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The forest-based bioeconomy in Latvia: economic and environmental importance

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Abstract. The bioeconomy is considered a means to achieving a climate-neutral economy as aimed for in the EU Green Deal. For Latvia, the forest-based bioeconomy has the potential to contribute to this aim. An operational definition of the forest-based bioeconomy is needed to calculate its size. This research aims to provide such a definition and to determine the contribution of the forest-based bioeconomy to GDP, employment, and greenhouse gas emissions. The direct and indirect contribution of the forest-based bioeconomy to economic indicators and climate change is identified using an input-output model. The results of the model show that the forest-based bioeconomy contributes 6.4% to GDP and 6.6% to total employment in Latvia. The contribution to greenhouse gas emissions is 4.9%. Furthermore, if CO_2 sequestration is included, the forest-based bioeconomy becomes climate neutral.

Keywords: forestry, input-output model, value added, employment, greenhouse gas emissions.
JEL Codes: C67, E01, Q23.

1. INTRODUCTION

A strong bioeconomy is a priority in recent EU policies, such as the Green Deal and the Bioeconomy Strategy, that strive towards a greener and more resource-efficient economy in the long run (EC, 2012, 2010, n.d.b). The bioeconomy comprises those parts of the economy that use renewable biological resources from the land and sea – such as crops, forests, fish, animals, and microorganisms - to produce food, materials, and energy (EC, n.d.a). Major societal challenges such as climate change call for a sustainability transition away from a fossil-based society toward a bioeconomy, in which energy and manufacturing processes are based on sustainable biological resources (Ronzon et al., 2015; Siebert et al., 2018). In this way, the bioeconomy contributes to the goals of the Green Deal to transform the EU into a modern, resource-efficient, and competitive economy, by reducing the emissions of greenhouse gases, and by decoupling economic growth from resource use (EC, n.d.b). Moreover, by promoting circular and sustainable production systems, the bioeconomy has the potential to contribute to all dimensions and objectives of the European Green Deal (EC, 2020).

This focus on the potential of the bioeconomy in EU policy narratives, makes it essential to monitor the bioeconomy and to understand its driving forces. An important step in this is to measure the contribution of the bioeconomy and its dimensions to the total economy of countries. There are ongoing efforts to measure this contribution. However, Bracco et al. (2018) point out that these efforts focus mainly on the economic importance of the bioeconomy in terms of value added and employment, whereas environmental aspects such as climate change mitigation are often ignored. An exception is Lazorcakova et al. (2022) who used input-output analysis to quantify economic as well as environmental indicators to measure the bioeconomy in the Visegrad countries. Despite studies on the economic importance of the bioeconomy, for many countries and subsectors of the bioeconomy, this information is limited or still missing (Wesseler & von Braun, 2017). This is especially true for the forest-based bioeconomy, which encompasses the entire forest value chain, from the management and use of natural resources to the delivery of products and services (Ladu et al., 2020). Lovrić, Lovrić, and Mavsar (2020) observed a high centralization of forest-based bioeconomy research in a few countries and organizations from North-Western Europe, while the Baltic countries and the countries in Central-Eastern Europe are not adequately represented. Current research contributes to closing this knowledge gap by measuring the forest-based bioeconomy (FBB) in Latvia. The focus on the forestry sector is especially relevant for Latvia, where the forest area covers more than 50% of the total territory.

