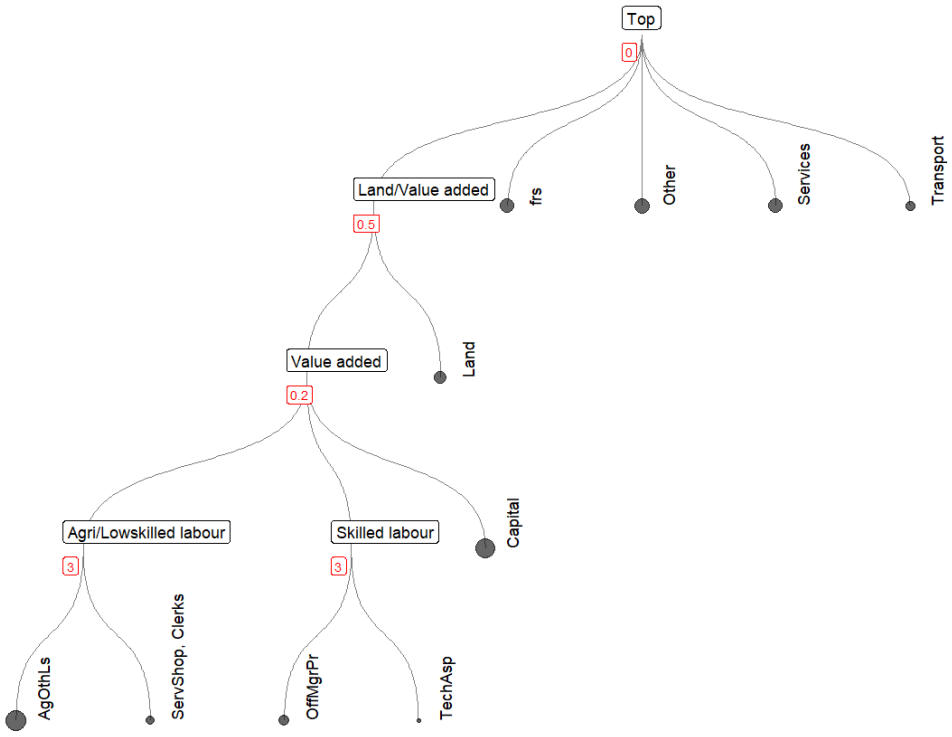

Figure 5: Forestry CES Production Tree (Red: substitution elasticities, black dots indicate relative contribution of inputs).

2.1.2. Representation of the forest sector

To enhance the assessment of forest material, this project has expanded the database and representation of forest materials in MAGNET. To this end, additional key material flows based on the GLOBIOM input have been linked to the relevant economic flows, providing a better representation of material uses and trends under different scenarios and policies. The forest-based sectors, in MAGNET, are the following:

- **Forestry**: forestry, logging and -related service activities
  - Sometimes referred to as ‘primary forestry’ as it uses land as a natural resource.
  - Additionally, MAGNET has introduced a separate ‘plantation’ sector dedicated to pellets for bioenergy, as well as a forest harvest residues sector used for bioenergy. These are, however, not included in our definition of the “forest sector“ reported in this study.

- **Wood products**: manufacture of wood and wood and cork products, except furniture, and manufacture of straw articles and plaiting materials.
  - Primary direct destination of ‘forestry’
  - Used mainly in construction and other manufacturing.

- **Paper & Pulp**: includes printing and reproduction of recorded media
  - direct destination of ‘forestry’

– also includes other publishing, according to the International Standard Industrial Classification of All Economic Activities (ISIC) and statistical classification of economic activities, the **N**omenclature statistique des **a**ctivités économiques dans la **C**ommunauté **e**uropéenne (NACE) falls under the category ISIC/NACE 18, where ideally, in the forest material production framework, only ISIC/NACE 17 would be included.

- **Construction**: building houses, factories, offices, and roads
  - Primary direct destination of 'wood products'

- **Other Manufacturing**: includes furniture and is an important user of the lumber sector.

- **Textiles**, which typically has main inputs from plant-based fibres and chemicals/plastics sectors.

The first three sectors listed (i.e., forestry, wood products, and paper & pulp) combined are typically called the '**Forest sector**'. Comparison of the forest sector outcomes across sources, for example, with economic numbers reported in the State of Europe's Forests, the totals for the forest sector are not always comparable. The reason is that unlike the typically exclusive ISIC/NACE 17 paper sector, the GTAP database also includes ISIC/NACE 18. Table 1 below provides an overview and description of the main forest sectors and the related international and GTAP classifications and subsectors.

Table 1: Overview of forest and relevant related sectors in MAGNET

	MAGNET code	Description	NACE/GICS	Comment
Forest sector	frs	Forestry	2	GTAP definition
	lum	Wood products	16	GTAP definition
	ppp	Paper & pulp	17+18	GTAP definition
Related sectors	omf	Other manufacturing	45	GTAP definition
	cns	Construction	49	GTAP definition
	tex	Textiles	27	GTAP definition
	frs_r	Forestry residues		MAGNET specific
	respel	Residues and pellets (total)		MAGNET specific
	bioe	Biomass based electricity		MAGNET specific

These forest sectors have different relevance in the contribution to the GDP of the different countries as shown by Figure 6 and Figure 7. In most EU countries, the paper & pulp product sector has the most preponderant contribution to GDP, with notable exceptions being Latvia and Estonia with relatively high contributions from forestry & wood products. Yet, as mentioned earlier, this is also an effect of the inclusion of the NACE18 sector, which increases the paper & pulp numbers which may thus be overrepresented.

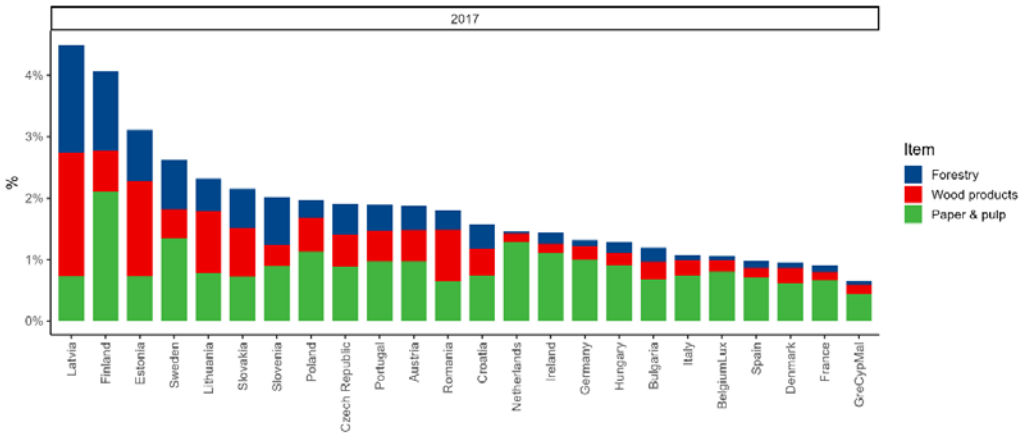

Figure 6: Relative contribution of main forest-based sectors to EU Economy. *Please note that Paper & pulp sector includes NACE 18.*

For global regions (see also Figure 10 for the MAGNET regional setup), Sub-Saharan Africa, India, and Other Asia show a higher contribution from primary forestry. The other regions show a higher reliance on paper & pulp products, like the EU countries.

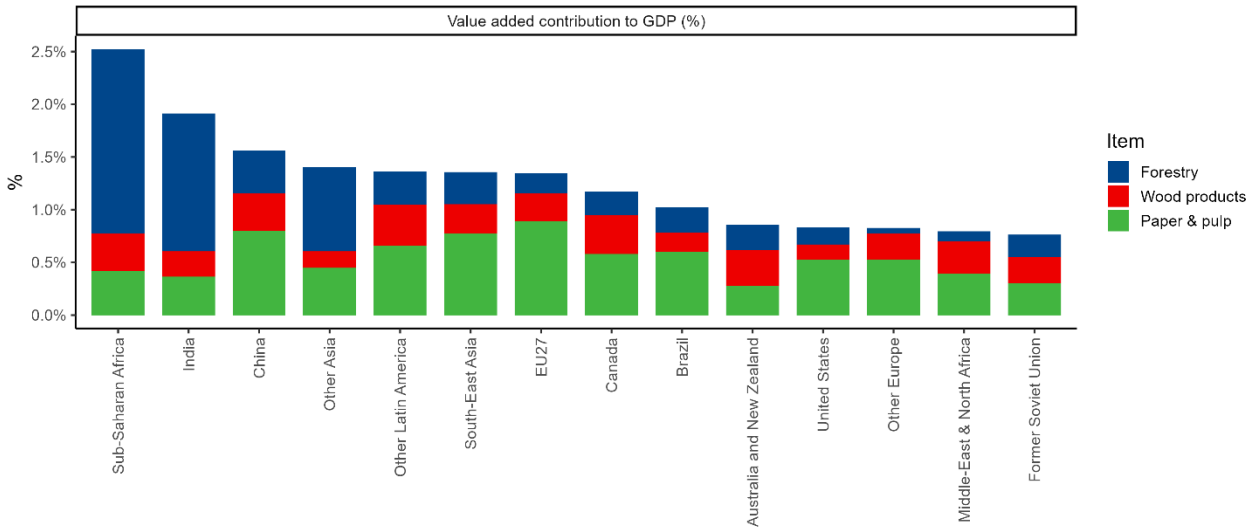

Figure 7: Relative contribution of main forest-based sectors to Global Economy

The contribution to regional GDP is not the only variable to understand the importance of the sectors. For example, trends concerning the sectorial importance in regional employment show that most of the employment in forest-related sectors in the EU comes from the wood products sector, while most of the developing countries have almost the totality of employment in the primary forestry sector, as shown in Figure 8 and Figure 9.

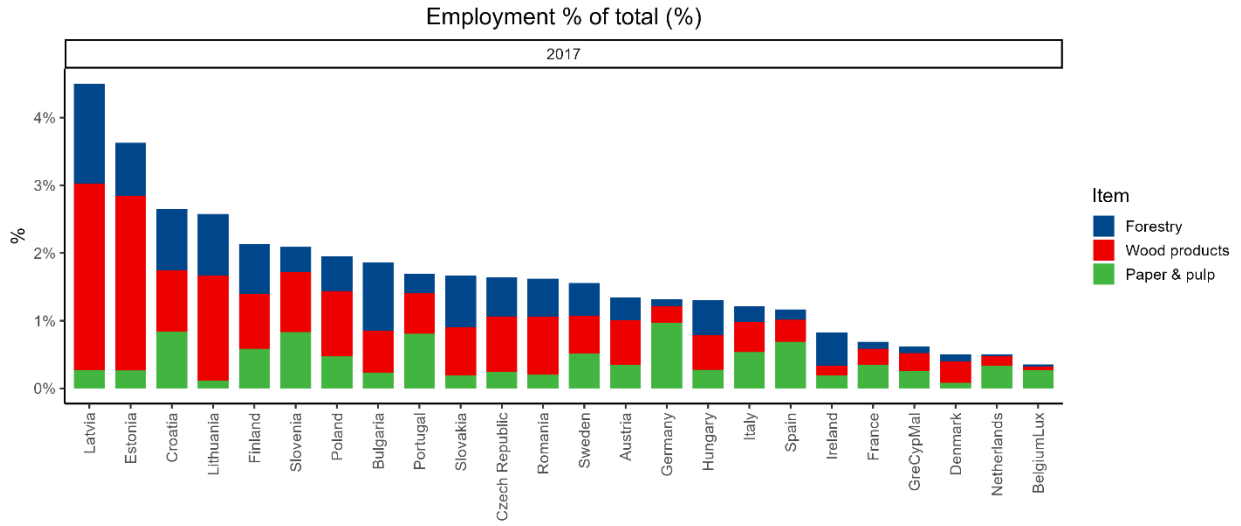

Figure 8: Relative contribution of main forest-based sectors to EU Employment

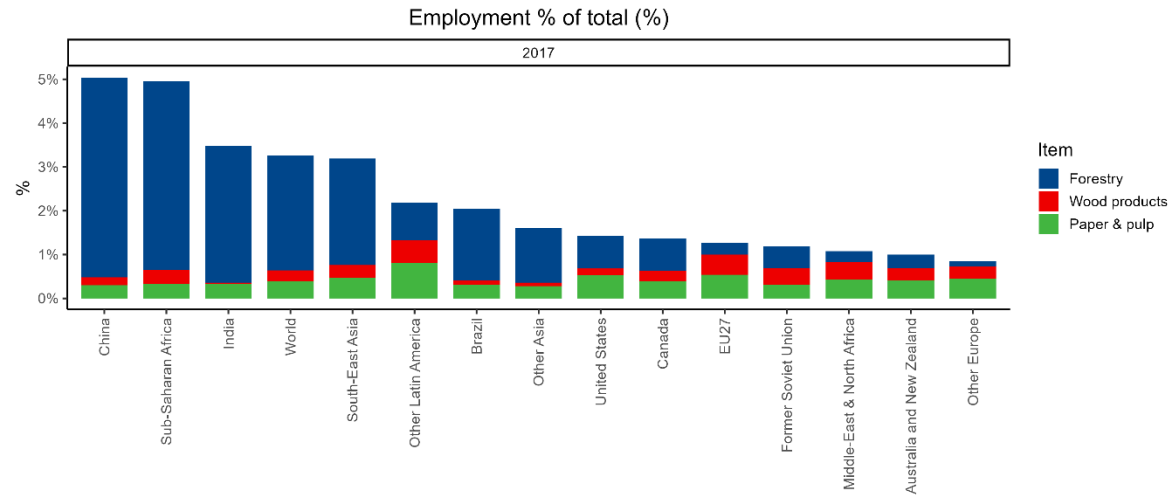

Figure 9: Relative contribution of main forest-based sectors to Global Employment

2.2. MAGNET Model Setup

The MAGNET model includes 160 countries and 130 sectors. Both countries and sectors have been aggregated to achieve the best representation of the key elements for the ForestNavigator project. In particular, the 160 countries have been aggregated into 37 regions, with most of the EU27 represented as single countries (except for Belgium-Luxemburg and Greece-Malta-Cyprus) (Figure 10). The aggregation of MAGNET's 144 commodities to the 94 sectors in use is reported in Table 9 in the Annexes.

MAGNET, as a CGE model, is frequently used to assess *what-if* scenarios, i.e., what is the impact of the variation of a specific variable relative to the base year or a base projection into the future? In this deliverable, all scenarios concerning to the possible developments of the EU (and global) forestry are evaluated against a baseline.

The basic scenario is calibrated in coherence with the most common socio-economic projections i.e., the business-as-usual (BAU) scenario from the Shared Socioeconomic Pathway 2 (O'Neill et al., 2017) up to the year 2050. This procedure allows MAGNET to capture the interaction between sectorial and socio-economic developments. This enhances the understanding of the role of the forest sector in terms of GDP, income, employment, land use, and emissions in the mid- and long-term future.

In addition to the base GDP and population assumption, there are several other trends that are considered the basis of future socio-economic developments.to these main macroeconomic (exogenous) drivers we usually add additional land productivity shocks, and agricultural (e.g., CAP in the EU) and biofuels policy. Growth in crop yields and livestock efficiencies are taken from the IMAGE model suite (Kram & Stehfest, 2012; OECD, 2012; Stehfest, 2014) and is based upon FAO projections up to 2050 (Bruinsma, 2003).

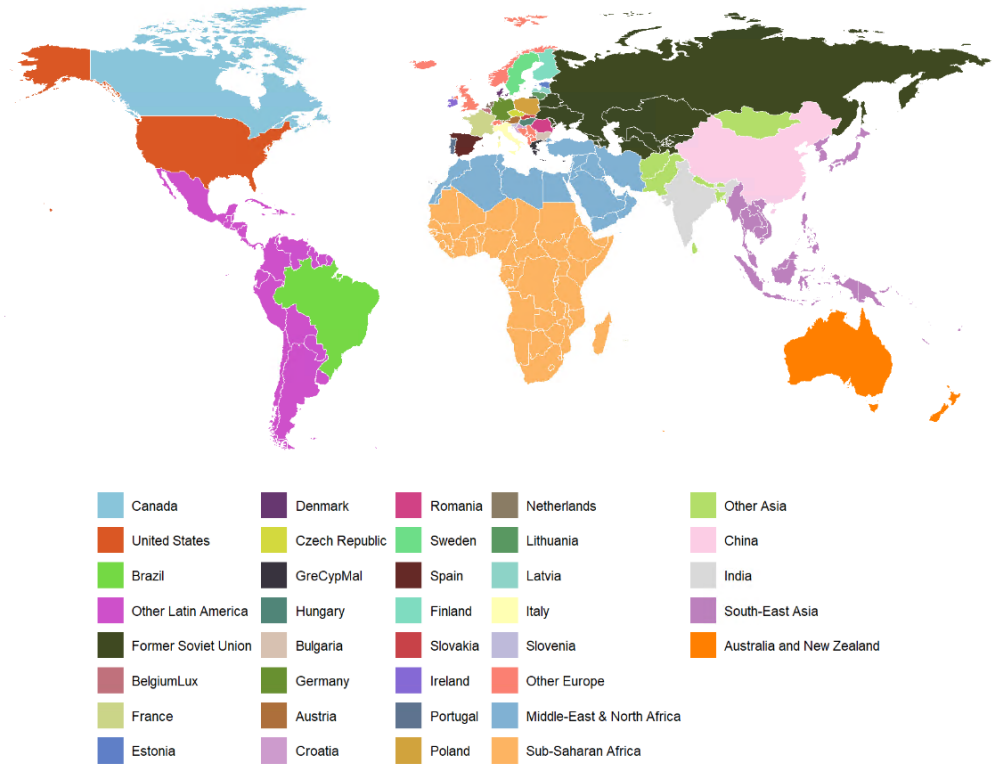

Figure 10: Regional Aggregation used in Forest Navigator

Figure 11 shows the main exogenous drivers of the MAGNET base model scenario regarding GDP, population, and employment i.e., the baseline (Base) scenario. The GDP path is used once to calibrate technical change parameters that are used in all subsequent scenarios (see Figure 11),

thus allowing for flexible outcomes, including GDP changes. The population and total regional employment are, however, always fixed inputs into the scenarios. For the European Union, these trends indicate a growing economy, despite a stable population and declining workforce. These trends are different for the rest of the world, where on average the population and workforce are still increasing, and the relative economic growth is projected to be stronger. This sets the scene from a macro-economic perspective where, although the EU27 economy is still growing, there is an outside world that is catching up.

