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EFI

Seeing the wood in the forests

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WE DARE NOT CONTINUE LIKE THIS

*Humanity is becoming too big for our planet. After relying on a fossil-based economy for 200 years, we are threatening to reach a tipping point, crossing the resilience boundaries of our world. Using the words of Greta Thunberg – **how dare you continue like this!** – it is time for transformational action.*

(top) Photo by: Sarah Brown on unsplash
(bottom) Photo by: Matt Howard on unsplash
(left) Photo by: Keagan Henman on unsplash

We need to accelerate the transition from the existing global fossil and wasteful economy towards a renewable economy: a circular bioeconomy that also addresses the past failure of our economy to value natural capital properly. A new economic model, that as His Royal Highness The Prince of Wales emphasised during the launching of the Sustainable Markets initiative at Davos in January 2020, "puts nature and the protection of nature's capital… at the heart of how we operate." We need to understand nature, our natural capital, as the basis for a new prosperity. A prosperity that needs to be based on renewable materials and energy, but also on a new and synergistic relationship between economy and ecology, bioeconomy and biodiversity, rural and urban areas.

Forests, sustainable forest management and forest-based solutions can catalyse this transformation: advancing the bioeconomy while enhancing biodiversity and supporting wealth creation in rural and urban areas. **Wood, the most versatile renewable material on earth,** will play a key role. To mitigate climate change, we have to replace fossil-based materials like concrete, steel, plastics or synthetic textiles with renewable materials. Sustainable, wood-based solutions are fundamental in achieving this.

However, it is important to emphasise that the most immediate means for a sustainable future is **reducing consumption.** This will help in climate change mitigation and in cutting resource use. It is also crucial to start using wood efficiently, for those purposes in which it has a comparative advantage from a sustainability and circular economy perspective relative to other materials.

But how much wood do we have to support a transformational change to a sustainable economy? For which purposes should we use it?

Global use of wood: half-and-half

Given the world population and middle-income class growth, and the need to replace fossil and non-renewable raw materials, products and energy, it is important to assess to what extent wood could provide more sustainable alternative. Part of this assessment needs to include the analysis of the trends in total roundwood consumption, and within it, the markets for industrial roundwood and wood fuel for energetic uses.

Global total roundwood production (good proxy also for world consumption) steadily increased from 1961 to 1990, after which it stabilised for two decades to around 3.5 billion cubic metres[4]. After 2010, it seems to have returned to the previous growth pattern (Figure 1). However, in 2018 the world produced only 10% more roundwood than in 1990. The share of wood fuel in total roundwood production has decreased from 60% in 1961 to 49.6% in 2018, while the opposite has taken place for industrial roundwood. In fact, 2018 was the first year in history that industrial roundwood production was bigger than wood fuel (Table 1). Thus, wood from global forests is used roughly half for energy and half for industrial purposes.

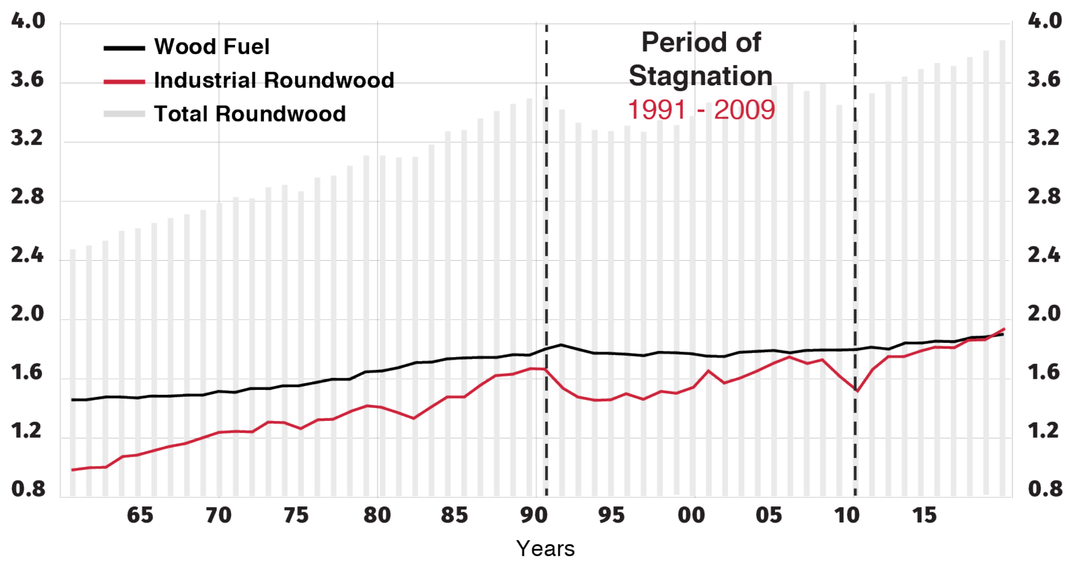

Figure 1. World total roundwood production, composed of industrial roundwood and wood fuel 1961-2018.
Data source: FAOSTAT[2]