This paper aims to determine the economic and environmental contribution of the FBB to the total performance of the economy in Latvia. However, measuring the FBB is not trivial, as there is no unique definition nor set of indicators, no uniform methodology for the assessment of the bioeconomy, and limited data available, especially for partially biobased sectors (Ronzon et al. 2017; FAO, 2018). FAO (2018) summarized the methodologies that can be used to assess the bioeconomy. These methodologies include the value-added/GDP approach, the input-output model, social accounting matrix multiplier models, computable general equilibrium (CGE) models, partial equilibrium models and the use of various disaggregated or composite indices. Two of these methods dominate the quantification of the bioeconomy: the value added/GDP approach and input-output (IO) models. In the value added/GDP approach, biobased shares of various products are estimated by experts and then sectorial statistics are adjusted according to these shares (Ronzon et al. 2017; Piotrowski, Carus, and Carrez, 2018). Input-output models build on the concept of biomass flows, namely, that individual industries produce biological resources or use inputs from primary biomass producing sectors, and this determines their contribution to the bioeconomy (Grealis and O'Donoghue, 2015; NordBio, 2017). The IO model has advantages over the value added/GDP approach because it automatically includes value added of all industries, and therefore GDP (sum of value added). Moreover, the IO model includes links between multiple producers and products and allows the integration of economic as well as environmental indicators (Gaftea, 2013).

In addition to traditional economic indicators (i.e., share in GDP and total employment), this research uses environmental indicators that are connected to climate change. Besides total greenhouse gas (GHG) emissions of carbon dioxide (CO_2), methane (CH_4) and nitrous dioxide (N_2O) and fluorinated gases (HFC, PFC, SF_6, NF_3) (see Appendix A), we also include a separate measure of CO_2 emissions as the main greenhouse gas. Furthermore, CO_2 is not only emitted, but also sequestered in forests and harvested wood products. Latvia's forestry sector has the potential to contribute greatly to this. Therefore, our research objective is to determine the economic and environmental contribution of the forest-based bioeconomy in Latvia.

To achieve this objective, the following approach is taken. Section 2 provides a review of the characteristics of the forest-based bioeconomy in Latvia. The framework of the IO model to measure the contribution of the forest-based bioeconomy to GDP, employment, and greenhouse gas emissions, the data used in the IO model and 3 scenarios are described in Section 3. In Section 4, we assess alternative approaches to measure Latvia's forest-based bioeconomy by using different combinations of inputs. The paper concludes with a discussion of the IO model results in Section 5.

2. THE FOREST-BASED BIOECONOMY IN LATVIA

Latvia is one of the Baltic countries situated between Lithuania and Estonia. It is a country rich in forest resources. In terms of forest area per capita, Latvia ranks 4th in the EU (behind Finland, Sweden, and Slovenia), followed by Estonia (Latvian Bioeconomy Strategy 2030, 2018). Forests occupy on average 33% of the land area in the EU, while in Latvia this is 52%, in Estonia 50%, and in Lithuania 33%. According to the Latvian State Forest Service (2019), the area of forest land was 3.35 million ha in 2018, of which forests occupied 3.04 million ha (91%), the rest being swamps and forest infrastructure. State-managed forests covered 1.49 million ha (49%), while 1.55 million ha (51%) were managed by local government and private forest owners in 2018.

Compared to 1923, when forest land had a share of 23% of the total area, the forest area in Latvia has more than doubled (Baders et al., 2019). The increase in forest area is expected to continue as a result of purposeful afforestation, as well as through the continued natural growth of forests on abandoned agricultural and non-agricultural lands. Additionally, forest biomass is increasing due to sustainable forest management in recent decades (Lazdiņš et al. 2019). In 2015, for example, the gross annual increase in biomass was 16.9 million m^3, while 10.6 million m^3 was harvested (see Appendix B for details).

Latvia's forests are mostly made up of conifers (53%), but a significant part is also occupied by other species such as birch (30%), white alder (7%) and aspen (7%) (Latvian State Forest Service, 2019). These species are common in all Baltic countries.

In Latvia we see that in 2015 24.27% of the domestically produced forestry products (CPA code A02) are used in the production of wood products (CPA code C16) being the largest user after the production of forestry products itself (39.30%). Moreover, 14.29% is exported. Although only 21.69% of domestically produced wood products are used by the domestic production of furniture (CPA code C31/C32), most are exported: 65.36%, it is the main variable input for the latter (24.21%). Therefore, we see that the production of these three products is vertically linked. However, each of them is also important on its own.