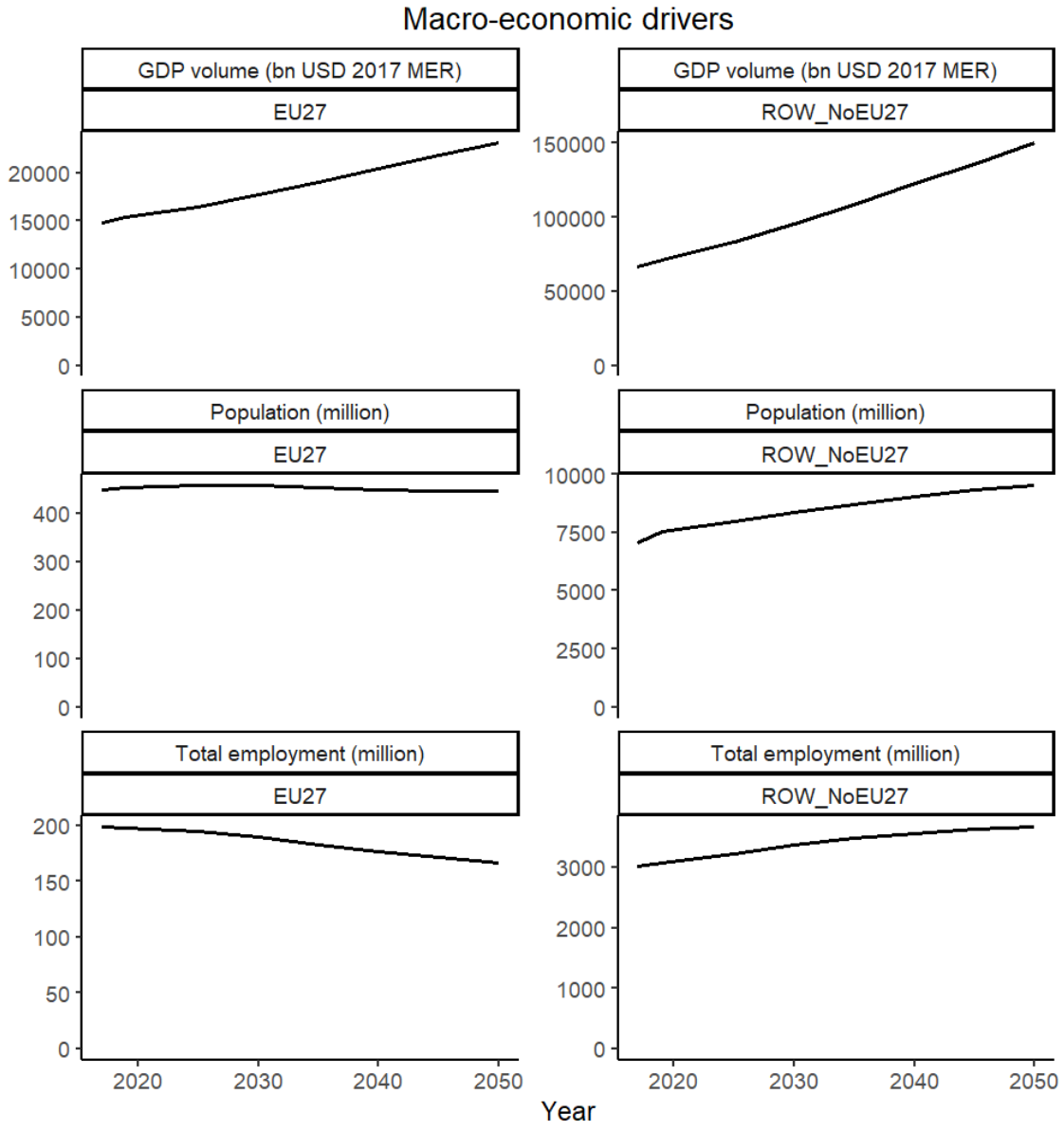

Figure 11: Macro-economic drivers for SSP2 for the EU and the world outside of the EU27

Figure 12 shows the total factor productivity trends as calibrated in the baseline scenario, which are used as inputs for all scenarios. The total productivity, as it is calibrated by GDP growth, is typically higher for the rest of the world compared to EU27. The levels of factor productivity improvements are, however, different per sector based on differing assumptions for productivity per input type where labour productivity is often an important determinant and assumed to increase more significantly for agricultural and low-skilled workers. Thus, it is seen that Forestry and Agriculture related productivity increases are substantially higher in the rest of the world.

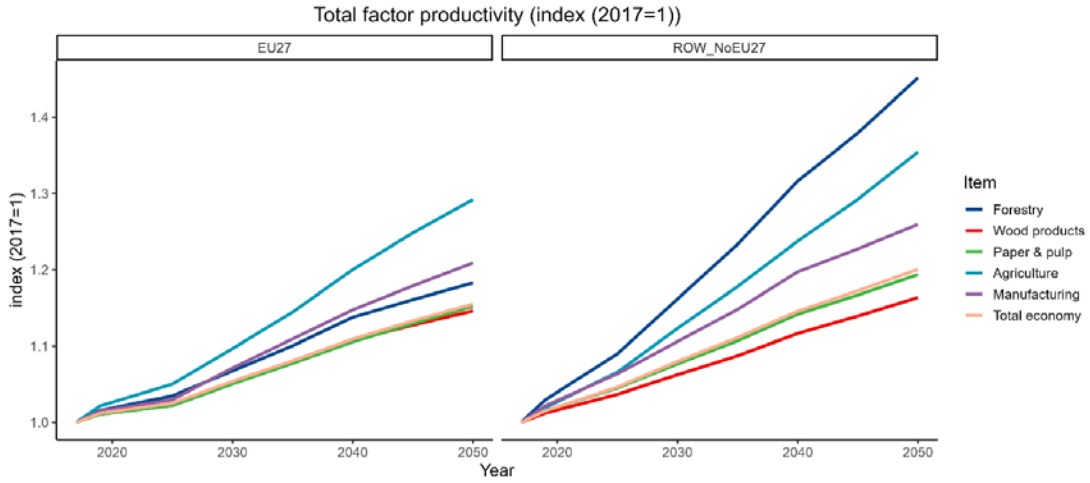

Figure 12: Total Factor Productivity

2.3. Model Linking between MAGNET and GLOBIOM

A close link was established between MAGNET and GLOBIOM in order to introduce a detailed representation of the forest sector in MAGNET, which helps to translate its projected sectoral outputs into physical volumes of production and demand of different wood products. Therefore, this linkage made it possible to derive estimates of material flow changes based on the simulated sectoral input-output changes in MAGNET under the four high-wood-demand scenarios.

The model linking is established through a post-processing module (Forest Material module) which allowed MAGNET to estimate corresponding physical quantities of forest-related products, using information from GLOBIOM's simulation of equilibrium forest sector production levels in the base year. This was achieved by developing a mapping between the sectoral input-output flows (including intermediate use, final demands, or total sectoral outputs) in MAGNET and the forest products simulated by GLOBIOM. GLOBIOM uses the same definition of forest product as FAOSTAT and aggregates them when conducting scenario simulations. The demand-supply balance and processing of forest products in GLOBIOM were also calibrated to the historical data available in FAOSTAT. Mapping materials allowed the identification the corresponding economic process and sectoral input-putout represented in MAGNET, which were ultimately mapped as shown in Table 2.

The different materials are then updated in the scenarios based on changes in the respective MAGNET outcome variables. For example, fuelwood is updated by the private household demand of the primary forestry sector in MAGNET. For the wood used by construction, instead, the material flow is updated with changes in the demand of the wood products sector by the construction sector in MAGNET. The complete description of all these mappings and update statements is provided in the annex (Section 6.2).

Table 2: Material flows between sectors based on Expert mapping.

Sectors/Materials	Bioenergy	Manufacturing	Household	Wood products	Other	Pellets	Paper & Pulp	Total
Primary forestry								
Fuel wood			49454,3					49454,3
Other log					4064,8			4064,8
Pulp log							27810,6	27810,6
Saw log				63941,8				63941,8
Wood products								
Bark	2760,5							2760,5
Fibreboard		50606,4						50606,4
Plywood		45059,5						45059,5
Sawdust	1590,2			1185,2		207,1		2982,4
Sawn wood		116046,2						116046,2
Wood chips	2437,9			2039,4		1058,7	1556,5	7092,5
Pellets								
Wood pellets	3420,6							3420,6
Plantation								
Energy plantation						131,9		131,9
Paper & pulp								
Bark	1522,6							1522,6
Black Liquor	5612,9							5612,9
Chemical Pulp							81737,4	81737,4
Mechanical Pulp							14145,6	14145,6
Residues forestry								
Logging Residues	1701,9							1701,9
Manufacturing								
Recycled wood	2585,3			979,0				3564,3

As a validation of this linking method, we compare the baseline projections of the quantities of selected main materials by MAGNET derived from this linking method, with the direct results from GLOBIOM for a baseline scenario ("RCPref", i.e., a business-as-usual scenario without climate change mitigation targets) and a mitigation scenario ("RCP1p9"). The RCP1p9 scenario corresponds to the baseline used in D5.1 for the GLOBIOM scenarios and constitutes higher bioenergy demands than the reference baseline. The comparison results of materials production quantities projected by MAGNET and GLOBIOM baselines scenario are reported in Figure 13 (for EU27 countries) and Figure 14 (for Global total).

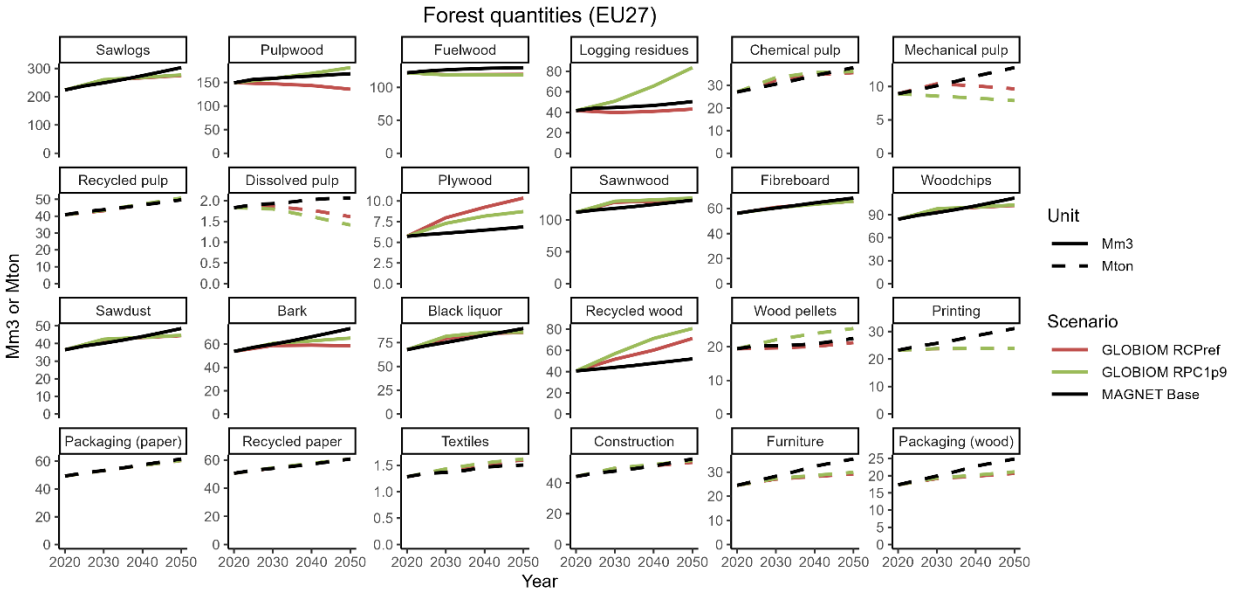

Figure 13: Comparison of projected forest material trends in MAGNET with those simulated in GLOBIOM – for the EU27 region.

As can be seen in the figures, the material projections display generally coherent trends between models. A notable exception can be detected in pulpwood, where the GLOBIOM projection has a slightly negative trend in RCPref, while MAGNET has a significantly positive one as it follows a similar production path as the sawlogs. For some items closely linked to private household consumption, like printing, furniture, and packaging, MAGNET tends to have a more positive expectation about the demand of forest materials. This is since GDP and Population projections are expected to be positive, and no real physical constraints are currently accounted for material uses in the MAGNET model. Apart from this, the projected baseline trends by MANGET using the forest material module with information from GLOBIOM corresponds well with the projections by GLOBIOM for the RCPref scenarios, with similar trends between the two models projected for most primary products (e.g., sawlog), semi-finished products (e.g., sawn wood, fibreboard), finished products (e.g., packaging, textiles, construction), and residues (e.g., logging residues, wood chips, black liquor).

Figure 14 below shows the same series of comparison results, yet for the global level. Here, the exceptions are larger and the high trends in GDP and private demand generally result in MAGNET giving stronger trends in increased production compared to GLOBIOM. As an example, in MAGNET, the fuelwood scales with household demand, which is projected to still increase significantly in developing regions, whereas GLOBIOM assumes this to remain stable.

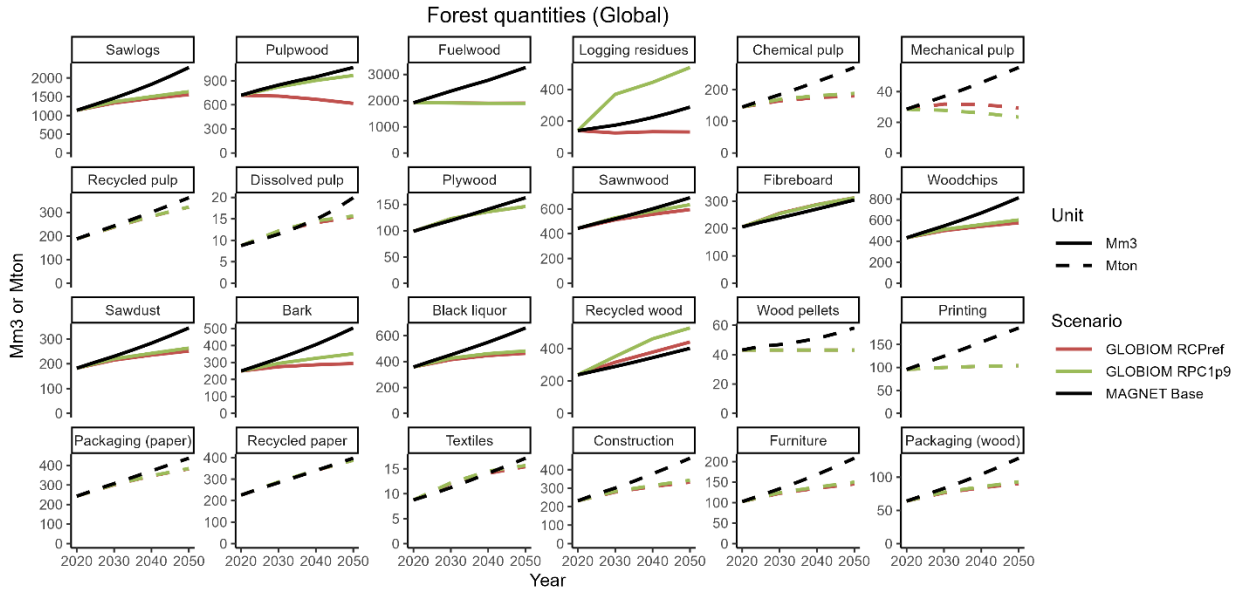

Figure 14: Comparison of projected forest material trends in MAGNET with those simulated in GLOBIOM – Global Total

2.4. Scenarios

The objective of this report is to highlight potential consequences for the forest sector and material use in Europe in different possible futures. A baseline plus three high-demand scenarios were set up, each of them connected to high development projections in a specific forest material-based sector. The overall description of the scenarios can be found in Table 3. The scenarios are additions to the baseline, with the implementation of the measures starting from 2025 (i.e., the first periods 2017-2025 are equal for all scenarios including the baseline).