Photo by: Daniel Soderman on unsplash

Most of the wood fuel (82%) is produced in Africa, Asia and South America and only 12% in Europe and North America. On the other hand, only 36% of the world industrial roundwood is produced in the southern continents, while 59% is produced in Europe and North America (Table 1). Given that Europe and North America have only 18% of the world population this share is especially large.

Fellings as a percentage of the annual growth of world forests typically vary between 30 – 80% in different regions of the world. For example, in Finland and Sweden the harvest rate has in recent years been around 75-80%, but the EU average is about 65%. In the USA, this is typically less than 50%, and in China and Russia 30% or less.

Another interesting feature of world industrial roundwood markets is that the regional demand and supply has changed in recent decades, especially due to China's increasing demand. World exports of industrial roundwood increased by 61% from 1990 to 2018, while at the same time production increased by only 15%. The major factor behind this change was increasing Chinese imports during this period (by 53 Mm³).

There are some important structural changes in how we use wood in the world. Figure 2 shows the diverse development of the global per capita demand for forest-based products in recent decades. It is apparent that economic development and per capita demand for some traditional

[1] Two political factors were major reasons behind the 1990s stagnation: the collapse of the Soviet Union and the reunification of East and West Germany. In 2001-2002 the world economic slump, and in 2008-2009 the financial crises and slump also led to stagnant world roundwood demand.
[2] FAO definition of wood fuel (sometimes 'woodfuel' or 'fuelwood'): Roundwood that will be used as fuel for purposes such as cooking, heating or power production. It includes wood harvested from main stems, branches and other parts of trees (where these are harvested for fuel) and wood that will be used for the production of charcoal (e.g. in pit kilns and portable ovens), wood pellets and other agglomerates. The volume of roundwood used in charcoal production is estimated by using a factor of 6.0 to convert from the weight (mt) of charcoal produced to the solid volume (m³) of roundwood used in production. It also includes wood chips to be used for fuel that are made directly (i.e. in the forest) from roundwood. It excludes wood charcoal, pellets and other agglomerates. http://www.fao.org/forestry/34572-0902b3c041384fd87f2451da2bb9237.pdf

	WOOD FUEL	INDUSTRIAL ROUNDWOOD	TOTAL ROUNDWOOD
WORLD *share of total roundwood*	1.93 49.6%	1.96 50.4%	3.89
AFRICA + ASIA + SOUTH AMERICA *share of world total*	1.59 82%	0.71 36%	2.30 59%
EUROPA + NORTH AMERICA *share of world total*	0.24 12%	1.16 59%	1.40 36%

Table 1. Roundwood production in 2018 (billion cubic meters)
Data source: FAOSTAT

large-volume products in the world have become decoupled from GDP growth, especially for graphics (communication) papers and wood fuel. On the other hand, in this century wood panels have been in greater demand than one would have expected based on economic growth.

It is clear that the industrial use of forest biomass is expected to become increasingly diversified across the world as the global forest industry is undergoing major structural changes (Hetemäki & Hurmekoski 2020). There is growing demand for some traditional products, such as pulp, tissue paper and packaging paper. The most significant increase in forest-based product markets, however, are expected to include innovative, engineered wood products in the construction sector, pulp used for textiles, chemicals, bioplastics and energy, and for a number of small niche markets, including cosmetics, food additives, pharmaceuticals, etc.

With many of the new products, the boundaries of classical industries will get blurred, as for example the chemical, textile and energy industries are investing in new forest-based products. Finally, the demand outlook for some large volume traditional products (especially graphics paper) is on contrast one of decline. However, the outlook for all these forest products can be somewhat different depending on which region one is analysing.

