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Circular bioeconomy concepts in forest-based industries – key findings

Note by the Secretariat

Summary

This document provides background information on circular bioeconomy concepts in forest-based industries**.**

It outlines the key findings of two studies: "General conditions for a transition to a sustainable and circular bioeconomy in forest-based industries" (ECE/TIM/2023/INF.4-FAO:EFC/2023/INF.4) and "Circularity concepts in the pulp and paper industry" (ECE/TIM/2023/INF.5-FAO:EFC/2023/INF.5) which will be finalized in 2023 and published in 2024.

The document is presented for information and discussion.

I. Background

1. During its 2021 (sixty-ninth) session the member States of the United Nations Economic Commission for Europe (UNECE) committed to "step up efforts to promote circular economy approaches and the sustainable use of natural resources, by mainstreaming circularity and the sustainable use of natural resources in the existing relevant ECE sectoral work programmes."

2. This was reiterated at the seventieth session of the ECE (April 2023) in its decision "C (70) Promotion of Circular Economy and the sustainable use of natural resources."

3. The forty-third session of the Food and Agriculture Organisation of the United Nations (FAO) Conference held in Rome, on 1-7 July 2023 "stressed the importance of bioeconomy for sustainable agri-food systems and highlighted the need to discuss this topic within governing bodies and technical committees of the FAO, bearing in mind the ongoing collaboration between COAG and COFO on the linkages between agriculture and forestry and the FAO Committee on Forests and the Committee on Agriculture (COFO-COAG) joint work roadmap."[1]

4. The Joint UNECE/FAO Forestry and Timber Section continues to work on a series of studies on the application of circular models in specific forest-based industries, developed in consultation with the UNECE/FAO Team of Specialists on Sustainable Forest Products, the FAO Advisory Committee on Sustainable Forest Industries, experts from member States, the private sector and sectoral associations. The series of studies, which include also good practice case studies, focuses on:

(a) "Circularity concepts in wood construction" (published in June 2023);

(b) "General conditions for a transition to a sustainable and circular bioeconomy in forest-based industries" (ECE/TIM/2023/INF.4-FAO:EFC/2023/INF.4);

(c) "Circularity concepts in the pulp and paper industry (ECE/TIM/2023/INF.5-FAO:EFC/2023/INF.5).

5. In the following text, the key findings from studies (b) and (c) are summarized. The studies will be finalized in 2023 and published in 2024.

II. Key findings from the two forthcoming studies

A. Understanding of a sustainable and circular bioeconomy in the studies

6. Bioeconomy is the production, utilization, conservation and regeneration of biological resources, including related knowledge, science, technology and innovation to provide sustainable solutions (information, products, processes and services) within and across all economic sectors and enable a transformation to a sustainable economy" (Global Bioeconomy Summit Communiqué, 2020).[2]

7. Bioeconomy is based on the sustainable and circular use of biological resources and processes to produce food, feed, bio-based products and services and has major untapped potential to support both climate change mitigation and adaptation. A sustainable and circular bioeconomy also presents opportunities to improve climate change adaptation and resilience, through promoting ecosystem restoration and nutrient and water retention in soils, supporting indigenous and local livelihoods based on biological products and services, and building the conditions for more sustainably managed forests and fisheries. The transition to a sustainable and circular bioeconomy involves challenges and risks as well as benefits and opportunities. While the bioeconomy offers many potential solutions for climate action, any potential trade-offs involved in choosing one policy option over another (e.g., regarding land use, food

[1] Report of the Conference of FAO https://www.fao.org/3/nm800en/nm800en.pdf

[2] https://gbs2020.net/wp-content/uploads/2020/11/GBS2020_IACGB-Communique.pdf, cited in the FAO Conference resolution C 2021/LIM/4 (14-18 June 2021).

security, human health, safety, etc.) should be carefully considered and mitigating measures put in place (Gomez et al., 2022).[3]

8. A bioeconomy refers to the production and consumption of biomass-based goods, services and energy. It encompasses sectors such as forestry, pulp and paper production, agriculture, fisheries and food industry. It also covers parts of the chemical, biotechnological and energy industries as well as the manufacturing of bio-based textiles. The vision for a bioeconomy entails a system where materials, chemicals and energy are based on renewable biological resources that allow economies to move away from fossil-based inputs. A bioeconomy is, as such, not about being circular but about breaking the dependence on non-renewable resources (UNECE/FAO, 2022).[4]