A general constraint about implementing MAGNET scenarios is that in CGE models it is not possible to simply impose an exogenous demand shift on itself. Since the full economy is balanced in the base year (i.e., in equilibrium) regarding supply, demand, and international trade, the model needs a variable to 'close' the system of linear equations that is solved to find the new global economic equilibrium. Besides the general drivers (e.g., GDP and Population) that push the model to new equilibria in future projections, targeting specific industries output or intermediate input use usually means endogenizing (i.e., solving for) either a tax variable or a technology shifter. In that way, the model can be told to optimize either the tax/subsidy or technical change required to reach a desired result. In some cases, such as in MAGNET's bioenergy module, the subsidies can be implemented in a sector-specific budget-neutral way to minimize impacts on other industries. Since applying a technology shifter can lead to some undesirable material flows (e.g., making more sawn wood out of sawlogs is not infinitely possible), we have opted for a fairly straightforward setups where (in the case of the High Construction scenario) a subsidy is placed on the use of wood products in the construction sector. By simultaneously allowing the model to shift inputs from cement and steel to wood this pushes the model to solve for higher wood use in construction. Similarly, the high textiles scenario places a subsidy on the use of pulp inputs in the textile sector,

while allowing substitution with fibre crops as inputs. For sake of simplicity, the subsidies are applied equally, in ad valorem manner (e.g., as percentage), to all countries.

Table 3: Scenario names and description.

Scenario	Description
Base	Baseline scenario, see section 2.1.
High Construction (HighCons)	EU wood-based construction materials consumption increases by 250% from 2020 to 2050. The shock started in 2025 and included increases in both domestic and imported demand, but only from other EU countries. To achieve the latter a preference shifter for domestic use of forestry and wood products is introduced.
High Textile (HighText)	Global pulp demand for wood-based textiles production grows 3 times compared to the baseline by 2050. Implemented through a uniform calibrated subside on the input use of the pulp sector into the textiles sector.
High Bioenergy (HighBioe)	Bioenergy demand increase to 2050 in line with the high bioenergy demand scenario from D5.1. Since the overlap between PRIMES and the MAGNET bioenergy module is currently not exact, we opted for a straightforward implementation where the share of biomass electricity is doubled by 2050. This largely affects the residues form forests, but also other related biomass.
High Bioeconomy	This scenario combines all the elements of the three scenarios listed above.

The High Construction scenario is based on the major wood increase scenario from the D5.1 scenarios. This is a stylized scenario which goes beyond the market assessment scenario with an assumption of wood in construction being able to increase to +250% of start year levels.

The High Textiles scenario assumes a tripling of the intermediate use of the pulp & paper sector in the textiles sector globally relative to the baseline development. This scenario was calibrated using a uniform subsidy rate to achieve this tripling by 2050. However, as will be see in the scenario results, this results in somewhat higher effect in the EU than globally, which indicates a relatively strong competitiveness of existing industries.

The High Bioenergy scenario does not directly follow the high bioenergy scenarios as described D5.1, mainly because the current MAGNET setup has different definitions of the sectors and does not allow a direct translation. Furthermore, the woody biomass-based electricity from in MAGNET is intertwined with other biobased energy as the residues from crop sectors are first combined into a single ‘residues and pellets’ sector. Thus, we opted for a simple implementation where we double the share of biobased electricity (compared to 2020 levels).

Deliverable 5.1 also implements a high circularity scenario, where the different recovery rate for recycled wood and wood reuse were implemented. Although we attempted to mimic this scenario, currently MAGNET lack the explicit representation of these type of recycling flows, and it was not feasibly to generate a realistic scenario with these settings. This topic will be picked up again in WP6 and 7, yet for now it means that the scenarios focus purely on high wood demand (and thus high harvest impact) scenarios, ignoring the potential for reducing the pressures these scenarios could provide by increasing recycling and reuse.

3. Results

The results section is structured such that the focus is first on the impact on total GDP and sectoral production volumes in the EU27 and in other world regions. This includes a focus on all economic sectors and how they affect each other. After this, it dives deeper into the forestry production sectors' volume, prices, and trade. The third section then continues with exploring the intermediate demand use changes of the forestry-related sectors, and the role of increased capital and labour demand in intensifying production per ha. Finally, we look at GHG emissions and land use change.

3.1. GDP and value added

3.1.1. Main GDP impacts

The repercussions of the high wood demand scenarios can be notable in terms of macroeconomic impacts. Indeed, while we see that at the overall EU27 level and in the rest of the world, the GDP impact of the scenarios are almost negligible (Figure 15), it is evident how at single country level it can be differentiated (Figure 16) even if the largest total GDP impact is at most 0.2% with respect to the 2050 base outcomes (in the HighBioeconomy scenario). Thus, although not negligible, none of the scenarios have a severely disruptive impact on the overall economy, especially on the EU27 level.

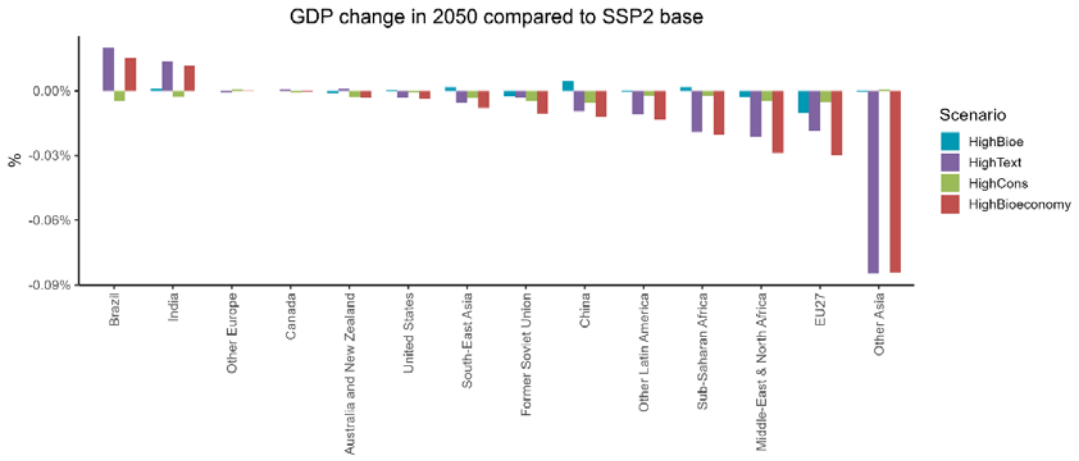

Figure 15: GDP change in 2050 compared to Baseline EU27 and Rest of the World

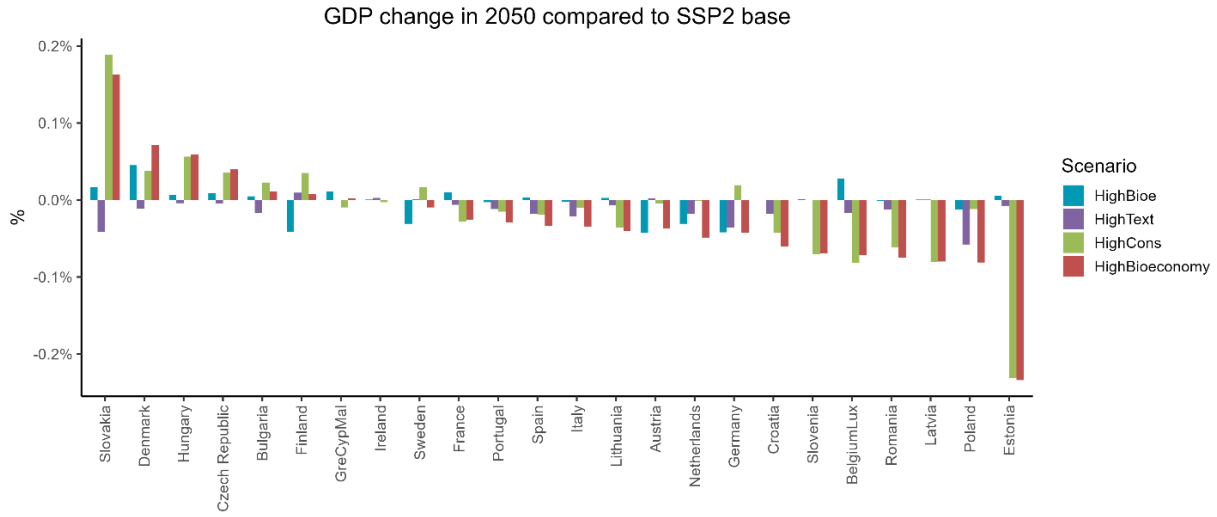

Figure 16: GDP change in 2050 compared to Baseline (EU member states).

3.1.2. Sectoral impacts

GDP impacts are generally interlinked with production and variations of sectorial value added, and analysing their trends can shed further light on the dynamics taking place in the different scenarios. For what concerns the High Textile scenario, for example, slight negative effects on the textiles industry outside of Europe, e.g., in India, Australia, New Zealand and the Former Soviet Union can be identified (Figure 17). This result is driven by the imposed subsidy's structure, which applies the same ad valorem rate globally, leading to increases in, particularly, the EU local production, which then becomes less dependent on imports. High increases in the wood-based textile production provide a general boost to the production of the primary forestry sector at the global level, and it may induce some resource competition use with the agro-food sector in regions such as Canada and India.

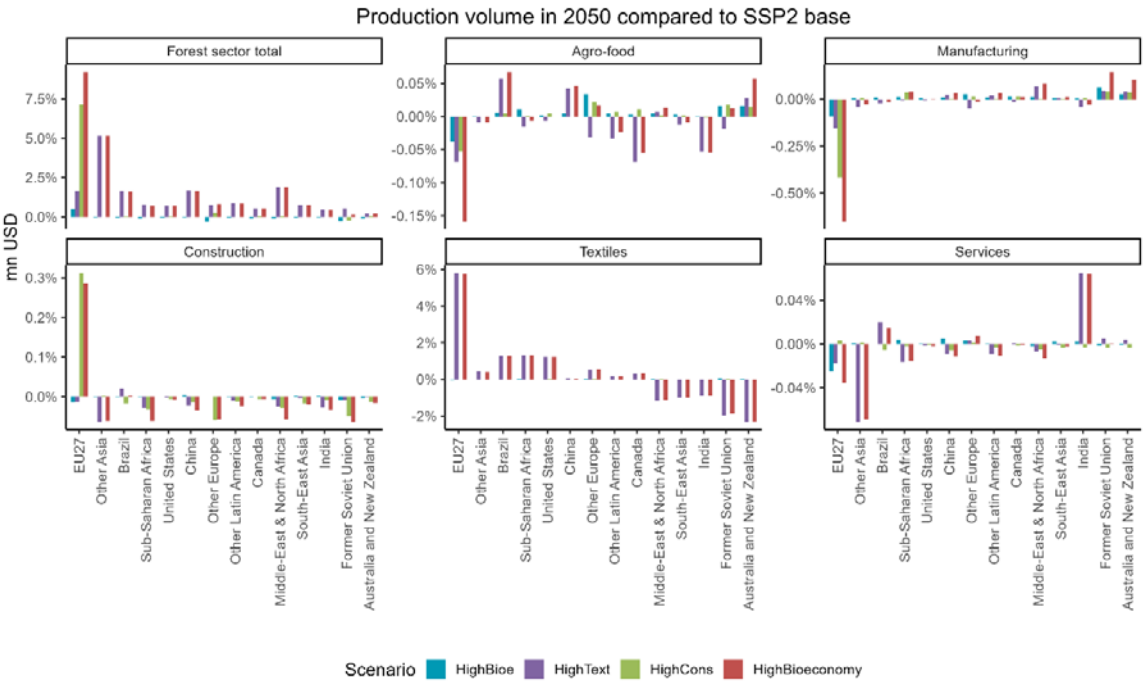

Figure 17: Details sectoral production volume changes – Percentages

The high bioenergy and high construction, instead, in consideration of the fact that they are only expected to be implemented in Europe, have lower relevance for non-EU regions. This said, their effect in the EU is quite relevant, particularly the High construction scenario, which shows a strong effect in the production of the construction and primary forestry sector. The latter increases up to +6%, that is 40 billion dollars[ii] (Figure 18). This leads to an increase in competition for resource uses and a decrease in production in the agro-food and manufacturing sectors.

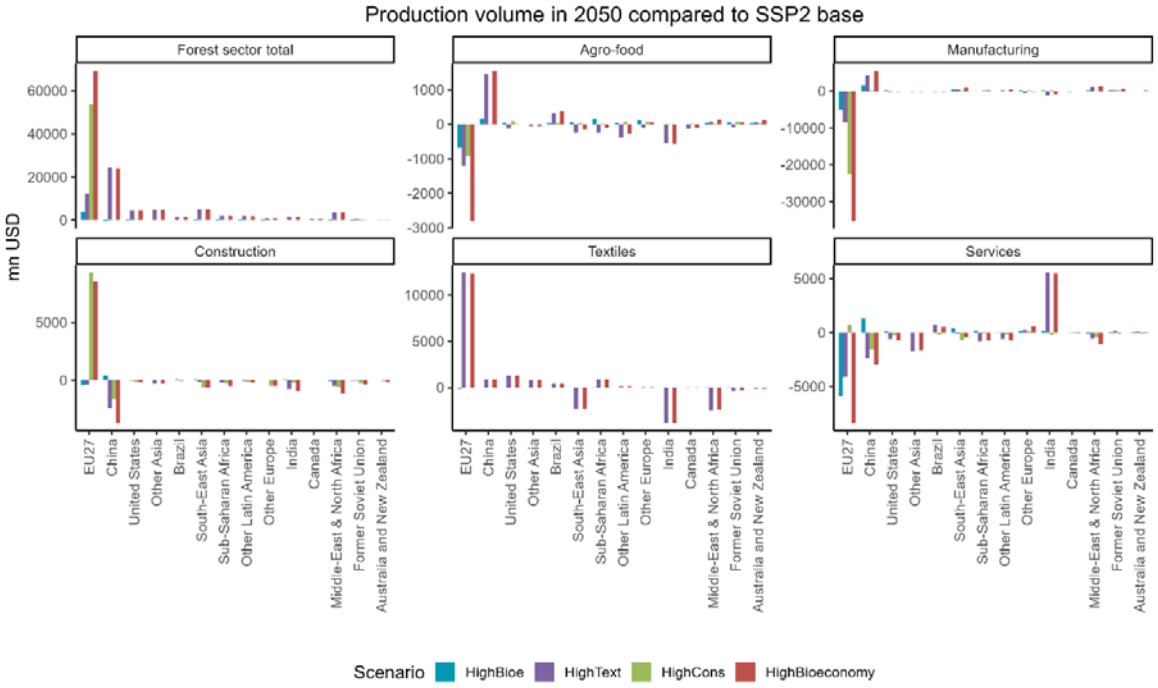

Figure 18: Details sectoral production volume changes – Levels

Interestingly, while the high textile and high bioenergy scenarios have country-specific impacts according to international specialization drivers and the structure of the country's economy, the High Construction scenario's impacts on the forest sector are more homogeneous between countries as wood use in the construction sector is more equally spread across countries. Indeed, it generally has positive impacts for the sectors connected to construction wood (primary forestry and construction) and generalized negative impacts for the others. On the other hand, scenarios like HighTex present development of clusters, such as the emergence of strong production in Poland, Germany, France, and Slovakia.

[ii] Please note that, given the nature of the GTAP database, all economic indicators are expressed as 2017 USD.

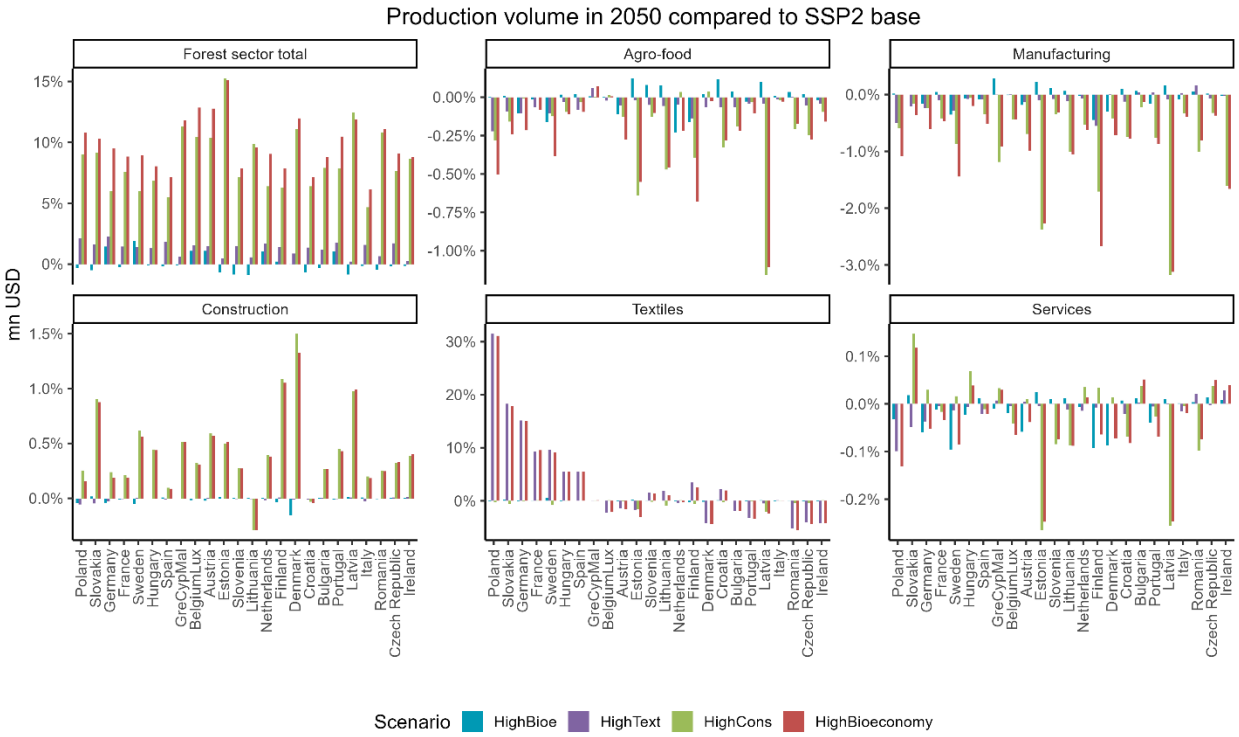

Figure 19: Sectoral production changes – Levels – EU focus

3.1.3. Value added forest sector

All in all, the relationship between sectorial production and GDP impacts can be explained by the contribution of the forest sector to the GDP. For example, in the EU27, the forest sector is projected to increase in the base scenario from 2017 to 2050, but in all scenarios, the relative contribution to GDP is expected to decrease by 2050. Figure 20 shows per sector the absolute value added to the GDP (left) and the relative contribution of the value added (in % right). This graph also includes the residue and pellets sector, which increases specifically in the high bioenergy scenario. Note, however, that this sector also includes crop residues and is thus not a pure forest sector.