We define the forest-based bioeconomy (FBB) as the direct (i.e. the production of forestry, wood and furniture products) and indirect production (i.e. the production of inputs needed in the direct production, e.g. the production of machinery to process wood) needed to enable the final demand of forestry, wood and furniture products. So, we have three 'sub-complexes'. Final demand in IO models consists of consumer demand, demand by the public sector (i.e., public institutions), investment demand, and exports.

Table 1 shows the importance of the forest sector in Latvia and the other Baltic countries. The forest sector in Latvia had a share of 4.8% of GDP in 2017, exports amounted to EUR 2.2 billion, or 20.0% of all exports, and employed 46,000 people (5.3% of total employment). These numbers deviate from those previously mentioned because of a different year (2017 instead of 2015). There are 7,000 enterprises in the forest sector, representing 3.8% of the total number of enterprises in Latvia (ZM, 2019). These companies are often the main pillar of support for rural economies.

An important role played by forests is that they sequester CO_2. Forest land and harvested wood products are net sinks of CO_2. In 2015, they sequestered 3.8 million tons of CO_2 (Table 2), which represents a share of 60.6% in total CO_2 sequestration in Latvia. The rest is sequestered by living biomass in other types of land (Skrebele et al., 2020). The amount of sequestered CO_2 by forest land and wood products represents 35% of the 10.8 million tons of total greenhouse gas emissions in Latvia.

However, it should be noted that nearly a third of forests in Latvia have exceeded their economic maturity age (depending on dominant tree species - 41 - 121 years). The ability of these forests to sequester carbon is lower than that of young and premature forests (Latvian State Forest Research Institute Silava, 2017), where young forests sequester less than premature forests. The afforestation implemented over previous decades is expected to sequester increasing CO_2 emissions after 2030 (Lazdiņš et al., 2019). Old-growth forests serve especially the EU Biodiversity strategy 2030 goals. However, there are many risks/shortcomings in that, for example, appearance of invasive species (Zute, 2022) and, as mentioned, the intensity of carbon sequestration is lower than that of young forests that grow more

Table 1. Economic indicators (in % of total) for the forest sector in the Baltic countries, 2017.

Country	Employment	Exports	GDP
Estonia	5.3	11.9	4.3
Latvia	5.3	20.0	4.8
Lithuania	4.8	9.9	4.0

Source: Author`s calculations based on Eurostat (2020b); Eurostat (2021a); Eurostat (2021b).

Table 2. Net GHG emissions by forest land and harvested wood products, 2015.

Source	Size	Net GHG emissions in kiloton CO_2 equivalent*
Forest land	3.561 million ha	-1,995**
Harvested wood products	10.626 million m^3	-1,850

*See Appendix B for composition.
**includes sequestration by living biomass and emissions by dead woods, litter, organic soils, and wildfires and controlled burning on forest land. The negative signs represent the net sequestering of GHG emissions.
Source: Skrebele et al. (2020) and CSB (2020).

rapidly, removing much more CO_2 from the atmosphere. A forest management that avoids large emissions from the loss of old trees while rapidly removing CO_2 from the atmosphere through young forest growth can provide both storage and sequestration benefits. In addition, well-managed forests produce wood products that store carbon long after the trees are harvested. These products provide an added benefit when they are used in place of more energy-intensive ones that require more fossil fuel emissions, such as several building materials (McKinley et al., 2011).