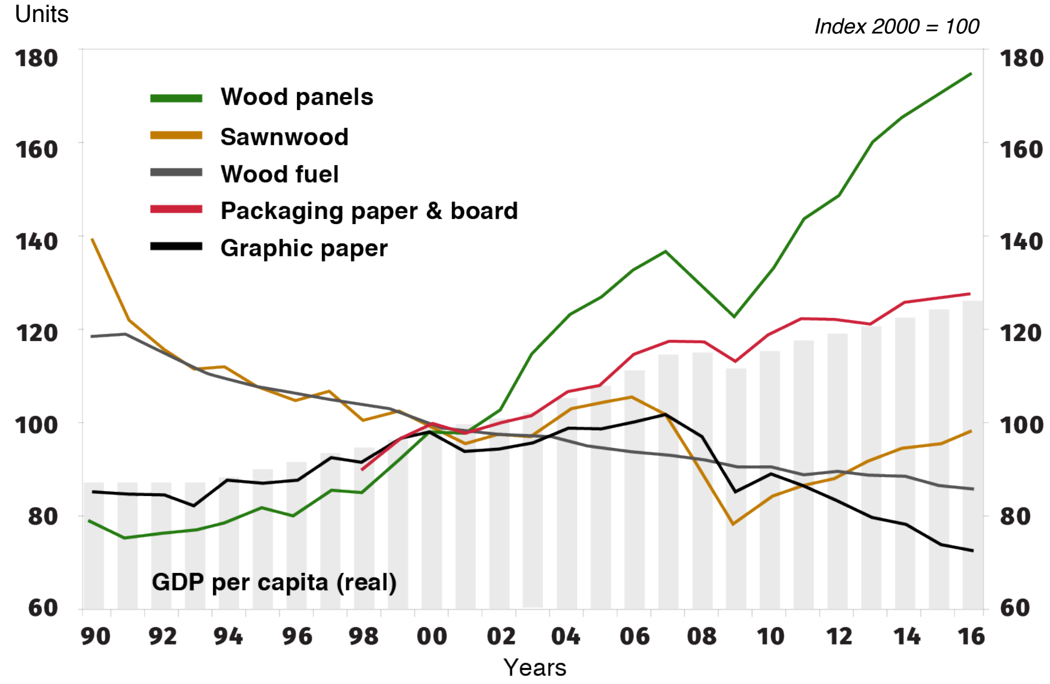

Figure 2. **World per capita consumption of forest-based products and GDP, 1990-2016**
Data: FAOSTAT, World Bank

What will the future demand for roundwood be?

Generally, there seems to be an understanding that the demand for roundwood will increase significantly due to replacing fossil-based raw materials in the energy and materials sectors with forest biomass and wood products.

For example, the WWF's Living Forest Model predicts that to meet this demand, wood harvesting will need to quadruple by 2050 (see discussion in Silva et al. 2018). In Buongiorno et al. (2012), the projected scale of world roundwood consumption in 2060 varies between 3.6 to 11.2 billion cubic metres (Bm³) depending on the scenario. That is, these projections range from roughly the current level (3.9 Bm³) to a three-fold that level. However, Buongiorno et al.'s projections do not take into account new forest bioproducts, and their projections for some current products (newsprint, printing and writing papers) are clearly outdated and mistakenly project growth in all of their scenarios.

The fact is that we currently lack a good understanding of what the implications of forest bioeconomy development will be for global forests. There is a lack of systematic and up-to-date outlook studies that would give a good basis for making conclusions on the world roundwood consumption in the decades to come (Hetemäki & Hurmekoski 2016).