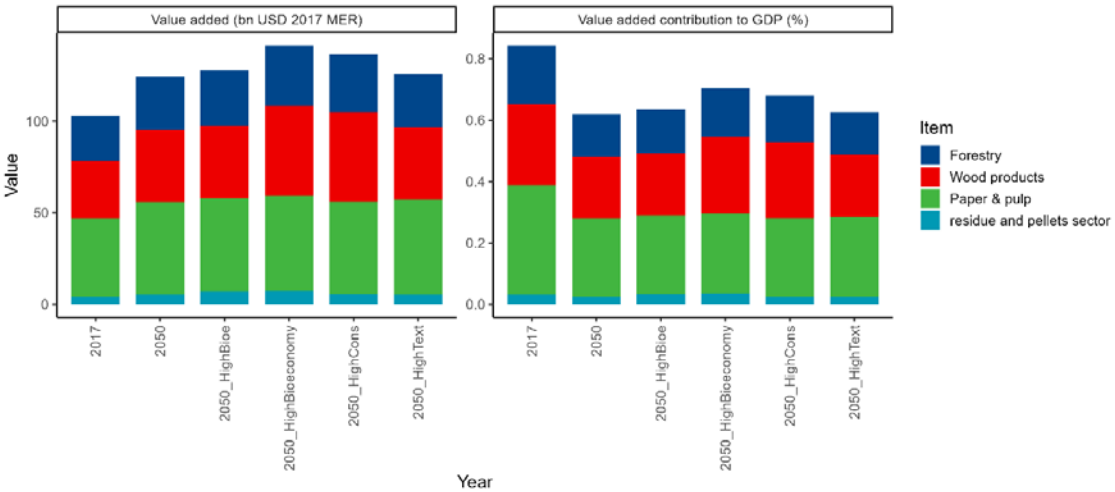

Figure 20: Value added per sector, absolute and relative, for EU27. In this graph the Paper & pulp sector is adjusted to only include the NACE 17 sector (thus excluding NACE 18, as in the core GTAP database this is a combined sector).

Table 4: Forestry value added (bn USD 2017 MER) in Base and HighBioeconomy

Scenario	Region	2017	2025	2030	2040	2050
Base	North EU	8.1	8.7	8.8	9.3	10.1
	Central-West EU	8.6	9.1	9.1	9.4	9.9
	Central-East EU	3.5	3.6	3.7	3.9	4.3
	South-West EU	3.7	3.8	3.8	3.8	3.9
	South-East EU	0.8	0.7	0.7	0.7	0.8
	EU27	24.7	25.9	26.2	27.2	28.9
HighBioeconomy	North EU	8.1	8.7	9.0	9.9	11.3
	Central-West EU	8.6	9.1	9.3	10.2	11.7
	Central-East EU	3.5	3.6	3.8	4.1	4.7
	South-West EU	3.7	3.8	3.9	4.0	4.2
	South-East EU	0.8	0.7	0.7	0.8	0.9
	EU27	24.7	25.9	26.7	29.0	32.8

MER = Market exchange rate

Table 5: Wood products value added (bn USD 2017 MER) in Base and HighBioeconomy

Scenario	Region	2017	2025	2030	2040	2050
Base	North EU	5.6	5.9	5.9	6.1	6.7
	Central-West EU	12.6	13.2	13.1	13.5	14.2
	Central-East EU	6.0	6.5	6.9	8.2	10.5
	South-West EU	6.5	6.8	6.9	7.1	7.3
	South-East EU	0.8	0.8	0.8	0.9	1.0
	EU27	31.3	33.1	33.6	35.7	39.6
HighBioeconomy	North EU	5.6	5.9	6.1	6.8	8.1
	Central-West EU	12.6	13.2	13.7	15.6	18.3
	Central-East EU	6.0	6.5	7.1	9.1	12.6
	South-West EU	6.5	6.8	7.1	7.8	8.8
	South-East EU	0.8	0.8	0.8	1.0	1.2
	EU27	31.3	33.1	34.9	40.3	49.0

MER = Market exchange rate

Figure 21 below exemplifies the increased reliance on the economic sectors in the high wood demand scenarios. The data shown is calculated by taking the intermediate inputs into a sector, e.g., the textiles industry, and calculating the share of the total forest sector (Forestry, pellets, wood products, paper & pulp) in these inputs. This excludes labour and capital inputs, focusing solely on material and energy inputs. The resulting numbers shown are, logically, closely aligned with the increases that were targeted in the scenarios, with, for example, the contribution in construction increasing from 3% to 6%. The total effect for all sectors combined, shown as 'total economy' is that the share of the forest sector in the EU27 economy grows from 3.2% in 2020 to 3.8% in the high bioeconomy, as compared to 3.4% in the base scenario. This latter number paints a different picture than the value-added developments alone (with decreasing contribution to GDP) and shows even in the baseline a continued reliance on material inputs based on the forest sector.

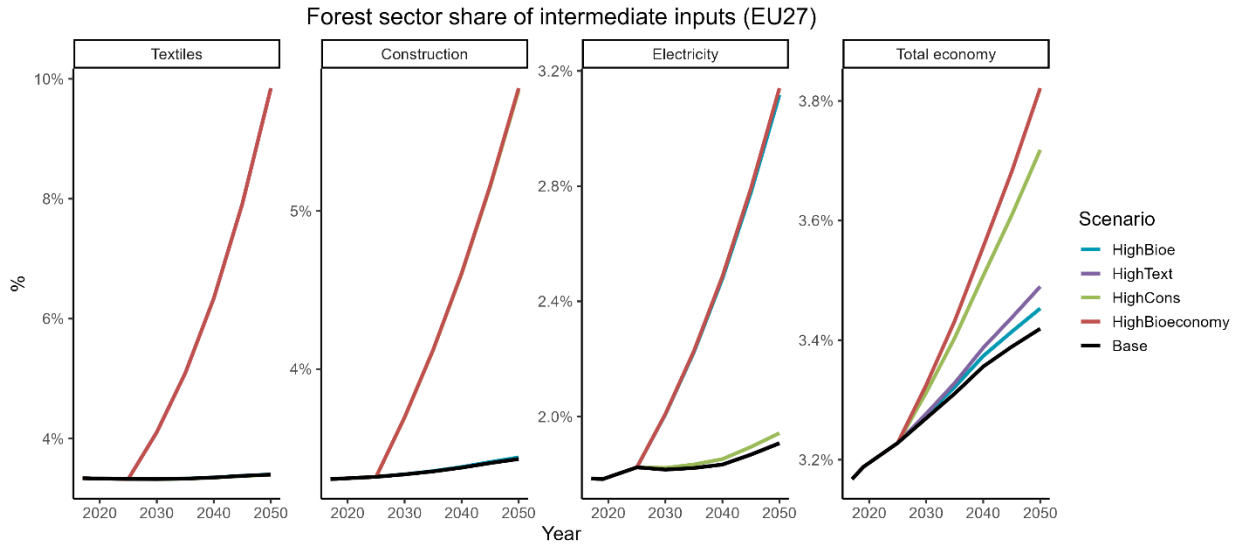

Figure 21: Forest sector share of intermediate inputs (EU)

3.2. Production and Trade

3.2.1. Forest Quantities

Table 6 compares the total roundwood production volumes in EU27 under the Base and HighBioeconomy scenarios. Here the roundwood volume is calculated as the sum of sawlogs, pulpwood, and fuelwood, whereas the biomass volume also includes logging residues and other wood. Overall, the baseline shows a sizeable increase in production of roundwood which is even more accentuated in the high construction scenario. This is relatively in line with the expectations of the State of Europe's Forests 2020 report, which reports an increase of 114 million m3 of roundwood for the period between 1990 and 2015, meaning an increase in EU production of +30% in 25 years. In MAGNET's baseline for the EU27 the increase is relatively modest compared to this historic trend and it reports a relatively milder increase for the future, i.e., increases by +16% in the 2025 to 2050 period.

Table 6: Roundwood production quantities in MAGNET (Mm3)

Scenario	Region	2017	2025	2030	2040	2050
Base	North EU	164.4	176.0	180.8	192.1	205.4
	Central-West EU	155.2	164.7	168.4	177.4	187.4
	Central-East EU	94.9	102.4	107.3	117.3	127.2
	South-West EU	41.8	43.4	43.9	44.8	46.1
	South-East EU	15.6	16.4	17.0	18.5	18.8
	EU27	471.8	502.8	517.4	550.2	584.8
HighBioeconomy	North EU	164.4	176.0	183.6	202.2	226.3
	Central-West EU	155.2	164.7	172.2	190.9	215.6
	Central-East EU	94.9	102.4	109.1	124.0	141.8
	South-West EU	41.8	43.4	44.3	46.3	49.4
	South-East EU	15.6	16.4	17.3	19.3	20.4
	EU27	471.8	502.8	526.4	582.6	653.4

Figure 22 below compares the development of roundwood production trends with that of primary forestry sector production (in dollar terms) and the total biomass volume under different scenarios.

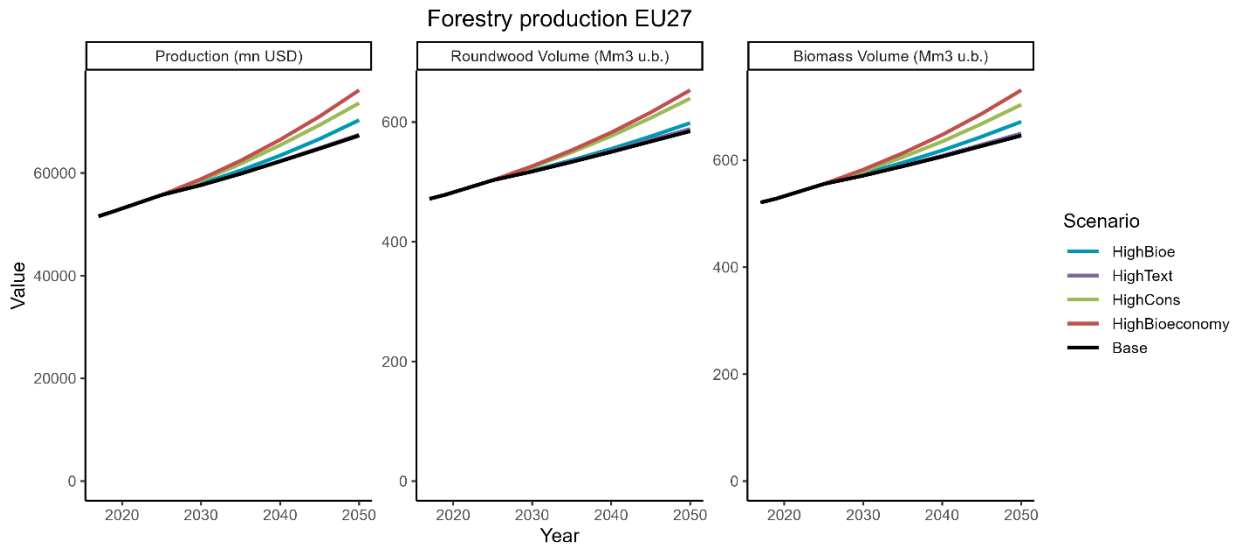

Figure 22: Main primary forestry quantities by scenario

Figure 23 shows the development of specific forest-related material quantities directly relevant to the implemented scenarios: wood used in construction, textile, and wood pellets. Here, the wood for construction quantities scales directly with the input of wood use in the construction sectors in EU27, which is implemented to double by 2050. Similarly, the wood-based textiles, which are related in MAGNET to the input of pulp into the textiles sector, increase by a little over 300% in quantities terms. The high bioenergy scenario shows a strong increase in the dedicated wood pellets sector in MAGNET, although other (non-forest) sectors contribute to the increased bioenergy supply in this scenario.

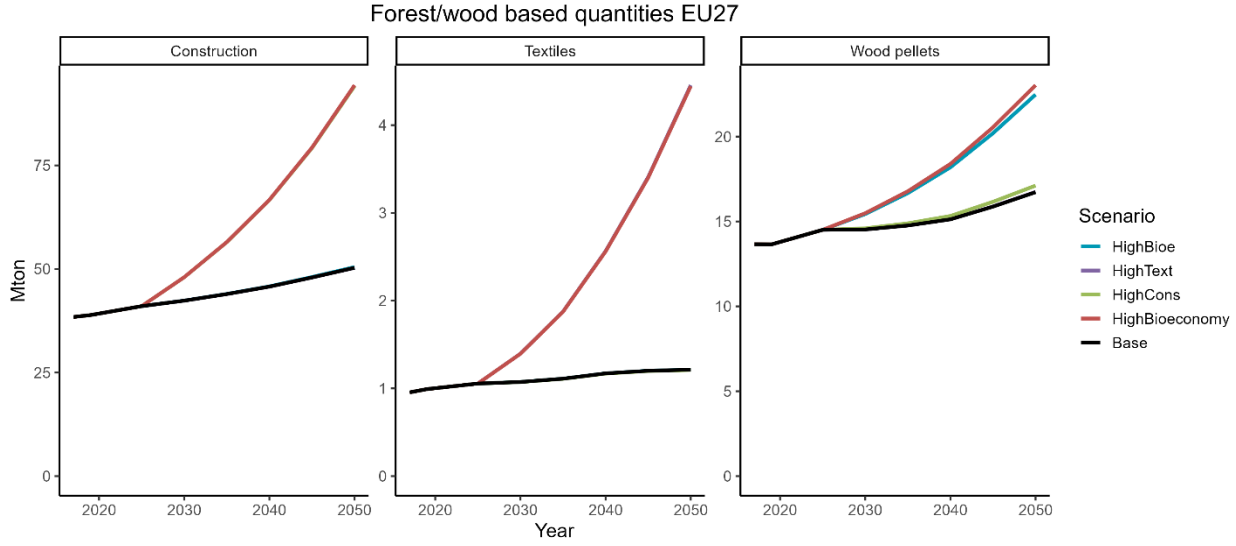

Figure 23: Main scenario relevant wood-based quantities by scenario

In the GLOBIOM scenarios described in the ForestNavigator D5.1 deliverable, the biomass harvest increases by 13% in the baseline from 2020 to 2040 and remains stable afterwards. This is quite close to MAGNET's projections, with an increase of 16% from 2017 to 2040. However, in the MAGNET scenario there is still a further increase of 6% in the 2040-2050 decade. In the scenario with the highest harvest, the GLOBIOM model projects a 38% increase by 2040 compared to 2020, whereas for MAGNET this is +40% by 2050. There are, however, some differences when looking in detail at the scenarios, as the GLOBIOM scenarios show a larger impact of the bioenergy-related scenarios compared to the construction scenario.

Below, Figure 24 shows the wood product-related quantities from the Forest Materials Quantities by Region (FMQR) module in more detail. The high construction drives up the trend of the Sawlogs production, which is therefore higher than the baseline. The same applies to Plywood, Sawnwood, Fiberboard, Woodchips, Bark, Recycled wood, and Construction. Logging residues grow more than the baseline in all the scenarios except for the Bioenergy one. Wood pellets grow more in the bioenergy scenario. Textile products, dissolving pulp and Printing are slightly higher in the high textiles. The rest of the materials have patterns similar to the baseline. The high bioeconomy scenario, having incorporated all the scenario assumption, shows the increase connected to all the other scenarios, and overlaps in the graphs with the related scenarios (e.g., textiles increase is identical in the high bioeconomy and high textiles scenario). The scenarios do not show any relevant trade-offs or multiplier effects in these outcomes, and the HighBioeconomy generally displays results that are the additive effect of the separate scenarios.