3. MATERIALS AND METHODS

3.1 Input-Output framework

Section 2 discussed the forest-based bioeconomy (FBB) and its three sub-complexes. Next, we quantify the economic and environmental performance of the FBB using an input-output framework that allows the disentanglement of the three sub-complexes. The input-output (IO) model was developed by Leontief in the late 1930s to analyse the economy as a whole and to study the interdependence among the different industries in an economy, since the output of one industry can serve as an input for another industry directly and indirectly (Miller and Blair, 2009). Therefore, a change in the final demand for the products of one industry affects the whole economy via direct and indirect linkages (Sink, 2010). Cingiz et al. (2021) analysed the value added of the bioeconomy in 28 EU member states using an IO model. The input-output model is suitable to track biomass inputs and to determine the contribution of different industries to the FBB and, consequently, the FBB's contribution to the total economy. The IO model is linear as it assumes fixed ratios between inputs and outputs (i.e., IO coefficients) and, therefore, is applicable to determine the direct and indirect size of the FBB.

The standard IO model calculates the vector of product-level output of the industries that is linked to the final demand of products and is given by the following (Miller and Blair, 2009):

$$x = (I - A)^{-1}f \tag{1}$$

where x is the vector of total output at basic prices, I is the unity (identity) matrix, A is the matrix of IO coefficients (the square technical coefficient matrix), f is the vector of final demand of, for example, forest-based products at basic prices (see Appendix C). IO coefficients give the fixed ratio between the amount of input i used for the production of output j.

However, we adjust the model to (e.g. Momigliano & Siniscalco, 1982; Pasinetti, 1973):

$$B = (I - A)^{-1}\hat{f} \tag{2}$$

Hence, we take the diagonal matrix of ($\hat{f}$) and, instead of the vector x, we get the matrix B that shows in each column the production needed in each industry of the economy to make the final demand of each industry's product possible. Consequently, the elements in column k (vector x_k) show the production in each industry needed to produce the final demand of products produced by industry k. In this way, we disentangle the three sub-complexes of the FBB.

Assuming a fixed ratio between economic indicators (i.e., value added and employment) and environmental indicators (i.e., CO_2 and GHG emissions) with output we get:

$$z_{kl} = \hat{b}_l x_k \tag{3}$$

where z_{kl} is value added (l=1); employment (l=2); emissions of CO_2 (l=3) and GHG emissions (l=4) for the sub-complex k of the FBB, $\hat{b}_l$ is the diagonal matrix of the fixed ratio of indicator l and the output, and x_k is column k of matrix B.

3.2 Data description

According to OECD (2019), Input-Output (IO) tables describe the sales and purchase relationships of goods and services (i.e. commodities) between producers and consumers within an economy. The table shows the inter-industry linkages, final demand, and value added created. Therefore, an IO table is a numerical overview of an economy. Commodities are defined as industry outputs, for example, the product produced by agriculture (*industry-by-industry* table), or as products, for example, milk (*product-by-product* table) (OECD, 2019). An IO table only includes commodities that have a monetary value, external effects (i.e. non-priced by-products as emissions) or leaves and small branches without economic value are excluded.

This research uses the product-by-product IO table of 2015 for Latvia. There are two versions of this table, one where imports constitute a separate row, implying that intermediate demands are commodities domestically produced and used. The second version is where intermediate demands include imports. Given that we are especially interested in domestic production, we decided to use the first table. The original table contains data for 63 goods and services (i.e., products i). However, some rows or columns showing intermediate demands are empty, that is why they are added to other related products. This results in a table containing 60 goods and services. The IO table is developed every five years by the Central Statistics Bureau (CSB) of Latvia. Data are compiled according to the European Union Statistical Classification of Products by Activity (CPA) and are expressed in basic prices (million euros). Industry-by-industry IO tables are not provided by CSB. IO tables for Latvia are also provided by OECD but, due to the high level of aggregation, they are not applicable for our purpose.