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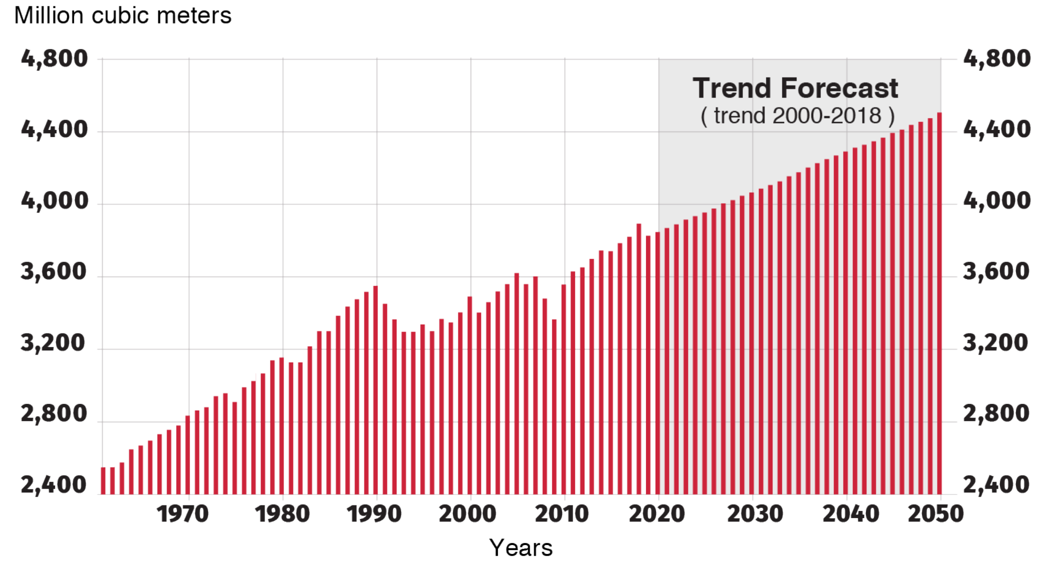

Figure 3. **World roundwood production 1961-2018 and trend (2000-2018) forecast to 2050**
Data source: FAOSTAT

Business-as-usual scenario

In order to have some basis for discussing possible future development, we computed a business-as-usual scenario for future development using the most recent data available. It is based on the simple assumption that the same trend that has taken place in this century, i.e. 2000-2018, would continue in future decades. It may be noted that during this period the world economy grew by 2.7-times[3], world population increased by 1.5 billion and world middle-income population grew from about 1.5 billion to 3.8 billion (Kharas 2017). During this period world roundwood production (and demand) increased "just" by 12%.

Figure 3 shows a simple trend forecast for world roundwood production to 2050. According to the forecast, roundwood production would increase from 3.89 billion cubic metres in 2018 to 4.50 Bm³ in 2050, i.e., by 16% or 614 million cubic metres. How big is this increase from a global forest perspective, and would there be enough forest resources to satisfy this increase sustainably?

To illustrate how this increase could be met "theoretically", assume that the harvesting intensity in Russia would increase from its current level (30%) to that of the current EU average (65%). This would imply Russian production that would generate 554 million m3 more wood than today, and it alone could satisfy 90% of the world roundwood demand increase projected by the business-as-usual scenario. In fact, considering the current challenges that Russia faces, the increasing use of the forest for bioeconomy purposes could in many ways be desirable. Russia is currently suffering from large forest fires (5-15 million hectares per annum), a significant amount of illegal logging (estimates up to 20 million m3 per annum), poor forest management and regeneration, and Russia is an especially large fossil-intensive and export economy. All these patterns are problematic from environmental (e.g. climate), economic and social perspectives. Enhancing forests' role in bioeconomy, and thereby creating more value for these, would generate incentives to take better care of forests.

Of course, the Russian example above is a purely hypothetical and would require many difficult changes to take place before it could be realised. Moreover, the world roundwood demand increase in

[3] From 50149 billion dollars to 135436. Source: IMF, GDP, current prices (Purchasing power parity; billions of international dollars).

reality would be satisfied from many different regions and countries, not just from Russia. However, it illustrates that the scale of increase in wood use would not be "alarming" from the global forest perspective.

Trends curbing the use of wood

Despite bioeconomy development introducing new forest products and bioenergy, there are also trends working in the other direction, i.e., reducing forest biomass demand. Perhaps the most important of these are declining consumption of some current forest products, and the increasing resource efficiency of using wood biomass as a raw material.

The production of some traditional key forest products, such as graphics paper (newsprint, printing and writing paper) is declining (Figure 4), and hence also the need for industrial roundwood for these purposes. In 2018, of the world paper and paperboard production, about 29% was graphics paper production. Since 2007 world graphics paper production has been declining due to digital media replacing paper (Figure 4).[4] If the same trend that we have observed since 2007 continued up to 2050, the world graphics paper consumption would decline from 117 million to 18 million tons, i.e. by 99 million tons.

Assume that this declined production was based 86% on chemical wood pulp and 14% on mechanical wood pulp.[5] Using a wood consumption multiplier of 5.7 m³/tons for coniferous pulp and 4.2 m³/ton for non-coniferous pulp, and assuming also that half of the world pulp production was based on coniferous and half on non-coniferous wood,[6] then the total use of roundwood for graphics paper consumption in 2018 would have been 544 million cubic metres.