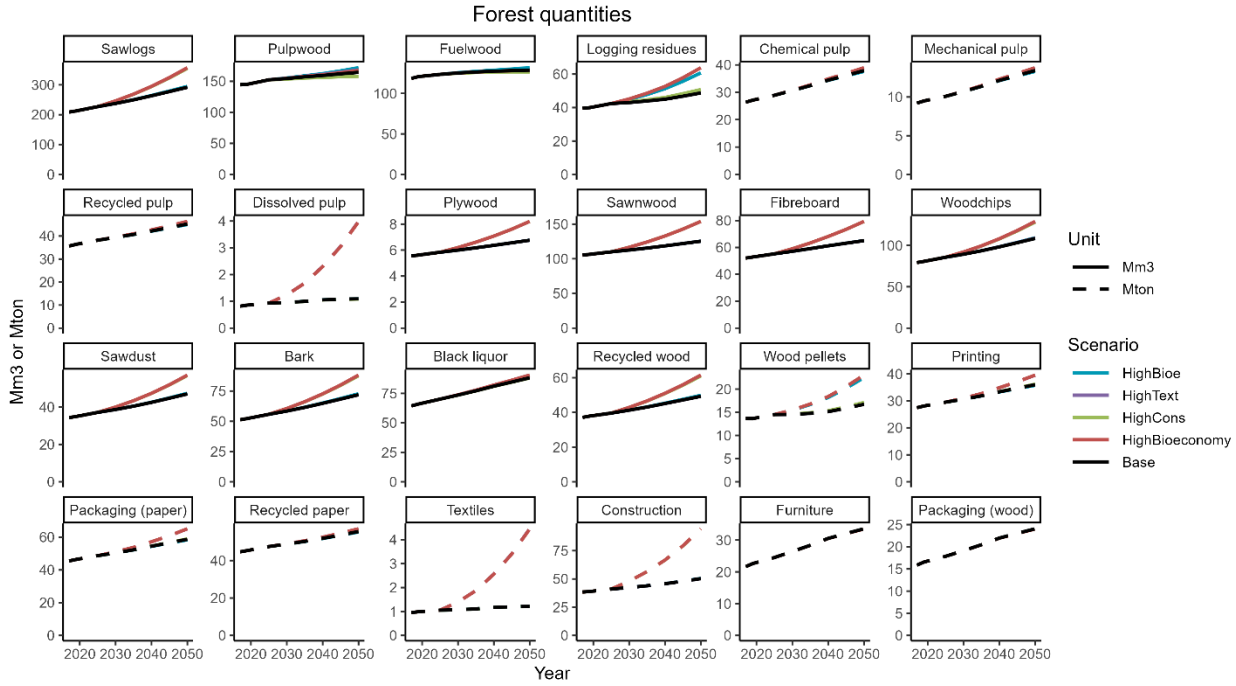

Figure 24: Extract of Forest Material Projections

3.2.2. Production volumes and prices

Figure 25 shows production and trade output of MAGNET's Forest sector. The domestic use of the lumber sector increases significantly due to the increased demand from the construction sector. Most of this is domestically compensated by an increase in production. Thus, while in the High

Construction scenario these is an evident net regional gain in the European wood sector, that is evident only in the high construction scenario and has repercussions only on the internal trade and not (significantly) on the external net trade level. The lumber industry's trade (as defined in million USD in MAGNET) is dominating the total trade figures of the forest sector, which explains why the high construction scenario shows large changes in the intra-EU trade. The high Bioenergy scenario projects a slight increase in exports compared to the baseline, likely due to the increased support of the wood pellets sector. This increase indirectly increases log production, which can be exported to the global market.

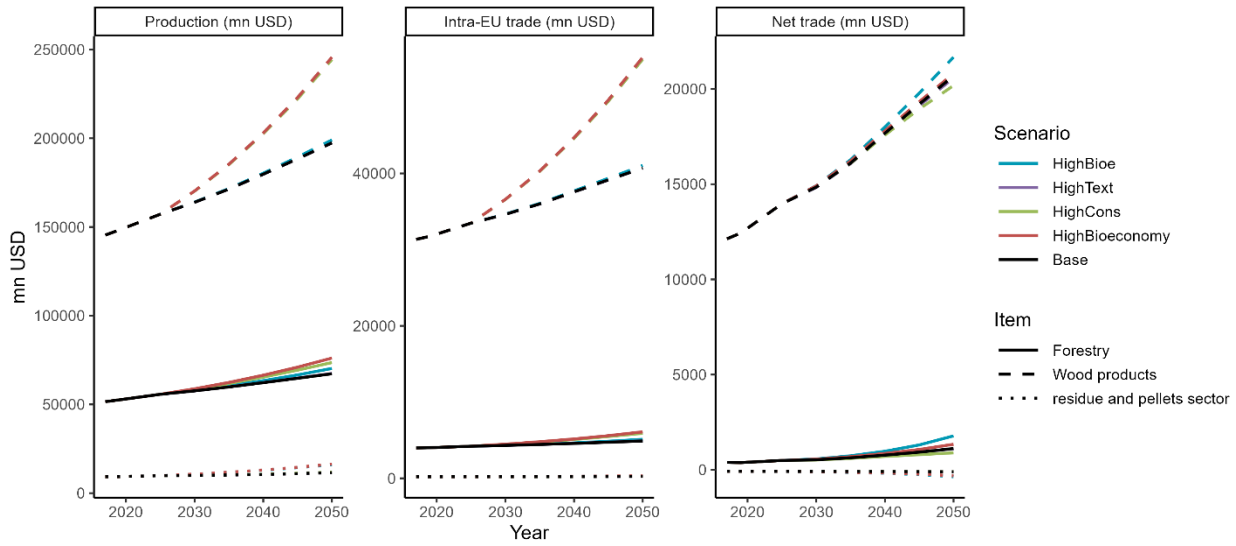

Figure 25: Production and trace in EU27 by scenario. For this figure, the paper & pulp sector is excluded, as the scenario effects are limited and NACE18 inclusion in the data skews the presentation.

Figure 26 shows the developments of producer prices, which should be noted in a general equilibrium model are all defined as '1' in the starting data and expressed as an index. In the baseline the primary forestry prices increase slightly, driven by increasing land prices due to overall land scarcity. Other sectors typically have slightly decreasing prices as technical change developments inputs can drive down prices. A direct effect seen in the high bioeconomy scenario is an increase in prices of the primary forestry sector driven by high wood demand for construction. Besides this, an obvious price increase is seen in the wood pellets sector in the high bioenergy demand. The paper & pulp sector price is only very slightly affected. In the lumber sector the prices decrease slightly in the high bioenergy scenario as the demand for pellets (which in MAGNET is only modelled through residue use) increases log supply without any added demand, thus suppressing prices.

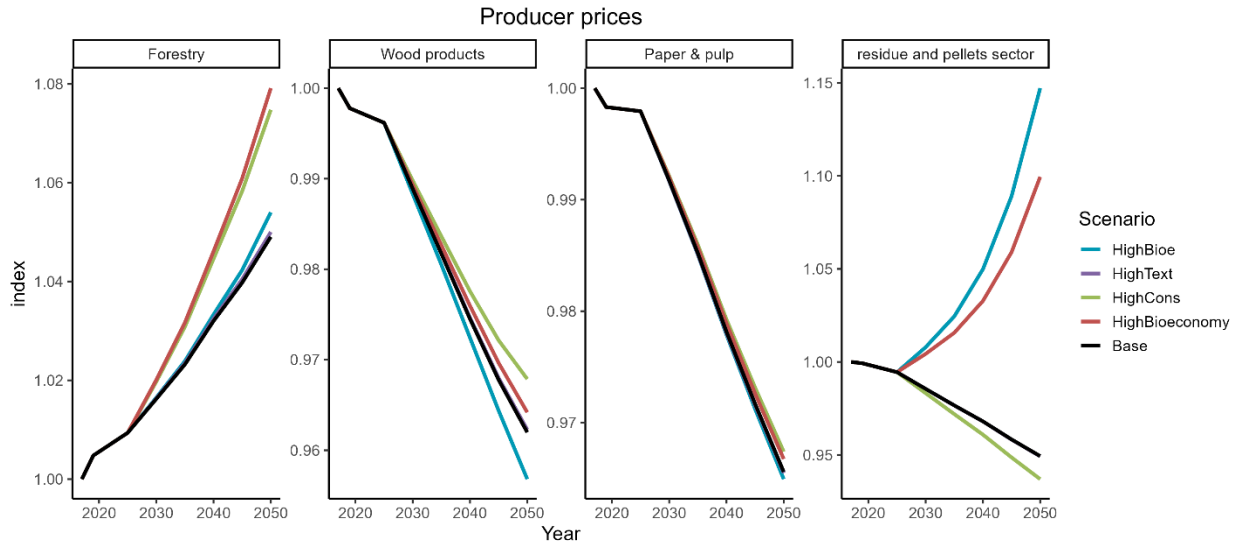

Figure 26: Sectoral producer prices by scenario (EU27)

3.2.3. Trade effects

The changes in international trade lead to some (minor) effects in terms of self-sufficiency, as shown in Figure 27. Indeed, while the import levels do not change significantly, there is a slight decrease in exports. Accordingly, self-sufficiency also decreases, particularly in wood products in the high construction and high bioeconomy scenarios.

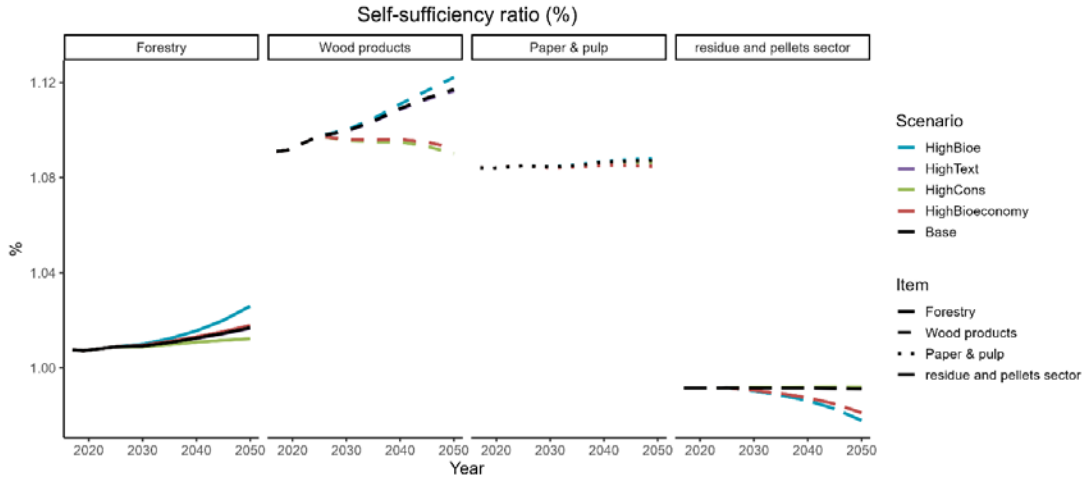

Figure 27: Sectoral self-sufficiency by Scenario (EU)

Figure 28 shows the total imports and exports of the EU27 to other regions. For example, the reliance of wood products imported from the former Soviet Union region, and high exports of the paper & pulp sector to the Middle East & North Africa region and China. Please note that the definition of paper & pulp sector includes the NACE 18 sector. Although the absolute numbers are not hugely affected by the various scenarios, looking at the changes in trade relative to the baseline shows more clearly that the main impacts arise where trade is already high. For example, the effect in the trade in the primary forestry products, where there is only substantial trade with China in the GTAP database, is clearly a decrease in the high construction sector due to higher domestic demand, but an increase in the high bioenergy scenario, as there is some surplus supply of non-bioenergy products projected.

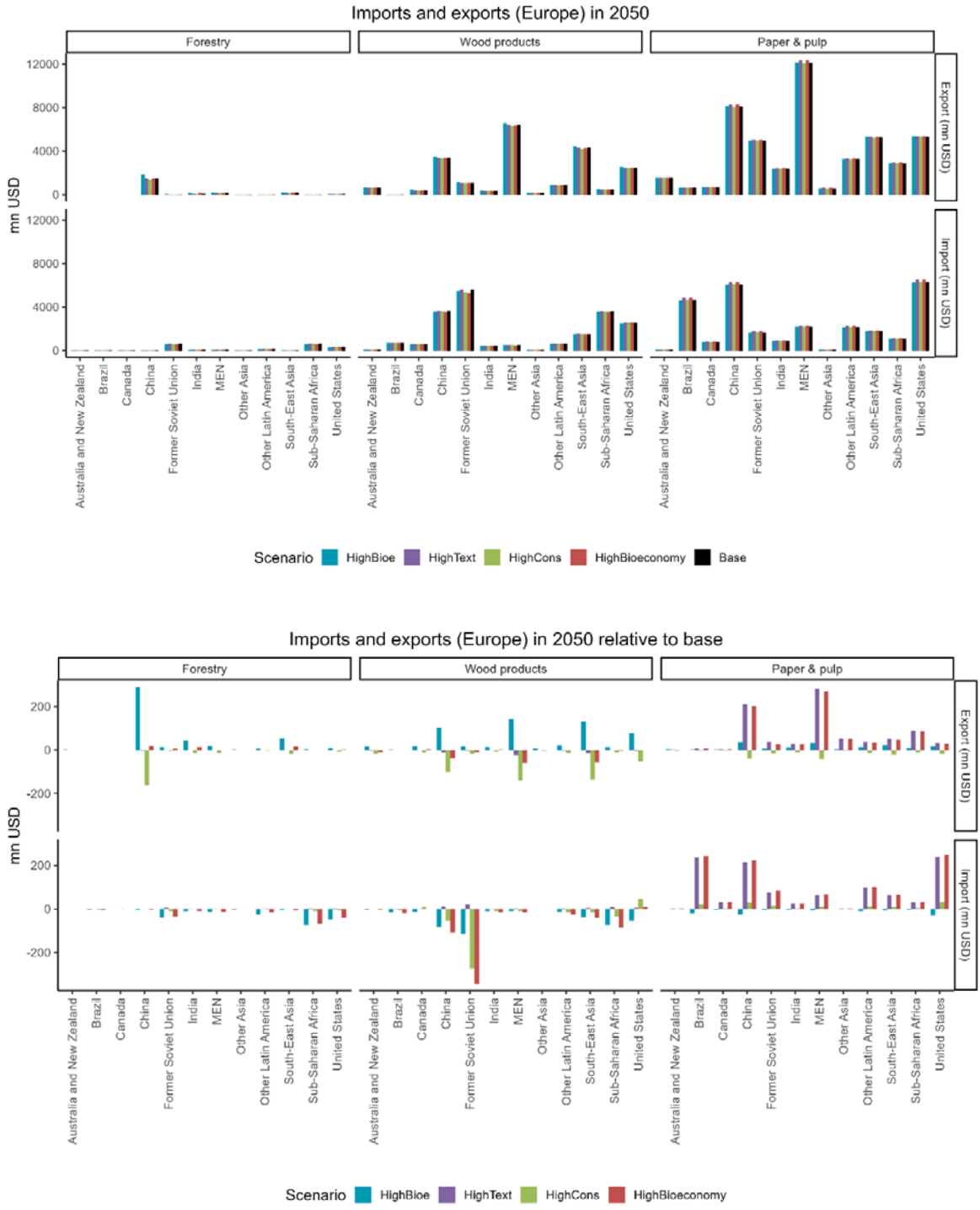

Figure 28: Total imports and exports of the EU to trading regions.

Figure 29 below shows the net trade of the various forest sectors per EU Member State. This shows clear regional differences from the start year. Finland and Sweden are the largest net exporters mainly through the paper & pulp sector. In contrast, France and the Netherlands are most reliant on imports. An interesting case in the bilateral trade data is Germany, which is a net importer from EU sources but an overall net exporter. These overall patterns do not significantly change in the projection to 2050 in the baseline, as well as the high bioeconomy scenario.

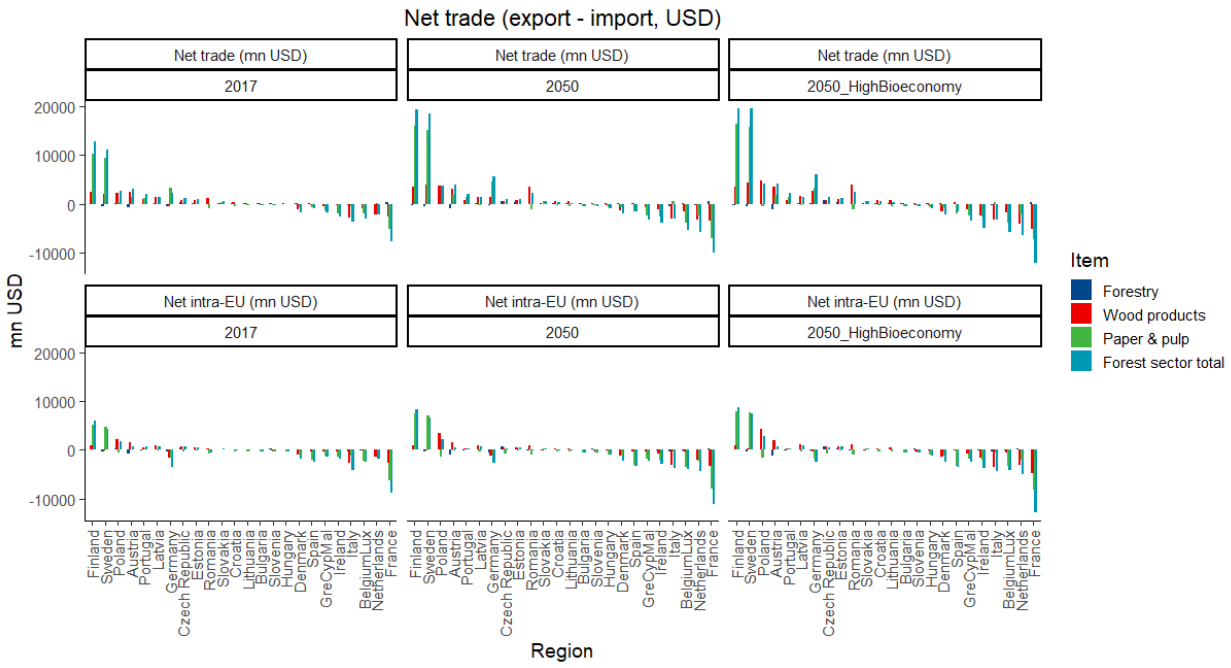

Figure 29: Net trade per member state

3.3. Factors of Production

Increases in production that lead to changes in value added accumulation and GDP growth are strongly dependent on primary resources uses, i.e., endowments, and intermediate products distribution between sectors. To evaluate the role of forestry as an intermediate input for other sectors is crucial to understand the role of forestry for green growth. The MAGNET model has 16 primary production factors, including five different types of labour and natural resources. This section will focus on the analysis of the main aggregated primary factors, i.e., Labour, Land and Capital.