To assess the economic and environmental importance of the FBB for Latvia, the following indicators are selected: value added, employment, carbon dioxide (CO_2) emissions (excluding CO_2 emissions from biomass combustion) and greenhouse gas (GHG) emissions. Value added at basic prices data (see Appendix C) are used from the IO table, employment data are used from the EU labour force survey of Eurostat (2020b), and emissions data are obtained from the air emissions accounts of Eurostat (2020a). All data used are from 2015 due to availability of the IO table. Table 3 gives the value added, employment and CO_2 and GHG emissions that are directly linked to the production of 'products of forestry, logging and related services' (CPA code A02, product i=2), 'wood and products of wood and cork, except furniture; articles of straw and plaiting materials' (CPA code C16, i=16) and 'furniture and other manufacturing such as jewellery, musical instruments, household tools, entertainment articles and other miscellaneous goods that are not covered in other parts of the classification' (aggregate CPA codes C31 and C32, i=31). In the rest of the paper, we indicate these three product categories as forest products (A02), wood (C16), and furniture (C31/32) products. Note that these data are not for the FBB as a whole because they do not include interdependencies with other sectors of the economy.

The table shows that the production of the three product categories directly contributes 5% to GDP and 5.8% to total employment in Latvia. The contribution to CO_2 emissions is 3.3% and to greenhouse gas emissions 2.6%, excluding CO_2 sequestration. 85% of GHG emitted by FBP is CO_2 (i.e. CO_2 234,009 ton/ GHG 276,656 ton).

4. SCENARIOS AND RESULTS

4.1 Scenarios

We defined the FBB as the direct and indirect production linked to the final demand for forestry products (A02), wood products (C16), and furniture (C31/32). We show the results of the FBB as a whole, but also its decomposition in the three sub-complexes linked to the final demand of the three products mentioned. Notice that the calculations imply that if forestry products (A02) are used in the production of wood products (C16) that production, value added, employment and emissions are linked to the sub-complex wood products (C16) and not to the sub-complex forestry products (A02).

4.2 Results

Table 4 shows the size of the FBB and its sub-complexes using 4 indicators. For all four indicators, the sub-complex wood products (C16) is the largest and the sub-complex furniture (C31/32) is the smallest. The overall share in GDP is 6.44%. However, if we include the value added created in the direct production of forestry

Table 3. Value added, employment, and emissions directly related to the production of Forestry (A02), Wood (C16), and Furniture (C31/32) products in Latvia, 2015.

	Value added		Employment		CO_2 emissions		GHG emissions	
	million Euros	% of GDP	thousand persons	% of total	ton	% of total	ton	% of total
Forestry products (A02)*	356	1.7	18.60	2.2	122,642	1.7	128,945	1.2
Wood products (C16)	546	2.6	23.50	2.7	100,586	1.4	136,785	1.3
Furniture (C31/32)	139	0.7	7.30	0.9	10,781	0.2	10,926	0.1
Total (A02+C16+C31/32)	1,041	5.0	49.4	5.8	234,009	3.3	276,656	2.6
Rest of the economy	20,204	95.0	809.6	94.2	6,882,766	96.7	10,501,761	97.4
Total	21,245	100	859	100	7,116,775	100	10,778,417	100

Note: GHG emissions include CO_2, N_2O in CO_2 equivalent, CH_4 in CO_2 equivalent, HFC in CO_2 equivalent, PFC in CO_2 equivalent, SF_6 in CO_2 equivalent, NF_3 in CO_2 equivalent.
* A02, C16 and C31/32 are CPA codes.
Source: Authors' calculations based on CSB (2016), Eurostat (2020a and 2020b).

Table 4. First four rows: Value added, employment, CO_2 and GHG emissions linked to the final demand of Forestry products (A02), Wood products (C16) and Furniture (C30/31) in Latvia, 2015. Next four rows (i.e. Rest): Value added, employment, CO_2 and GHG emissions of Forestry products (A02), Wood products (C16) and Furniture (C30/31) that are linked to the final demand of other products in Latvia, 2015.