According to the trend forecast, it would decline to 84 million cubic metres in 2050. That is, **460 million cubic metres less roundwood** would be needed for graphics paper production in 2050 than in 2018.

Looking ahead, one would expect that due to urbanisation, rapid middle-income group growth and more efficient bioenergy production (e.g. more efficient stoves), together with increasing use of solar and wind energy, the share of wood fuel will continue to decrease globally. This will most likely take place despite possible increasing forest bioenergy production e.g. in North America and Europe. Indeed, the longer in the future the time horizon reaches, the more likely it is that wood used for energy purposes will be smaller than today.

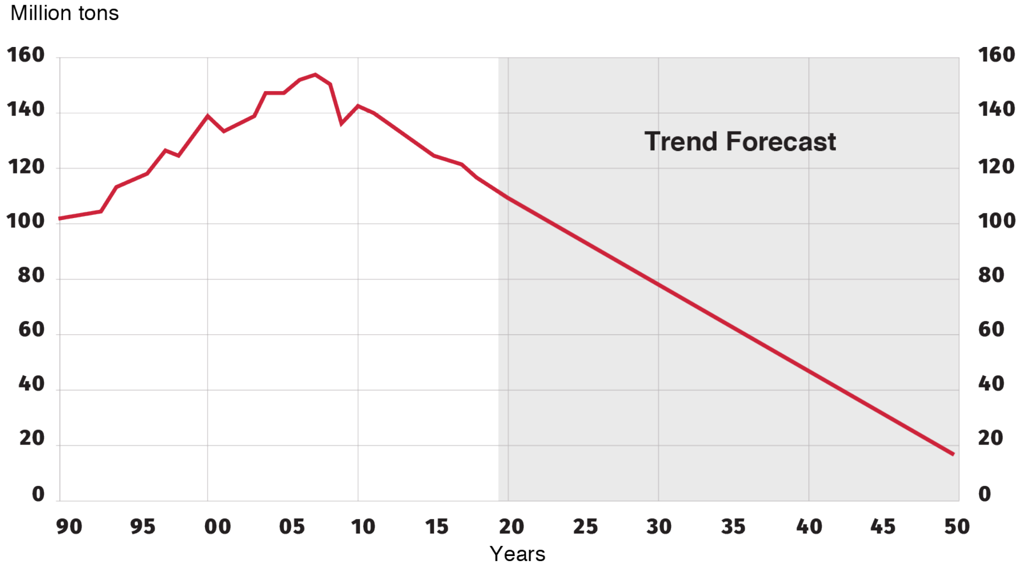

Figure 4. World graphics paper production 1990-2018 and trend (2007-2018) forecast to 2050.

Consider again a hypothetical "what-if" example. In Africa from the total roundwood production of 767 million cubic metres, 90% (693 Mm³) was used for wood fuels (bioenergy) in 2018, and only 10% for industrial roundwood (FAOSTAT). The bioenergy is often produced using inefficient technologies and has negative health and environmental impacts. According to recent studies, there is a need and significant potential for improvements in energy production in Africa (World Bank 2011; Copenhagen Centre on Energy Efficiency 2015, Ouedraogo 2017). Assume that technological efficiency and fuel wood consumption in Africa could be improved e.g. by 30%, and/or 30% of the wood energy could be produced using other energy sources (e.g. solar panels, wind energy, natural gas). Thus, the same amount of energy as in 2018 could be produced by using about **208 million cubic metres less wood.** This is clearly more than Canada's total roundwood production (in 2018 it was 152 mil. m³), or equal to the total roundwood production of the three biggest producers in the EU combined in 2018 (Finland, Germany and Sweden produced 213 mil m³). Clearly, similar development could take place also in other big traditional energy wood consumption areas, such as in China and India, which together consumed 446 Mm³ of wood fuels in 2018. In summary, there is a huge potential to produce energy more efficiently than is done today from roundwood, and use other energy sources for this purpose, and therefore decrease roundwood consumption.