3.3.1. Land

The first, tightly connected to the primary forestry sector, is Land. The land endowment is an important factor of production, and it can display specific dynamics, especially in land-scarce regions like the EU. In the baseline the managed forest area increases from 121.8 in 2017 to 127.5 in 2050 with increases observed in all the regions (Table 7). This increase in forest area is mainly facilitated by a reduction of land used for agriculture. In the high bioeconomy scenario, the expansion is only moderately higher compared to the baseline scenario.

Table 7: Forestry land cover projections in MAGNET (Mha) in Base and HighBioeconomy.

Scenario	Region	2017	2025	2030	2040	2050
Base	North EU	45.3	45.5	45.6	45.9	46.3
	Central-West EU	26.6	27.2	27.6	28.3	28.9
	Central-East EU	22.2	22.7	23.0	23.6	24.3
	South-West EU	17.9	18.3	18.6	19.1	19.5
	South-East EU	9.8	10.0	10.2	10.5	10.8
	EU27	121.8	123.7	125.0	127.3	129.9
HighBioeconomy	North EU	45.3	45.5	45.7	46.1	46.6
	Central-West EU	26.6	27.2	27.7	28.7	29.8
	Central-East EU	22.2	22.7	23.1	23.8	24.7
	South-West EU	17.9	18.3	18.7	19.3	19.8
	South-East EU	9.8	10.0	10.2	10.5	10.9
	EU27	121.8	123.7	125.4	128.4	131.8

Besides the mild expansion trends, most of the roundwood production increase described in the previous section comes from an ongoing trend of increasing production factor use, which is expected to be even more prominent in the future. Indeed, the EU is already showing an intensification trend, i.e., it is expected to use more input of capital and labour relative to land. Indeed, Figure 30 shows how, while the land cover increases are quite similar between scenarios, HighCons and HighBioeconomy presents significantly higher volumes of roundwood production, due to an increase in forest yields (Figure 31 and Table 8).

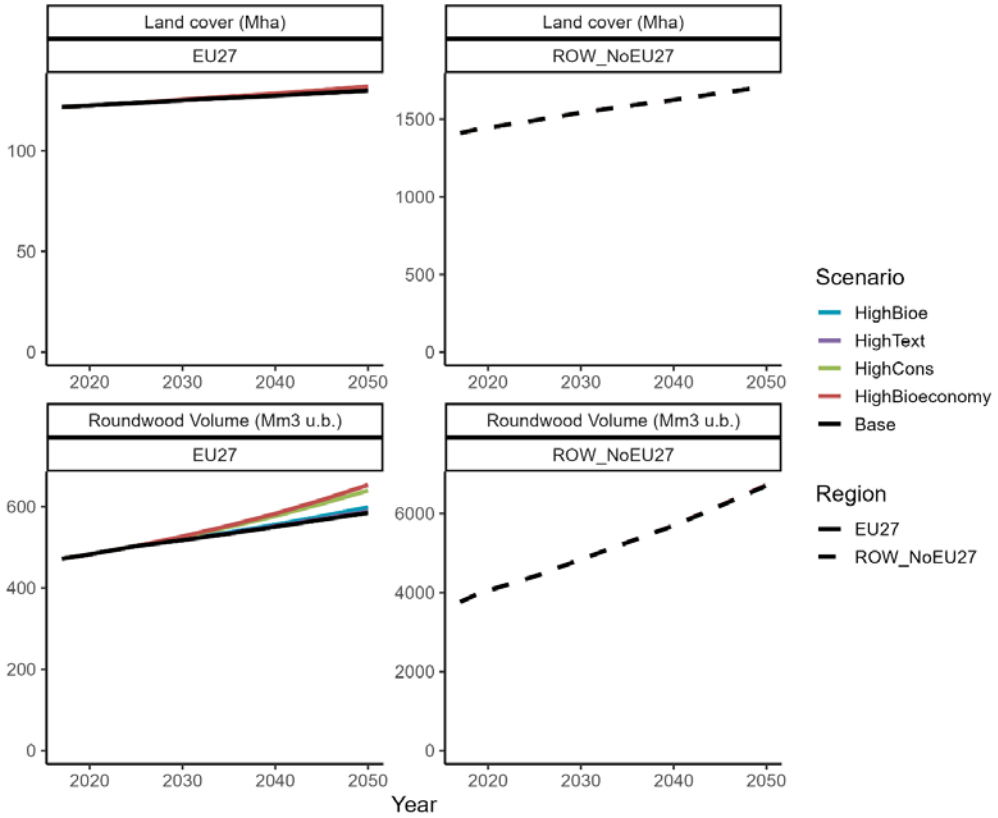

Figure 30. Land use for managed forest vs. roundwood production

Forestry yields are expressed in Figure 31 and Table 8. Yields are expressed in USD/ha, which is calculated by dividing the total output volume in dollar terms of the sector as represented in MAGNET, by the forestry land demand in each timestep. The calculated relative trend is the same as for the physical yields (i.e., the roundwood production per ha) as those values are updated using the economic variables in MAGNET. As can be seen in Table 8, a large variety in the yields in the start data exists per region, yet the increasing trends are rather uniform. This uniformity is partly due to the nature of the scenario implementation, with similar shocks per member state, but also due to lack of regional granularity in the representation of country-specific forest sectors in MAGNET.

Table 8: Forestry yields (USD/ha) for Base and HighBioeconomy

Scenario	Region	2017	2025	2030	2040	2050
Base	North EU	318.4	341.2	351.4	377.7	409.7
	Central-West EU	794.3	842.3	853.2	897.1	950.1
	Central-East EU	398.5	430.1	448.6	486.0	504.6
	South-West EU	311.6	321.1	322.8	325.9	334.3
	South-East EU	161.9	165.8	169.4	180.3	187.4
	EU27	423.3	450.3	460.9	489.0	518.1
HighBioeconomy	North EU	318.4	341.2	357.6	399.6	454.1
	Central-West EU	794.3	842.3	871.4	960.8	1084.6
	Central-East EU	398.5	430.1	454.0	504.4	539.5
	South-West EU	311.6	321.1	326.2	338.4	360.0
	South-East EU	161.9	165.8	171.0	185.6	197.2
	EU27	423.3	450.3	469.2	517.8	577.3

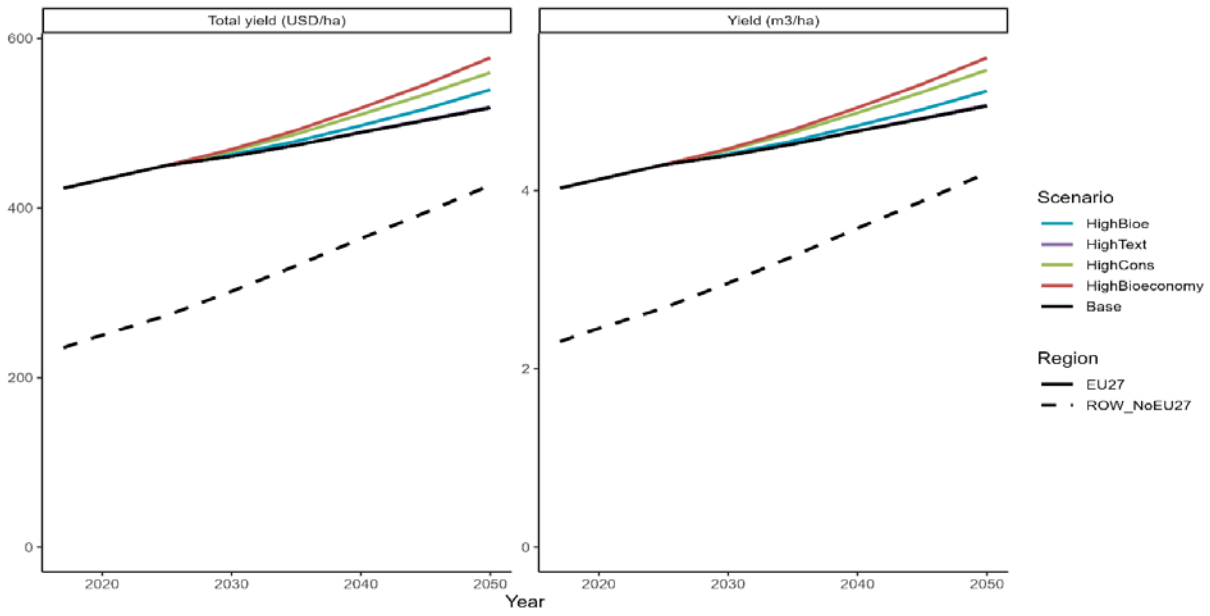

Figure 31: Total Forest Yields, monetary and physical.

3.3.2. Capital

The observed yield increases are mainly explained by a more intense input of capital and labour. Figure 32 shows the increase in demand for capital and other intermediates compared to land expansion. These changes in absolute demand are, for a large part, a result of the increased size of the sector. As shown by the graph, for both primary forest and wood product sectors there is a substantial increase in capital demand relative to the baseline, particularly in the High Construction and High Bioeconomy scenarios. The increase in demand is also noticeable for intermediate products demand (which includes materials and energy), at least for the wood product sector. In contrast, the primary forestry sector seems to maintain a relatively homogeneous level of use of intermediates.

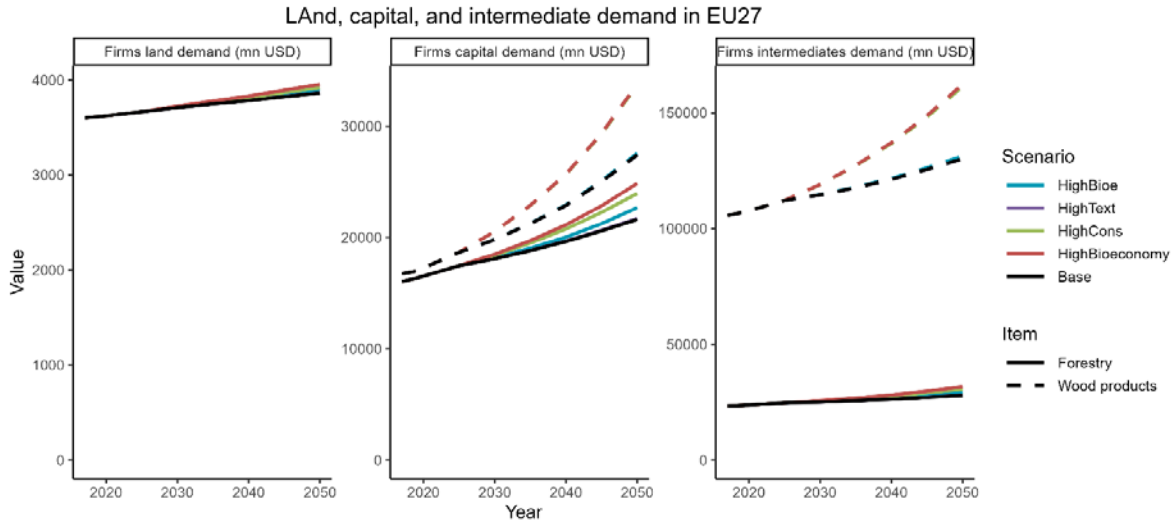

Figure 32. Land, capital, and intermediate demand

3.3.3. Labour

Concerning the labour endowment, some similarities with the other factors can be identified, as in Figure 33. In the high bioeconomy scenario, there is a notable increase in labour demand, both for the primary and for the wood production sector relative to the baseline. Higher demand increases the employment perspectives in the EU. As such, part of the production increase is driven by a more productive (left-end panel) higher number of people employed in forest-related sectors. Thus, it can be concluded that at least part of the higher production in the EU is driven by the creation of more green, circular jobs.

Two additional indicators are also shown: the value added per worker and the worker-to-ha ratio. The first is the total value added (Land, Capital, & Labour) of each sector divided by the total employment, and the worker/ha is the total employment divided by the land demand for forestry. The value added per worker shows a strongly increasing trend across scenarios for both sectors, indicating higher labour productivity and rising wages (see also Figure 34). Even though it increases ever so slightly for the high-demand scenarios, this indicator shows little difference between scenarios, as both the capital and labour components of the value added increase in comparable amounts. The development of worker/ha is another indicator of increasing labour productivity.

However, here the trend is changed to more worker/ha needed in the high wood demand scenarios, and the declining trend flattens out toward 2050.

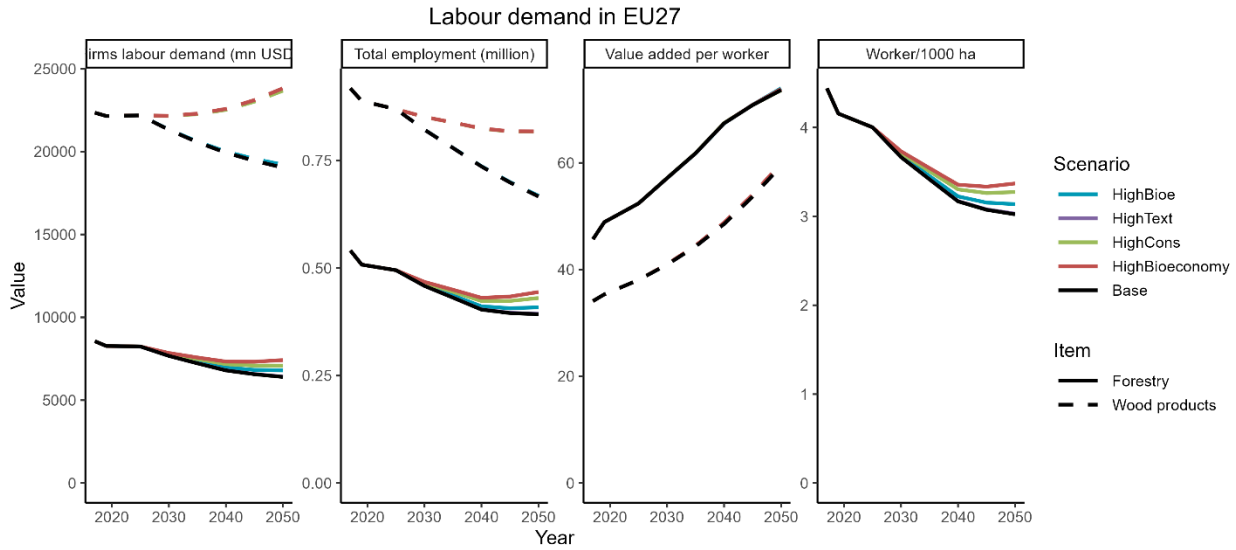

Figure 33: Labour demand and total employment (EU27)

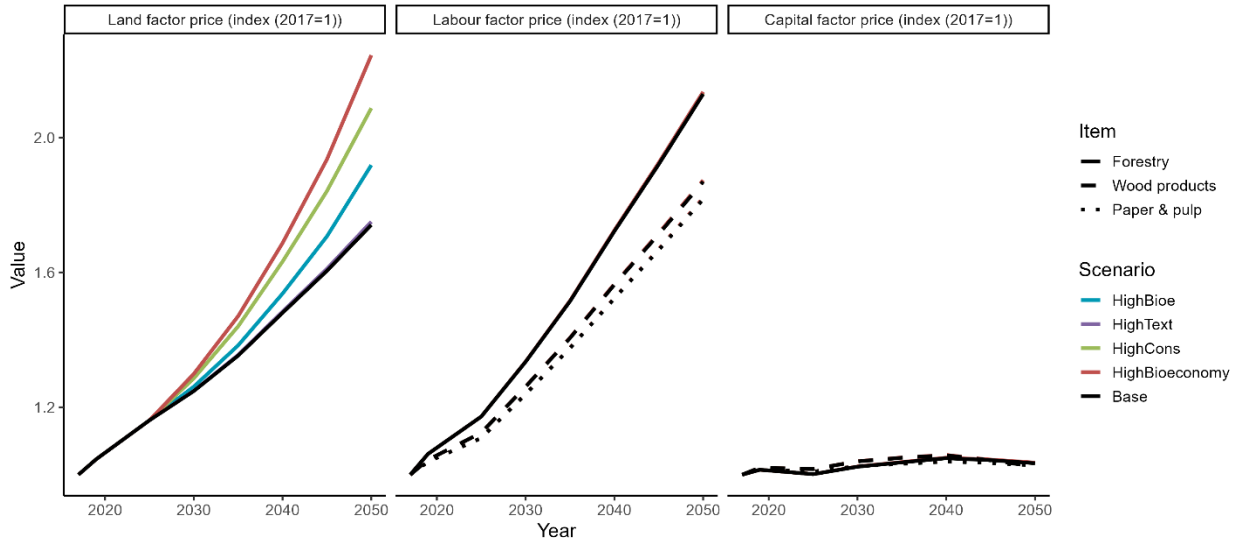

Figure 34: Factor input prices (EU)

As shown in Figure 34, the price of the scarce (in high demand) factors increases significantly over time. Land, in particular, is under pressure with respect to the baseline, therefore its price increase is even more accentuated in the scenarios. Capital price, on the other hand, which is dynamically modelled as an endogenous factor in the model, remains relatively constant over time and homogenously prices across wood-based (and other economic) sectors.