B General conditions for a transition to a sustainable and circular bioeconomy in forest-based industries

9. The forest sector, which is situated in both the biological and technical cycles of a circular economy, has a major role to play in a transition to a sustainable and circular bioeconomy. Therefore, the study on the "General conditions for a transition to a sustainable and circular bioeconomy in forest-based industries" examines the context for understanding and effectively managing the increasing interest in forest-based materials ensuing from this transition.

Forest resources in a circular economy as a sustainable alternative to the linear use of fossil-based materials

10. Forest-based resources provide a number of sustainable alternatives to the growing demand for raw materials and energy, thus contributing to an effective reduction of the global reliance on fossil fuels, related CO2 emissions and, in general, a more sustainable use of natural resources.

11. The fact that forest-based resources provide sustainable alternatives to fossil materials is related to the restoration cycle considered unique to biomass, where waste biomass contributes to the formation of new biomass through restorative material flows that return a resource to nature, e.g., through composting or bioenergy. This can be thought of in mass-balance terms of CO2 at the start and the end of the biomass lifecycle. This in particular holds true once emission-free energy is available. Cascaded use in terms of down-cycling until the remaining fibres are burnt should then be avoided as far as technically feasible.

12. The theoretical concept of a circular economy, which is often compared to a perpetual motion machine, is not attainable in many circumstances. The objective is to reduce waste and limit the consumption of finite resources to achieve sustainability in the long term. More sustainable practices represent already an improvement that can be measured against existing economic models and do not aim to transform the entire global economy into a circular bioeconomy at all costs. Therefore, the study considers a number of challenges and opportunities for the forest sector related to the ongoing transition to a sustainable and circular economy.

Factors affecting sustainable provision of forest biomass in a circular bioeconomy

13. As forest ecosystems are diverse and widely distributed around the world, they have a capacity for widespread and substantial contribution to the sustainable production and consumption of forest-based materials. They are also highly valued by rural, suburban and urban communities for a variety of ecosystem services of significant importance to local economies and social life. However, the growing demand on ecosystems to provide biomaterials must stay within the ecological boundaries of the sustainable provisioning of

[3] Gomez San Juan, M., Harnett, S. and Albinelli, I. 2022. Sustainable and circular bioeconomy in the climate agenda: Opportunities to transform agrifood systems. Rome, FAO. https://doi.org/10.4060/cc2668en

[4] https://unece.org/sites/default/files/2022-05/Circularity%20concepts%20in%20forest-based%20industries%20ECE_TIM_SP_49.pdf

forest-based materials. An essential condition for a sustainable and circular bioeconomy is that all forest functions are ensured.

14. There are many threats that create pressure on ecosystems. Forest ecosystems are directly affected by deforestation because of expanding agriculture and other land-use change, wildfires and pests that impact sustainability and system resilience. Many of these threats are worsened by climate change effects. The latter, as well as other global challenges such as pollution, waste or the phasing out of plastics, create not only threats but also opportunities for the forest sector.

Conditions for a successful transition to a sustainable and circular bioeconomy

15. A sustainable and circular bioeconomy includes environmental, economic and social aspects that relate to forests. These include supply chains and organizational factors, policy innovations and public and private institutional roles. The transition to a sustainable and circular bioeconomy can be facilitated by policy and regulations that are based on the capacities of the private sector, available (waste) resources and market conditions. Policies can support resource efficiency, waste minimization and better planning and decision-making to facilitate integration across sectors. A circular bioeconomy will be the result of transformational processes across entire value chains and require new business models, public-private collaboration and the adoption of innovative technologies and tools.

16. Cooperation and collaboration at the global scale are essential elements for the successful transition to a sustainable and circular bioeconomy. They should, among others, build on partnerships between the Global South and Global North. Resources essential for the circular bioeconomy are often available in the Global South that, in turn, may require support to promote innovations, technologies and investments to ensure the sustainable use of their resources. The Global North, on the other hand, contributes to the growing demand for products and biomaterials. Also, as future supply sources in the Global North may face challenges in balancing the growing demand, the biomaterial supply from the Global South will contribute to balancing the global markets. Consequently, the alignment between supply and demand at a global scale is an important condition for an effective transition to a sustainable and circular bioeconomy.