Finally, as Hurmekoski et al. (2018) show, many of the new forest bioproducts will be based on the raw material side-streams of current products, and will be using the current raw materials more efficiently, such as black liquor, lignin, bark, forest residues, etc. Their results indicate that if the four traditional major forest products producers, Canada, Finland, Sweden and USA, increased or started to produce bioproducts for global biofuels, chemicals, construction, textile, plastics and packaging and textile markets, the increase in roundwood demand could be moderate. The increase in primary wood use, almost entirely attributed to construction and to some extent textiles markets, would be in the range of 15–133 million m³. This corresponds to 2–21% of the current industrial roundwood use in these four countries. Clearly, the markets also set restrictions to roundwood demand: if there was a significant demand increase pressure, roundwood prices would go up, which in turn would tend to curb the demand.

To summarise the above discussion, there are several different future trends in world roundwood production (or consumption). Some of the traditional products will require more roundwood (e.g. packaging products), some less due to decline in demand (e.g., wood fuel in Africa, and graphics papers globally). Some of the new emerging bioeconomy products will increase roundwood demand (e.g. engineered wood products), while others may use the side-streams of current products, such as pulp side-products (e.g. lignin) for new biochemical, or forest residues for biofuels. The latter therefore do not generate "new" demand for roundwood, but are based on increasing resource-efficiency.

Given these trends, the forest-based bioeconomy development ***does not necessarily imply a large net increase*** *in global roundwood demand compared to the current situation.* Yet, it seems evident that the

[4] Buongiorno et al. (2012) project that the world graphics paper consumption in 2060 would be 2-3-times bigger (248-350 million tons) than today (117 million tons), depending on their scenario.
[5] The share of mechanical pulp in total pulp production was 14% in 2018 (FAOSTAT). A small part is also based on semi-chemical pulp and some paper grades are using also recovered paper as raw material.
[6] These are typical wood multiplier numbers for pulp production.

population and middle-income growth and bioeconomy development could also cause roundwood demand to increase in some countries and regions. This would also create potential trade-offs between the different ecosystem services that forests provide (Hetemäki et al. 2017). In order to govern this type of situation, clear sustainability criteria and monitoring would need to be in place (Wolfslehner et. al. 2016). It would also require policies to balance the different needs.

Sustainability needs to be implemented, not assumed

The above situation in global forests and wood consumption patterns seem to facilitate the transformational changes towards sustainable circular bioeconomy we called for in the beginning of this article. In other words, sustainable wood production does not necessarily create a bottleneck for development. Clearly, sustainability in the different uses of wood cannot be assumed as a matter of course, but needs to be requested, enforced and monitored.

In order to illustrate the possible developments in forest bioeconomy, let's look at the implications of moving globally in greater quantity to wood-based solutions in two major economic sectors: building construction and the textiles sector. The building construction sector is currently dominated by two carbon-intense, non-renewable materials: concrete and steel. Their production represents more than 10% of the global carbon emissions. The construction sector is also very material-intense as it uses 50% of all resources we extract globally - around 40 billion tons of resources. On the other hand, the construction sector has not experienced major productivity increases or great innovations for decades (Hurmekoski 2017).
However, the new generation of engineered wood products have the potential to be a real game changer in terms of environmental footprint and productivity aspects. First, using wood in construction is one of the most effective ways we have to mitigate CO_2 and store carbon. The average "substitution factor" for structural (e.g. a building, internal or external wall, wood frame, beam) and non-structural construction (e.g. a window, door, ceiling cover or floor cover, cladding, civil engineering) is 1.3 and 1.6 kg C/ kg C wood product, respectively (Leskinen et al. 2018). This roughly means that wood products, which substitute non-wood products in structural and non-structural construction, can lead to average emission reductions of 1.3 and 1.6 times compared to alternative materials, respectively. Moreover, carbon can be stored in wood products for decades or even centuries. For example, in some cases it can be stored in wood products longer than in forest ecosystems, like in old farmhouses in mountainous areas of Southwest Germany or in the ceilings of large historical buildings like churches (Kauppi et al. 2018).

In addition, the new technologies and process innovations in producing engineered wood products are likely to trigger an innovation revolution in the sector towards prefabrication and economically more competitive wood buildings. For example, industrial prefabrication means that wood elements and modules, such as fully completed rooms for multi-storey buildings, are built inside factories, and then moved to the building site and assembled like Lego blocks. This reduces construction time and increases productivity and safety, and reduces transportation costs, material demand, noise and waste.