Products	Value Added		Employment		CO_2 emissions		GHG emissions	
	million EUR	% of GDP	thousand persons	% of the total economy	ton	% of total	CO_2 equivalent ton	% of total
Linked to final demand of:								
Forestry products A02	211.8	1.00	10.1	1.18	72,854.5	1.02	77,109.9	0.72
Wood products C16	953.0	4.49	37.1	4.31	350,815.8	4.93	402,382.1	3.75
Furniture C30/31	202.8	0.95	9.4	1.09	45,389.6	0.64	49,657.0	0.46
Total	1,367.6	6.44	56.5	6.58	469,059.9	6.59	529,149.0	4.93
Rest								
Forestry products A02	46.6	0.22	2.4	0.28	16,046.4	0.23	16,871.2	0.16
Wood products C16	34.2	0.06	1.5	0.17	6,296.9	0.09	8,563.0	0.08
Furniture C30/31	13.7	0.16	0.7	0.08	1,056.7	0.01	1,070.9	0.01
Total Rest	94.5	0.44	4.6	0.53	23,400.0	0.33	26,505.1	0.25
Total + Total Rest	1,462.1	6.88	61.1	7.12	492,459.9	6.92	555,654.1	5.17

Source: Authors' calculations.

(A02), wood (C16) and furniture (C31/32) products that are used as intermediate inputs in the production of the final demand for other products we get a share of 6.88%. We see a similar increase for the other three indicators. This illustrates that forestry products (A02) are important in the production of wood products (C16) which, in turn, are important for the production of furniture (C31/32).

5. DISCUSSION AND CONCLUSIONS

We measured the FBB contribution to Latvia's economy using share in GDP, employment and CO_2 and GHG emissions. We did this using an IO model that incorporates the direct and indirect use of intermediate inputs in the production needed to enable the final demand of forestry (A02), wood (C16) and furniture (C31/32) products.

These linkages appear to be important, especially forestry products (A02) form an important input in the production of wood products (C16) which, in turn, are important for the production of furniture (C31/32). These linkages determine our definition of the FBB. For another country another definition could apply depending on the linkages present. For example, in other countries like Finland the paper industry, which is not present in Latvia, could be part of the FBB. The FBB had in 2015 a share of 6.44% in GDP and if we include also the value added created with the production of forestry (A02), wood (C16) and furniture (C31/32) products that are used as intermediate inputs for the production of final demand of non-FBB products, the share equals 6.88%. Similar percentages apply for employment (6.58% and 7.12%) and CO_2 (6.59% and 6.92%). The share of the FBB in total GHG emissions is somewhat lower (4.93% and 5.17%). The outcomes for the FBB are higher than the sum of the value added, employment, CO_2 and GHG emissions created with the production of forestry (A02), wood (C16) and furniture (C31/32) products, since it includes the indirect use of other products in the production of these products. To our knowledge, this is the first research that takes these linkages into account for the FBB of Latvia.

The contribution to the emissions of CO_2 and GHG excludes CO_2 sequestration. Forest land and harvested wood products sequester an estimated 3.8 million tons of GHG emissions. This is 35.2% of total GHG emissions in Latvia in 2015. GHG sequestration has increased in recent years due to the expansion of forest land and the annual growth of forest biomass. The EU Green Deal states that the EU has to become climate neutral by 2050. This requires that EU member states reduce net greenhouse gas emissions to zero. Our results show that Latvia already achieves this goal set by the EU if we take into account GHG sequestration. Furthermore, there is a great potential for further sequestration of GHGs from forest biomass. At the moment, sequestration is not included in the EU emissions trading system, including it would provide opportunities for the Latvian economy.

Besides the assumed fixed shares between inputs and outputs (i.e., IO coefficients), other drawbacks of IO models are the absence of a link between income creation and spending, and the assumption of a perfectly elastic supply of factor inputs (i.e., labour and capital) (Guerra & Sancho, 2014; Acemoglu & Azar, 2020). These drawbacks are not relevant in this research, as we use the IO model for descriptive purposes. Moreover, the IO model that we use can be applied to any country by using national or regional data sets, statistics of employment, value added, and emissions. In this way, the FBB becomes country-specific and can form a benchmark and information source for policy formulation to achieve the goals of the Green Deal because it enables monitoring the bioeconomy and understanding its driving forces.