17. The elements of cooperation and collaboration for a sustainable and circular bioeconomy include the enhanced understanding of industrial ecosystems and its connections with businesses and communities. Forest value-chains include a wide range of stakeholders and depend on available forest resources. Local communities, including Indigenous Peoples, are vital stewards and partners in a sustainable and circular bioeconomy; traditional knowledge and practices of local populations, responsible landowners and forest managers can contribute to positive economic transitions and results.

18. The social impacts and potential results of a transition to a sustainable and circular bioeconomy will generate the need for new skill sets at all levels. This includes workforce and employee development via training and innovative educational curricula. Some of the new skill sets will need to take aboard Indigenous Traditional Ecological Knowledge (ITEK) and the relationships between ITEK and other research methods and scientific practices. Forests have a special place in a sustainable and circular bioeconomy because of their deep connections to Indigenous Peoples diverse and abundant ecosystem services, and their capacity to regenerate and provide resilience and livelihoods in a changing climate and evolving world.

Opportunities and challenges of wood products for forest-based-industries resulting from a transition to a sustainable and circular bioeconomy

19. Among the various products provided by trees and forests, wood can play an important role in the transition to a sustainable and circular bioeconomy because it is a renewable material with many natural and beneficial attributes. It is used in various industries such as wood construction, chemicals and textiles. Among them, cross-laminated timber and cellulose-based textile fibres are seeing the most significant growth.

20. As industry boundaries blur, forest-based industries adopt new value chains and more and more sectors increasingly rely on wood as their primary raw material. Many wood-based

products suitable for bioeconomy are under development. Some promising early-stage products include wood foam, glycols, bioplastics, lignin-based adhesives and wood-based composites, all expected to enter the market within the next two decades.

21. To fully realize this potential, it is important to ensure that the conditions for material recovery, renewability, biodegradability and sustainability are enhanced for wood-based products in a sustainable and circular bioeconomy. Maintaining and further developing long-lived value chains is also essential for waste reduction.

22. Today, the existing dominant economic model is based on the linear use of raw materials and contributes to escalating environmental, health and social risks. A circular bioeconomy allows communities and societies to maintain sufficient economic performance, while, at the same time, to reduce the environmental footprint on ecosystems, human health and the planet overall. Application of the concepts of biomimicry[5] and industrial ecosystems can enhance the alignment with natural systems and economic efficiency.

23. The full potential of forests in a sustainable and circular bioeconomy can be realized through a never-wavering focus on the principles of sustainable forest management supported by incentives, investments and regulations, coupled with innovation and modernization in the industry, and a trained and skilful workforce, the optimized cascading use of wood at every manufacturing step, and expanded commitment to material reuse, including the greater recovery of post-consumer wood. The transition to a sustainable and circular bioeconomy should focus on holistic approaches that extend beyond specific products. Natural cycles of forest health and growth, the carbon cycle and the expansion of landscape-restoration activities can all be supported in a sustainable and circular bioeconomy to contribute to reversing trends of biodiversity loss and ensuring that all forest functions thrive.

C. Circularity concepts in the pulp and paper industry

24. When considering sustainability and circularity in the pulp and paper industry, the recycling of paper products emerges as the most prominent feature. Therefore, the study focuses on the use of recovered materials as a priority feedstock for pulp mills in line with material efficiency and circularity rules.

25. The benefits of increased paper recycling are not only the diversion of paper waste from other disposal options. The circularity of paper and paperboard products has also a wider benefit for all forest-based industries, as it broadens the availability of renewable raw material for all forest-based products and reduces the dependence on virgin fibres from the forest. When less virgin material is used for pulp production, this virgin material can be directed to other applications, with a recognition that the long-term sustainability of supply depends on sustainable forest management.