The textile sector is dominated by two materials, which for different reasons cannot be considered sustainable: fossile-based synthetic fibres which have high carbon emissions and in addition are generating problems for the oceans due to microplastics; and cotton, which competes with agriculture for arable land and water resources in regions where such resources are often scarce. The fashion industry, which is estimated to be responsible for around 10% of the carbon emissions from current materials and value chains, can be transformed sustainably by a new generation of wood-based textiles. The use of new wood-based textiles can reduce the carbon footprint by even up to five times (i.e., displacement factor can be 5) compared to synthetic fibres (Seppälä et al. 2019). In addition, these new technologies can use circular systems to minimise water use and chemicals.

Impacts of wood substitution

In 2017, the world textile fibre production was estimated to be 103 million tons, of which less than 10% was based on man-made cellulosic fibres (Fiber Year Consulting 2018). Assume a hypothetical example, that half of the world's production would be produced based on wood fibres (dissolving pulp). This would require 290 million m^3 of roundwood (assuming multiplier 5.65 m^3/ton), which is equal to about 15% of the world industrial roundwood production in 2017. Note that some of the new technologies under development will produce textile fibres using significantly less wood per ton of textile than dissolving pulp (e.g. Spinnova). Thus, in terms of roundwood consumption we are talking about amounts that could be reasonably realistic being achieved in the coming decades (e.g. with increasing plantations and resource efficiencies).

According to the Ellen MacArthur Foundation (2017), global textile industry emissions are at 1.2 billion tonnes of CO_2 equivalent per-year, close to the level of emissions from the automobile industry. Given that wood fibre-based textiles are estimated to have around a 3 to 5 times lower carbon footprint than cotton and synthetic fibres (Leskinen et al. 2018 and Seppälä et al. 2019), the potential substitution impact could be large. For example, assuming world production was 50% based on wood textiles, the reduction of CO_2 emissions could be in the range of 400 to 480 million tons compared to current emissions.[7]

One could do a similar type of hypothetical computation for wood construction. For example, Hurmekoski (2017) provided a hypothetical example for Europe. Assuming that wood construction would account for a 100% share of all European building construction, this would translate to a maximum demand of 400 Mm^3 of wood. This is equivalent to around 50% of the annual growth of EU forests, or roughly equal to the total EU industrial roundwood production in 2018 (381 Mm^3). Clearly, 100% market share is not realistic, and something like a 20% share could in future be more realistic. Even with this share, the climate mitigation impacts could be significant, perhaps around 100 Mt CO_2 in Europe. In addition, the carbon would be stored in buildings for decades, if not centuries.

In summary, significant climate mitigation impacts can be achieved by substituting fossil-based, and other problematic products (e.g. cotton) with wood-based products. In terms of roundwood availability, the potential for supplying wood for such increases is likely to exist. However, it would be essential to implement policies and monitoring systems that would ensure that roundwood procurement would not cause trade-offs for biodiversity and the other ecosystem services that global forests provide.

[7] This is a very rough and simplistic estimation. First, assuming that wood textiles would help to replace emissions from the half of the 1.2 billion tons emissions, i.e., from 600 million tons. For this amount, the emissions would be 3-5 –times lower, i.e. 120 to 200 million tons. This would amount to 400 to 480 million tons less than today.

The Green Deal needs wood

The interest in the opportunities that forest-based products may provide, from replacing fossil raw materials and products to providing for a true forest bioeconomy, is still a fairly recent phenomenon at the global scale. This also means that societies have not yet had much time to reflect on the implications associated with it. Thus, although the bioeconomy landscape is promising, it is also broad, complex, and even confusing, i.e., not short of wicked problems. More research is needed to comprehensively understand the multitude of implications of the bioeconomy for society and the forest sector.

Today, 55% of the world population is living in urban areas (World Bank statistics) and this share is predicted to increase to 68% in 2050 (UN 2018). In order for the forest-based bioeconomy to succeed and be societally inclusive, it is difficult to see how it could happen without engaging support from majority of the population (voters), i.e. urban citizens. Yet, forestry and bioeconomy is often advanced in strategies and political rhetoric in a manner that focuses on and appeals to the rural population: more rural jobs, income for rural people, keeping rural regions inhabited, etc. If the urban population is aware of the bioeconomy concept at all, they may easily relate it to rural areas and programmes. Perhaps even seeing this as something taking their tax income away and distributing to rural people. In order for the bioeconomy to succeed, it would need to change this view. There is a need for a forest bioeconomy narrative that engages also the urban population to gain their support.