3.4. GHG emissions

Considering the importance of the climate change issue and its relevance for the EU and global policies, it's important to assess the consequences of the different scenarios in terms of GHG

emissions. Increases in sectoral production may lead to increases in related environmental and emission impacts. Indeed, Figure 35 shows the level of sectorial emissions from fuel use by the forest sector, with stable or increasing trends. Interestingly, two significant scenario results can be identified. First, the High Bioenergy scenario leads to a decrease in emissions related to the electricity sector compared to the baseline, stabilising the emission amount to the 2020 level. Second, the High Construction scenario results in a reduction in emissions associated with the cement and concrete sectors. Emissions associated with primary forest production (e.g., related to fuel use) are low and stable, regardless of the scenario.

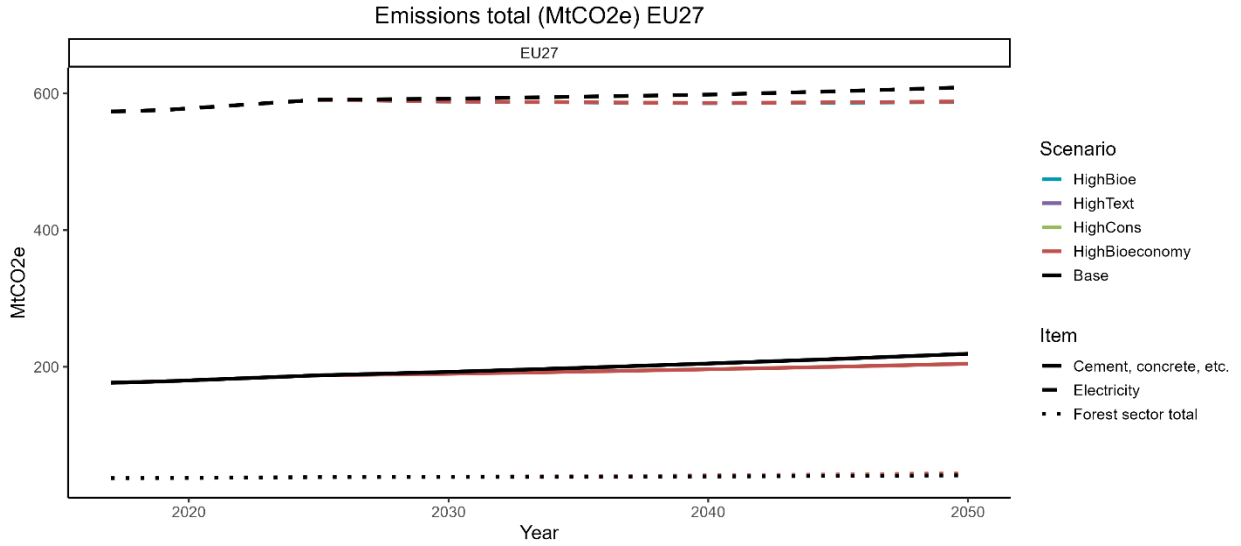

Figure 35: Sectoral emissions (EU27)

More in detail, Figure 36 and Figure 37 show that each scenario drives up the emissions connected to the total forest sector, though this implies a decrease in the emissions associated with complementary sectors. As such, the High construction scenario increases the forestry-related emissions by around four per cent but decreases the ones connected to the manufacturing sector by around 3%. This translates to a total net decrease of 0.3% of total EU emissions, i.e., around 15 Mt CO2 equivalents. A similar trend can be identified for the High Bioeconomy, which lowers the manufacturing and electricity emissions by around 3% each, leading to a decrease of almost 1% of total EU emissions, i.e., around 40 million tons CO_2 equivalents by 2050.

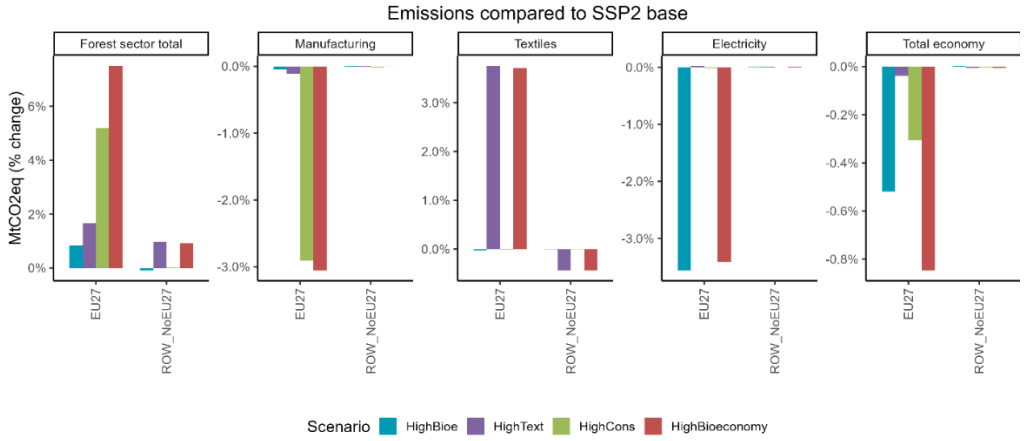

Figure 36: Emissions compared to the Base scenario in relative terms.

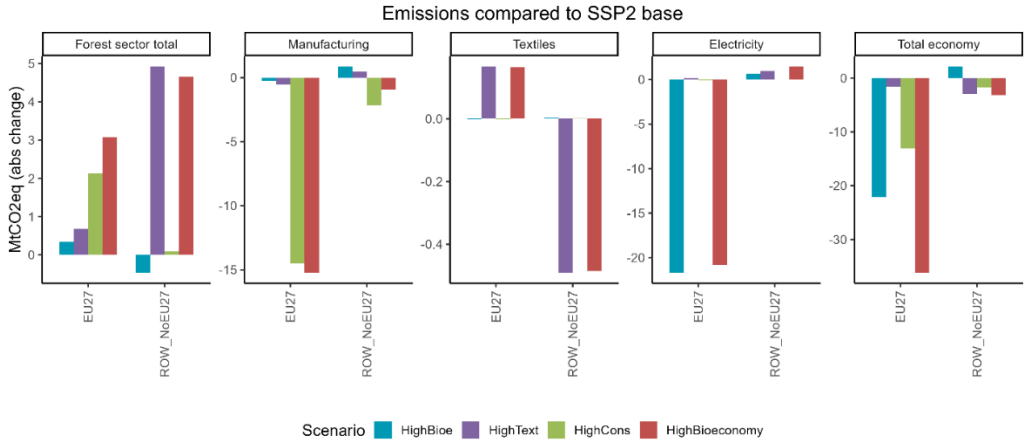

Figure 37: Emissions compared to the Base scenario in absolute terms.

3.4.1. Land cover changes and potential carbon sinks

Figure 38 show that the high construction scenario creates an incentive for land conversion from other uses to forest use, which increases the potential European carbon sink. While the GHG emissions module in MAGNET calculates emissions associated with fuel use and output of emitting sectors, land use is not categorized as an emission source in that module. The result of the land use change emissions module in MAGNET would be a slightly increasing carbon sink, as forest land is expanding in the baseline, and more so in the high bioeconomy scenario. However, for drawing any conclusions about the overall impact on emissions, more detailed modelling is required, as MAGNET is not currently capable of including dynamics around the changes in the management intensity in connection to the forest carbon stocks. This topic will be analysed in more detail in Work Package 6 and 7, making use of the connections between MAGNET and GOBIOM that are under development.

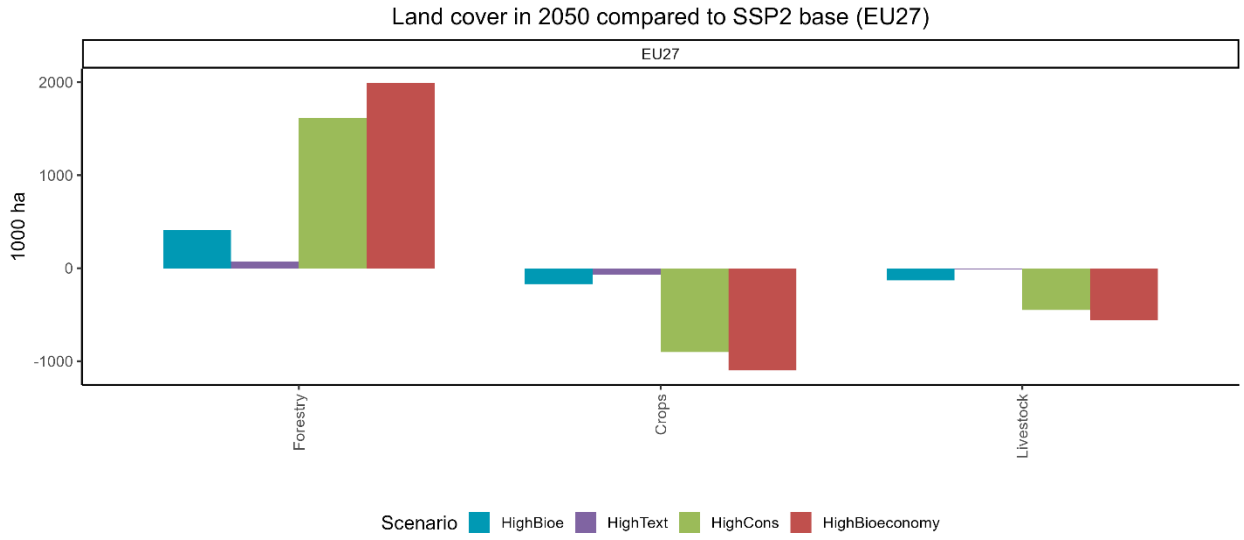

Figure 38: Land cover changes of forestry, crops, and livestock by scenario

4. Conclusion

This deliverable provides a comprehensive assessment of the macro-economic impacts of various wood demand scenarios on the forest sector, utilising the MAGNET model. The analysis highlights the potential for green growth and job creation within the forest-based sector under high-demand scenarios for construction, textiles, and bioenergy. The analysis is enhanced by the development of a linkage with a more detailed representation of forest-related sectors through a post-processing module of GLOBIOM data, which adds additional useful indicators for interpreting scenarios.

The results indicate that while the scenarios have a significant impact on forest-related sectors, their overall effect on the EU27 economy is relatively mild. The largest impact on country-level total GDP in the high bioeconomy scenario is at most 0.2% with respect to the 2050 baseline outcomes. In the baseline, the share of the forest sector to the EU economy experiences a relative decline, despite a significant increase in absolute terms. The projected decrease in labour force, driven by dynamics of labour productivity and intensification, is partly alleviated in the high wood demand scenarios for the forestry and wood products sectors. Overall harvest levels are increasing, and the additional roundwood volume needed in high wood demand scenarios is mainly achieved through intensification (e.g., added capital and labour) as the room for expanding forestry land is limited.

The various high wood demand scenarios have a significant yet heterogeneous impact on the forest sector. The High Construction scenario, focused on Europe, has a strong positive effect on the production of the construction and primary forestry sectors, with primary forestry increasing by up to +6% (40 billion USD). Within the EU, this scenario significantly increases domestic use and production in the lumber sector, resulting in a net regional gain for the European wood sector,

primarily affecting internal trade. The impacts of this scenario are quite homogeneous across EU countries. The High Textile scenario shows slight negative effects on the textile industry outside of Europe due to the globally applied subsidy, leading to increased EU local production. The High Bioenergy scenario and High Textile scenario have more country-specific impacts based on international specialisation and economic structure. All scenarios can lead to increased competition for resources and decreased production in the agro-food and manufacturing sectors.

In conclusion, the report suggests that increasing the reliance on forest-based production through high-demand scenarios can foster green job generation and contribute to meeting European environmental targets without negatively affecting overall macroeconomic growth.

4.1. Discussion & next steps

This deliverable highlighted the potential significance of forest sector-oriented policies and demonstrated how increases in forest-based materials production can contribute to the creation of green jobs and foster green growth. Nevertheless, improvement will be developed in the next phases of the ForestNavigator project. First, further details will be added to the sectoral modelling of one of the biggest forest sub-sectors: paper and pulp. As such, work has started to split the GTAP-based 'ppp' into its NACE17 and NACE18 components to add a more detailed trace of the material flows. This is an important improvement, which will allow separating the material value added in the sector from the knowledge-based publishing production part.

Second, further refinements to the scenarios will be made, especially to enhance the connection with bioenergy using PRIMES data. This work will be completed in WP 6 and 7.

Finally, additional crucial details will be added regarding the connection between the forest sector and the environmental/emission impact from land use and forest management. Further steps will be taken to improve this representation of forest conditions and related carbon sink potentials by connecting MAGNET with GLOBIOM.

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6. Annexes

6.1. Details MAGNET model

Table 9: MAGNET Commodities and Aggregation

Commodity	Description	Disaggregated MAGNET sets	Mapped GTAP sets
pdr	Paddy and processed rice	pdr	pdr
wht	Wheat	wht, r_wht	wht, wht
grain	Cereal grains nec	gro	gro
veg	Vegatables	v_f, veg, r_v_f, r_veg	v_f, veg, v_f, veg
fruit	Fruit	fruit, r_frt	fruit, fruit
nuts	Nuts	nuts, r_nuts	nuts, nuts
roots	Roots and tubers	roots, r_root	roots, roots
pulses	Pulses	pulses, r_puls	pulses, pulses
oils	Oil seeds	osd	osd
sug	Sugar cane, sugar beet	c_b	c_b
oagr	Other agriculture	pfb	pfb
crops	Crops nec	ocr, r_ocr	ocr, ocr
othctl	sheep, goats, horses	ctl	ctl

cattle	cattle sector	bfctl	ctl
pigpls	Pig and other animal product	oap	oap
pltry	poultry sector	pltry	oap
milk	Raw milk	rmk	rmk
wol	Wool, silk-worm cocoons	wol	wol
frs	Forestry	frs	frs
plan	Plantation	plan	frs
wfish	Wild fish	fsh	fsh
aqcltr	Aquaculture	Diad, Fresh, Crust, Marin, Molus	fsh, fsh, fsh, fsh, fsh
coa	Coal	coa	coa
oil	Crude oil	oil	oil
gas	Gas	gas	gas
oxt	Minerals nec	oxt	oxt
othcmt	Meat: other cattle, sheep, goats,horse	cmt	cmt
bfmt	beef meat	BFCMT	cmt
othmt	Other meat product nec	omt	omt
pulmt	poultry meat	poum	omt
vol	Vegetable oils and fats	vol	vol
cvol	Crude vegetable oil	cvol	vol
oilcake	Oil cake byproduct of cvol used as animal feed	oilcake	vol
dairy	Dairy products	mil	mil
pcr	Processed rice	pcr	pcr
sugar	Sugar	sgr, SugSc	sgr, ofd
mola	Molasse	mola	sgr
ofd	Processed food	ofd	ofd
fishp	Fish processing	Fishp	ofd
fishm	fish meal	fishm	ofd
b_t	Beverages and tobacco products	b_t	b_t
lum	Wood products	lum	lum
ppp	Paper products, publishing	ppp	ppp
p_c	Petroleum, coal products	p_c, aviaf, ftavia	p_c, p_c, p_c
biog	Biogasoline	biog	p_c
fstck	Feedstock	bf_g, bf_s, bf_m, bf_o	p_c, p_c, p_c, p_c
biod	Biodiesel	biod	p_c
ddgs	Biogasoline byproduct	ddgs	p_c
bf2nd	2nd gen biofuel	ftfuel, eth	p_c, p_c
respel	residue and pellets sector	res, pel	p_c, lum
chm	Chemical products	chm, f_chem, pest	chm, chm, chm
bph	Basic pharmaceutical products	bph	bph
rpp	Rubber and plastic products	rpp	rpp

bioch	bio chemicals	bioch	chm
bioph	bio pharmaceuticals	bioph	bph
biopl	bio plastics	lsug, pe, pla, bfchem, biopl	sgr, chm, chm, chm, rpp
fert_n	fertilizer nutrient n	fert_n	chm
fert_p	fertilizer nutrient p	fert_p	chm
fert_k	fertilizer nutrient k	fert_k	chm
manu	Manufacturing	i_s, nfm, fmp, ele, eeq, ome, mvh, otn	i_s, nfm, fmp, ele, eeq, ome, mvh, otn
nmm	Mineral products nec	nmm	nmm
omf	Other Manufacturing, includes furniture	omf	omf
ely	Electricity	ely, edt	ely, ely
ely_c	electricity from coal	ely_c	ely
ely_g	electricity from gas	ely_g	ely
ely_n	electricty from nuclear	ely_n	ely
ely_h	electricty from hydro	ely_h	ely
ely_w	electricty from wind and solar	ely_w	ely
bioe	bioelectricity 2nd gen	bioe	ely
heat	heat	heat	ely
bioh	bioheat	bioh	ely
gas_dist	Gas manufacture, distribution	gdt, Bgas	gdt, gdt
ser	Services	wtr, trd, whs, cmn, ofi, ins, rsa, obs, dwe	wtr, trd, whs, cmn, ofi, ins, rsa, obs, dwe
edu	Education	edu	edu
foodserv	Food services	afs, ros, osg, hht	afs, ros, osg, hht
trans	Transport sector	otp, wtp, atp	otp, wtp, atp
r_pdr	residue pdr	r_pdr	pdr
r_gro	residue gro	r_gro	gro
r_osd	residue osd	r_osd	osd
r_frs	residue frs	r_frs	frs
Swd	Seaweed	Swd	fsh
fdctl	feed cattle	feed, fdctl	ofd, ofd
fdpig	feed pigs	fdpig	ofd
fdplt	feed poultry	fdplt	ofd
fdfsh	feed fish	fdfsh	ofd
mnctl	manure cattle	mnctl	ctl
mnbctl	manure beef cattle	mnbctl	ctl
mnoap	manure other animals	mnoap	oap
mnrmk	manure rawmilk	mnrmk	rmk
mnpltry	manure poultry	mnpltry	oap
cns	Construction	cns	cns