We used the Eurostat IO table of 2015 to analyse the importance of the forest-based bioeconomy due to the lack of data in recent years. Notably, outcomes can differ between years. Ideally, we would have information for more years that would enable us to detect and analyse the development of the forest-based bioeconomy over time. A general drawback of the use of the Eurostat IO table is the high level of aggregation, preferable we would like to have more detail on the products produced in the forest-based bioeconomy. This is especially relevant in case we, for example, would like to formulate product related policies or obtain regional detail. A more specific caveat of the use of the IO table of 2015 is that in the light of the Green Deal and the Russian invasion of Ukraine, it is expected that Latvia will try to increase the use of forest-based biomass for energy production. This potential increase of the FBB cannot be investigated with the present model. Despite these drawbacks, this paper gives a first attempt to derive the size of the FBB in Latvia using not only economic but also environmental indicators and by including direct and indirect linkages in the economy.

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APPENDIX A
CO_2 AND GHG EMISSIONS

Information from the national inventory reported to the United Nations Framework Convention on Climate Change (UNFCCC) and the Convention on Long-range Transboundary Air Pollution, as well as data from the Central Statistical Bureau (CSB), is used for the calculation of CO_2 emissions.

The GHG emission indicator measures the total national emissions of the so-called 'Kyoto basket' of greenhouse gases, including carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), and the so-called F-gases (hydrofluorocarbons, perfluorocarbons, nitrogen trifluoride (NF_3) and sulphur hexafluoride (SF_6)). For each gas' individual global warming potential (GWP), they are integrated into a single indicator expressed in units of CO_2 equivalents.

Emissions data are submitted annually by the EU Member States as part of the reporting under the UNFCCC (UNFCCC, 2008).

APPENDIX B
SEQUESTRATION

Table B.1. Forest land, gross annual increment, potential harvest, and harvested wood products in Latvia, 2015-2018.

Year	Forest land, 1,000 ha	Gross annual increment, 1,000 m^3	Potential harvest, 1,000 m^3	Harvested wood products, 1,000 m^3
2015	3,561	23,637.10	16,927.00	10,626.50
2016	3,561	25,166.92	17,276.44	10,555.81
2017	3,576	26,312.66	17,235.59	11,443.42
2018	3,585	26,480.09	17,584.81	12,861.65

Source: Latvian State Forest Service (2019), Skrebele et al. (2020), and CSB (2020).

Table B.2. Net GHG emissions by forest land and harvested wood products, 2015-2018 (thousand ton CO_2 equivalents).

Source	2015	2016	2017	2018
Forest land	-1,995.01	-3,179.63	-4,905.08	-3,213.87
Harvested wood products	-1,850.36	-2,129.34	-2,251.33	-2,064.57
Total	-3,845.46	-5,308.97	-7,156.41	-5,278.44

Source: Skrebele et al. (2020).

APPENDIX C
PRICES

The World Bank (World Bank, 2020) provides the following price definitions:

- **The basic price** is the amount receivable by the producer, exclusive of taxes payable on products, and inclusive of subsidies receivable on products. The equivalent for imported products is the c.i.f. (cost, insurance, and freight) value, that is, the value at the border of the importing country.
- **The producer price** is the amount receivable by the producer inclusive of taxes on products except deductible value added tax and exclusive of subsidies on products. The equivalent for imported products is the c.i.f. value plus any import duties or other taxes on imports (minus any subsidies on imports).
  Producer prices = Basic prices + taxes on products (excluding VAT) - subsidies on products
- **The purchaser price** is the amount payable by the purchaser. This includes trade margins realized by wholesalers and retailers (by definition, their output) as well as transport margins (that is, any transport charges paid separately by the purchaser) and non-deductible VAT.
  Purchaser prices = Producer prices + trade and transport margins + non-deductible VAT