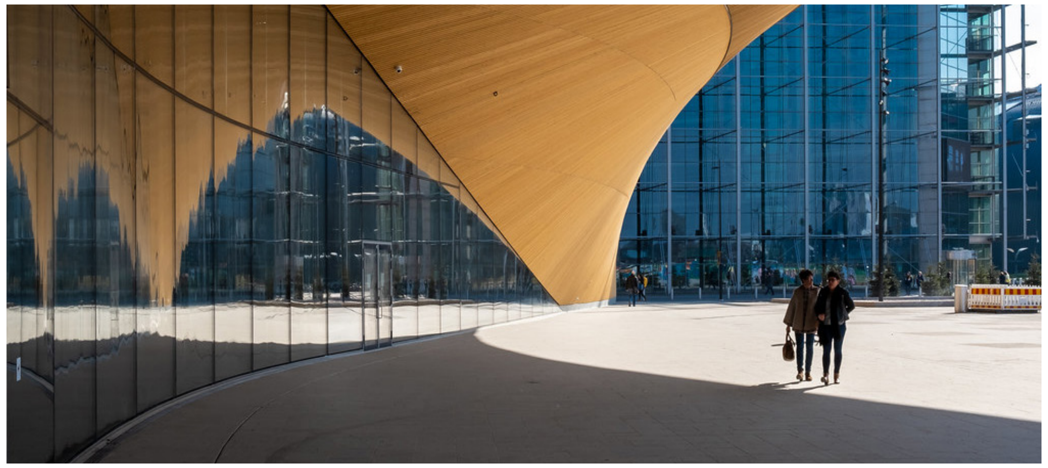

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Photo by: Kuvio

So far, the research on bioeconomy has been very much technology-driven and specialised. However, now that the technology is moving to commercial applications, there is a need for a synthesis of current knowledge, and analytical assessment of future environmental, economic, social and policy prospects. We need more analysis on the future trends in material and energy uses of wood in the context of climate change and the Sustainable Development Goals (UN Agenda 2030). In this development, the new plantation forests in different parts of the world can also play important role (Freer-Smith et al. 2019).

To support sustainable bioeconomy development requires implementing policies, such as a carbon prices (taxes, emission trading schemes), renewable energy standards and targets, and incentives to enhance biodiversity conservation. It is also important to understand the global synergies and trade-offs between forest biomass production versus other ecosystem services. Therefore, policies and forest management should aim to maximise the synergies and minimising the trade-offs between forest products markets and other forest ecosystem services.

Quite recently, requests for a “New Green Deal” have been at the centre of measures to tackle climate change.[8] It is clear that these deals cannot be truly green and sustainable without also recognising that it requires the use of natural capital and resources like wood from forests to replace fossils and non-renewables. Notably, recently also His Royal Highness, The Prince of Wales very much stressed the role of bioeconomy in reaching a sustainable future and established a Sustainable Markets Expert Network with the support of the World Economic Forum to help strengthen efforts for this.[9] In summary, we should not only see the forest, but also the wood in the forest. However, the use of wood needs to be done even more sustainably, resource-efficiently and circularly than we have done in the past. We dare not to do otherwise.

The increasing diversity and complexity of wood uses and forest product markets implies challenges for planning and monitoring the development of our world’s wood resources and their utilisation. It also makes the design of policy regulation more demanding. There is an increasing need for policy coordination across different policy sectors, as well as a long-term stable policy environment that helps to reduce uncertainties and, consequently, makes the investment environment more predictable (Hetemäki et al. 2017, Wolfslehner et al. 2018). This, however, will need much more investment in research on these questions than is the case today. As a result, for example, the European Forest Institute (EFI), the Center for International Forestry Research (CIFOR) and World Agroforestry (ICRAF) are determined to work together to invest in these vital questions. Yet, it is also essential to engage global policy leaders to coordinate forest-related policies to enhance reaching the Paris Climate Agreement and the Sustainable Development Goals.

To this end, the Directors of EFI, CIFOR and ICRAF have published an Open Letter[10] to the Heads of States on the need for an Earth Forest Summit.

[8] In the USA, this has been most notably demanded by some Democratic Party Members of the Congress (e.g. Alexandra Ocasio-Cortez). In December 2019 the EU published its communication on “The European Green Deal” (European Commission 2019).
[9] https://www.euronews.com/2020/01/22/watch-live-prince-charles-to-tell-davos-sustainability-should-be-cheaper
[10] https://www.efi.int/articles/open-letter-heads-states-need-earth-forest-summit

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