tex	Textiles	tex	tex
lea	Leather products	lea	lea
wap	Wearing apparel	wap	wap

Table 10: Regional aggregations MAGNET model setup

MAGNET region	GTAP	ISO	Country
Australia and New Zealand	aus	AUS	Australia
Australia and New Zealand	aus	CXR	Christmas Island
Australia and New Zealand	aus	CCK	Cocos (Keeling) Islands
Australia and New Zealand	aus	HMD	Heard Island and McDonald Islands
Australia and New Zealand	aus	NFK	Norfolk Island
Australia and New Zealand	nzl	NZL	New Zealand
South-East Asia	xoc	ASM	American Samoa
South-East Asia	xoc	COK	Cook Islands
South-East Asia	xoc	FJI	Fiji
South-East Asia	xoc	PYF	French Polynesia
South-East Asia	xoc	GUM	Guam
South-East Asia	xoc	KIR	Kiribati
South-East Asia	xoc	MHL	Marshall Islands
South-East Asia	xoc	FSM	Micronesia, Federated States of
South-East Asia	xoc	NRU	Nauru
South-East Asia	xoc	NCL	New Caledonia
South-East Asia	xoc	NIU	Niue
South-East Asia	xoc	MNP	Northern Mariana Islands
South-East Asia	xoc	PLW	Palau
South-East Asia	xoc	PNG	Papua New Guinea
South-East Asia	xoc	PCN	Pitcairn
South-East Asia	xoc	WSM	Samoa
South-East Asia	xoc	SLB	Solomon Islands
South-East Asia	xoc	TKL	Tokelau
South-East Asia	xoc	TON	Tonga
South-East Asia	xoc	TUV	Tuvalu
South-East Asia	xoc	UMI	United States Minor Outlying Islands
South-East Asia	xoc	VUT	Vanuatu
South-East Asia	xoc	WLF	Wallis and Futuna
China	chn	CHN	China
China	hkg	HKG	Hong Kong
South-East Asia	jpn	JPN	Japan
South-East Asia	kor	KOR	Korea, Republic of
Other Asia	mng	MNG	Mongolia
South-East Asia	twn	TWN	Taiwan, Province of China
South-East Asia	xea	PRK	Korea, Democratic People's Republic of
South-East Asia	xea	MAC	Macao
South-East Asia	brn	BRN	Brunei Darussalam

South-East Asia	khm	KHM	Cambodia
South-East Asia	idn	IDN	Indonesia
South-East Asia	lao	LAO	Lao People's Democratic Republic
South-East Asia	mys	MYS	Malaysia
South-East Asia	phl	PHL	Philippines
South-East Asia	sgp	SGP	Singapore
South-East Asia	tha	THA	Thailand
South-East Asia	vnm	VNM	Viet Nam
South-East Asia	xse	MMR	Myanmar
South-East Asia	xse	TLS	Timor-Leste
Other Asia	afg	AFG	Afghanistan
Other Asia	bgd	BGD	Bangladesh
India	ind	IND	India
Other Asia	npl	NPL	Nepal
Other Asia	pak	PAK	Pakistan
Other Asia	lka	LKA	Sri Lanka
Other Asia	xsa	BTN	Bhutan
Other Asia	xsa	MDV	Maldives
Canada	can	CAN	Canada
United States	usa	USA	United States
Other Latin America	mex	MEX	Mexico
United States	xna	BMU	Bermuda
United States	xna	GRL	Greenland
United States	xna	SPM	Saint Pierre and Miquelon
Other Latin America	arg	ARG	Argentina
Other Latin America	bol	BOL	Bolivia, Plurinational State of
Brazil	bra	BRA	Brazil
Other Latin America	chl	CHL	Chile
Other Latin America	col	COL	Colombia
Other Latin America	ecu	ECU	Ecuador
Other Latin America	pry	PRY	Paraguay
Other Latin America	per	PER	Peru
Other Latin America	ury	URY	Uruguay
Other Latin America	ven	VEN	Venezuela, Bolivarian Republic of
Other Latin America	xsm	FLK	Falkland Islands (Malvinas)
Other Latin America	xsm	GUF	French Guiana
Other Latin America	xsm	SGS	South Georgia and the South Sandwich Islands
Other Latin America	xsm	SUR	Suriname
Other Latin America	xsm	GUY	Guyana
Other Latin America	cri	CRI	Costa Rica
Other Latin America	gtm	GTM	Guatemala
Other Latin America	hnd	HND	Honduras
Other Latin America	nic	NIC	Nicaragua
Other Latin America	pan	PAN	Panama

Other Latin America	slv	SLV	El Salvador
Other Latin America	xca	BLZ	Belize
Other Latin America	dom	DOM	Dominican Republic
Other Latin America	hti	HTI	Haiti
Other Latin America	jam	JAM	Jamaica
Other Latin America	pri	PRI	Puerto Rico
Other Latin America	tto	TTO	Trinidad and Tobago
Other Latin America	xcb	AIA	Anguilla
Other Latin America	xcb	ATG	Antigua and Barbuda
Other Latin America	xcb	ABW	Aruba
Other Latin America	xcb	BHS	Bahamas
Other Latin America	xcb	BRB	Barbados
Other Latin America	xcb	CYM	Cayman Islands
Other Latin America	xcb	CUB	Cuba
Other Latin America	xcb	DMA	Dominica
Other Latin America	xcb	GRD	Grenada
Other Latin America	xcb	MSR	Montserrat
Other Latin America	xcb	ANT	Netherlands Antilles
Other Latin America	xcb	KNA	Saint Kitts and Nevis
Other Latin America	xcb	LCA	Saint Lucia
Other Latin America	xcb	VCT	Saint Vincent and the Grenadines
Other Latin America	xcb	TCA	Turks and Caicos Islands
Other Latin America	xcb	VGB	Virgin Islands, British
Other Latin America	xcb	VIR	Virgin Islands, U.S.
Austria	aut	AUT	Austria
BelgiumLux	bel	BEL	Belgium
Bulgaria	bgr	BGR	Bulgaria
Croatia	hrv	HRV	Croatia
GreCypMal	cyp	CYP	Cyprus
Czech Republic	cze	CZE	Czech Republic
Denmark	dnk	DNK	Denmark
Estonia	est	EST	Estonia
Finland	fin	ALA	Lland Islands
Finland	fin	FIN	Finland
France	fra	FRA	France
France	fra	GLP	Guadeloupe
France	fra	MTQ	Martinique
France	fra	REU	Réunion
Germany	deu	DEU	Germany
GreCypMal	grc	GRC	Greece
Hungary	hun	HUN	Hungary
Ireland	irl	IRL	Ireland
Italy	ita	ITA	Italy
Latvia	lva	LVA	Latvia
Lithuania	ltu	LTU	Lithuania

BelgiumLux	lux	LUX	Luxembourg
GreCypMal	mlt	MLT	Malta
Netherlands	nld	NLD	Netherlands
Poland	pol	POL	Poland
Portugal	prt	PRT	Portugal
Romania	rou	ROU	Romania
Slovakia	svk	SVK	Slovakia
Slovenia	svn	SVN	Slovenia
Spain	esp	ESP	Spain
Sweden	swe	SWE	Sweden
Other Europe	gbr	GBR	United Kingdom
Other Europe	che	CHE	Switzerland
Other Europe	nor	NOR	Norway
Other Europe	nor	SJM	Svalbard and Jan Mayen
Other Europe	xef	ISL	Iceland
Other Europe	xef	LIE	Liechtenstein
Other Europe	alb	ALB	Albania
Other Europe	srb	SRB	Serbia
Former Soviet Union	blr	BLR	Belarus
Former Soviet Union	rus	RUS	Russian Federation
Former Soviet Union	ukr	UKR	Ukraine
Former Soviet Union	xee	MDA	Moldova, Republic of
Other Europe	xer	AND	Andorra
Other Europe	xer	BIH	Bosnia and Herzegovina
Other Europe	xer	FRO	Faroe Islands
Other Europe	xer	GIB	Gibraltar
Other Europe	xer	GGY	Guernsey
Other Europe	xer	VAT	Holy See (Vatican City State)
Other Europe	xer	IMN	Isle of Man
Other Europe	xer	JEY	Jersey
Other Europe	xer	MKD	North Macedonia
Other Europe	xer	MCO	Monaco
Other Europe	xer	MNE	Montenegro
Other Europe	xer	SMR	San Marino
Former Soviet Union	kaz	KAZ	Kazakhstan
Former Soviet Union	kgz	KGZ	Kyrgyzstan
Former Soviet Union	tjk	TJK	Tajikistan
Former Soviet Union	uzb	UZB	Uzbekistan
Former Soviet Union	xsu	TKM	Turkmenistan
Former Soviet Union	arm	ARM	Armenia
Former Soviet Union	aze	AZE	Azerbaijan
Former Soviet Union	geo	GEO	Georgia
Middle-East & North Africa	bhr	BHR	Bahrain
Middle-East & North Africa	irn	IRN	Iran, Islamic Republic of
Middle-East & North Africa	irq	IRQ	Iraq

Middle-East & North Africa	isr	ISR	Israel
Middle-East & North Africa	jor	JOR	Jordan
Middle-East & North Africa	kwt	KWT	Kuwait
Middle-East & North Africa	lbn	LBN	Lebanon
Middle-East & North Africa	omn	OMN	Oman
Middle-East & North Africa	pse	PSE	Palestinian Territory, Occupied
Middle-East & North Africa	qat	QAT	Qatar
Middle-East & North Africa	sau	SAU	Saudi Arabia
Middle-East & North Africa	syr	SYR	Syrian Arab Republic
Middle-East & North Africa	tur	TUR	Turkey
Middle-East & North Africa	are	ARE	United Arab Emirates
Middle-East & North Africa	xws	YEM	Yemen
Middle-East & North Africa	dza	DZA	Algeria
Middle-East & North Africa	egy	EGY	Egypt
Middle-East & North Africa	mar	MAR	Morocco
Middle-East & North Africa	tun	TUN	Tunisia
Middle-East & North Africa	xnf	LBY	Libyan Arab Jamahiriya
Middle-East & North Africa	xnf	ESH	Western Sahara
Sub-Saharan Africa	ben	BEN	Benin
Sub-Saharan Africa	bfa	BFA	Burkina Faso
Sub-Saharan Africa	cmr	CMR	Cameroon
Sub-Saharan Africa	civ	CIV	Côte d'Ivoire
Sub-Saharan Africa	gha	GHA	Ghana
Sub-Saharan Africa	gin	GIN	Guinea
Sub-Saharan Africa	mli	MLI	Mali
Sub-Saharan Africa	ner	NER	Niger
Sub-Saharan Africa	nga	NGA	Nigeria
Sub-Saharan Africa	sen	SEN	Senegal
Sub-Saharan Africa	tgo	TGO	Togo
Sub-Saharan Africa	xwf	CPV	Cape Verde
Sub-Saharan Africa	xwf	GMB	Gambia
Sub-Saharan Africa	xwf	GNB	Guinea-Bissau
Sub-Saharan Africa	xwf	LBR	Liberia
Sub-Saharan Africa	xwf	MRT	Mauritania
Sub-Saharan Africa	xwf	SHN	Saint Helena
Sub-Saharan Africa	xwf	SLE	Sierra Leone
Sub-Saharan Africa	caf	CAF	Central African Republic
Sub-Saharan Africa	tcd	TCD	Chad
Sub-Saharan Africa	cog	COG	Congo
Sub-Saharan Africa	cod	COD	Congo, the Democratic Republic of the
Sub-Saharan Africa	gnq	GNQ	Equatorial Guinea
Sub-Saharan Africa	gab	GAB	Gabon
Sub-Saharan Africa	xac	STP	Sao Tome and Principe
Sub-Saharan Africa	xac	AGO	Angola
Sub-Saharan Africa	com	COM	Comoros

Sub-Saharan Africa	eth	ETH	Ethiopia
Sub-Saharan Africa	ken	KEN	Kenya
Sub-Saharan Africa	mdg	MDG	Madagascar
Sub-Saharan Africa	mwi	MWI	Malawi
Sub-Saharan Africa	mus	MUS	Mauritius
Sub-Saharan Africa	moz	MOZ	Mozambique
Sub-Saharan Africa	rwa	RWA	Rwanda
Sub-Saharan Africa	sdn	SDN	Sudan
Sub-Saharan Africa	tza	TZA	Tanzania, United Republic of
Sub-Saharan Africa	uga	UGA	Uganda
Sub-Saharan Africa	zmb	ZMB	Zambia
Sub-Saharan Africa	zwe	ZWE	Zimbabwe
Sub-Saharan Africa	xec	BDI	Burundi
Sub-Saharan Africa	xec	DJI	Djibouti
Sub-Saharan Africa	xec	ERI	Eritrea
Sub-Saharan Africa	xec	MYT	Mayotte
Sub-Saharan Africa	xec	SYC	Seychelles
Sub-Saharan Africa	xec	SOM	Somalia
Sub-Saharan Africa	xec	SSD	South Sudan
Sub-Saharan Africa	bwa	BWA	Botswana
Sub-Saharan Africa	swz	SWZ	Swaziland
Sub-Saharan Africa	nam	NAM	Namibia
Sub-Saharan Africa	zaf	ZAF	South Africa
Sub-Saharan Africa	xsc	LSO	Lesotho
Australia and New Zealand	xtw	BVT	Bouvet Island
Australia and New Zealand	xtw	ATA	Antarctica
Australia and New Zealand	xtw	IOT	British Indian Ocean Territory
Australia and New Zealand	xtw	ATF	French Southern Territories

Table 11: Selection of socio-economic variables available from MAGNET

Magnet Variable	Unit of Measure
Population	million
GDP volume	bn USD 2017 MER
Harvested area	1000 ha
Land cover	1000 ha
Production	mn USD
Export	mn USD
Import	mn USD
Bilateral trade	mn USD
Net trade	mn USD
Production quantity	1000 t

Export quantity	1000 t
Import quantity	1000 t
Emissions total	MtCO2e
Land use change emissions	MtCO2e
Total yield	USD/ha
Domestic use	mn USD
Self-sufficiency ratio	%
Value added	bn USD 2017 MER
Total factor productivity	index, 2017=1
Firms capital demand	mn USD
Firms labour demand	mn USD
Firms land demand	mn USD
Firms intermediates demand	mn USD
Crop yield	t/ha
Calorie supply	kcal/cap/d
Producer prices	index
Consumer prices	index
Wages total	USD/worker
Labour factor price	index, 2017=1
Capital factor price	index, 2017=1
Land factor price	index, 2017=1
Intermediates demand price	index, 2017=1
Energy input price	index, 2017=1
Capital share	%
Labour share	%
Total employment	million
Employment % of total	%
Value added contribution to GDP	%
Forest quantites	million t DM/yr
Firms intermediates demand forest sector	mn USD
Private consumption	mn USD
Government consumption	mn USD
Investment consumption	mn USD
Firms consumption	mn USD
Fuel used	Mtoe

6.2. MAGNET Forest Material module

The Module for the quantification of Forest Materials Changes is mainly built by subdividing the forest material by groups and describing their behaviour through different equations driven by the final or intermediate demand for the different forest-related sectors. The production quantities in the base year come from GLOBIOM's baseline simulation; then, in the projected periods in MAGNET's forward-looking simulation, the estimated changes in product quantities are updated (calibrated) to the growth rates of different economic flows simulated by MAGNET, as follows.

- Primary forest materials: Sawn wood and pulpwood, depend on the flow of use of the primary forest to wood sector and primary forest to paper and pulp respectively. Other wood follows the overall primary forestry sector development. Fuelwood and wood biomass follows the flow of primary forestry demand directly from private households.
- Primary extended forest materials. Energy plantation follows the flow of use of the plantation sector to bioenergy. Logging residues follow the flow of production of forest residues.
- Paper and Pulp products: Chemical pulp, Mechanical pulp, Recycled pulp, dissolved pulp, and other pulp are calibrated on the economic flow of auto-use of pp products in pp sectors.
- Final materials from Paper and Pulp: Newsprint, print paper, packaging, other paper, recycled paper, and black liquor is based on the increase in the demand for paper sector services to other sectors.
- Black liquor depends on the final demand of the paper and pulp sector for bioenergy.
- Final materials from the wood sector. Plywood, Bark, sawn wood, and fibreboard are based on the increase in the wood sector demand from the construction, transport, and manufacturing sectors.
- Woodchips follow the use of the wood sector by the paper, pellet, bioenergy and lumber itself.
- Sawdust follows the use of lumber by the pellet, bioenergy, and lumber itself.
- Wood pellets follow the residues and pellet sector production trends.
- Final materials from the wood sector. Recycled wood, construction, furniture, and wood packaging follow specific flows of wood sector uses, respectively self-use of wood in the wood sector, construction, and other manufacturing.
- Final materials from the paper and pulp sector. Textiles are calibrated on the use of paper & pulp sector by the textile sector.