26. The study also recognizes that circularity in the pulp and paper industry requires resource efficiency in a variety of raw materials accompanying the production processes, including closed water and residues (e.g., fibre-containing sludges) cycles, energy efficiency (when possible), bioenergy use and the effective use of processing chemicals. For that reason, although the study focuses mainly on the circularity of the cellulose-based raw materials, other accompanying materials and resources are duly mentioned.

27. Overall, this study presents theoretical sustainable and circular economy concepts and how they relate to the sector. The analysis has been placed in a general industry context directed towards resource efficiency evolution as well as sustainable production and consumption trends in the industry over the last few decades. Conclusions from the study follow.

28. **The changing industry context impacts the structure of the sector**. Paper and paperboard products are part of people's everyday lives, but the way they are used has been changing noticeably since the 2000s. While the use of printing and writing papers has greatly decreased, the use of paper-based packaging has soared. A lot of paper and paperboard is consumed where it is not visible to end consumers, namely in the supply chains of the

[5] Biomimicry is the imitation of natural biological designs or processes in engineering or invention.

globalized economy and its logistics. The Covid-19 pandemic and the related lockdowns accelerated the trend away from printing and writing papers to packaging papers. Sustainability efforts by companies have caused a shift from plastic to paper-based packaging in many fields, also owing to strong progress in resource efficiency by the pulp and paper industry. This resource efficiency was observed in several areas that are hotspots for pulp and paper making. They include energy efficiency gains, increased use of renewable energy, the reduction of CO2 emissions and the diversion of residues from landfills. Most notably, recycling rates have increased at the global level which led to global paper and paperboard consumption being increasingly decoupled from the use of virgin pulp production.

29. **Further growth in packaging papers will depend on the uptake of reusable packaging.** A further decrease in the use of printing and writing papers will likely contribute to increasingly more conversions of paper machines into machines producing packaging papers. The demand for and production of packaging papers is projected to grow in light of the move towards more sustainable packaging solutions. Discussions on reusable options complementing recycling as well as general waste reduction are emerging, but it is not possible to predict yet if reusable packaging will stay a niche or gain a significant market share in some sectors. The long-term benefits of reusable packaging will need to be evaluated on a case-by-case basis considering all sustainability aspects, beyond the sole aspect of circularity.

30. **Paper recycling rates will keep increasing. However, a continuous inflow of virgin fibres will be needed**. The availability of paper for recycling for the industry is reaching high levels in many countries; however, there is still potential, especially in the collection from households or consumer packaging disposed of away from home. Even if this remaining potential can be realized, a continuous inflow of virgin fibres is needed and should ideally be considered in regions and through product applications where virgin fibres have a clear advantage over other sustainability aspects. Industry experts expect the share of recovered paper in the global consumption of fibrous raw material of the pulp and paper industry to reach 60%-70%.

31. **Pulp mills also implement circularity approaches through the development of innovative products in biorefineries.**[6] The transition of activities into biorefineries, which make more added value products, e.g., cellulose fibres for textiles or bio-composites, is becoming a way of closing production loops in some pulp mills. It provides an opportunity not only for expanding the market portfolio of conventional pulp mills but also keeps the valorization of forest and sawmill residues in the sector, thus contributing to a higher value-added of the sector. This synergistic combination provides an attractive business case from both a socioeconomic and environmental point of view.[7] The biorefineries concept also allows for a more efficient use of all the production side streams, including residues of the pulping process, such as bark and black liquor.

32. **Circular design is key for both high recycling rates and high quality of products made from recovered paper**. The most prominent feature of circularity in the pulp and paper industry is the high recycling rate of paper products. What distinguishes paper recycling from other product recycling, including the cascaded use of wood-based products, is not only the high rate, but also the fact that paper products are recycled back at this high rate in a closed material loop. This means paper products are recycled in the paper industry and become recycled pulp and paper for new paper and paperboard products, instead of being used outside the sector. Several factors contribute to the success of paper recycling as it involves many actors, including some that are outside the pulp and paper industry value chain. Two main factors are the circular design and its link to the circular management of paper products. The core precondition of circular design is the design professionals' knowledge of and inclusion of the production and the recycling processes, not only a focus on the final product

[6] A biorefinery is a facility (or network of facilities) that integrates biomass conversion processes and equipment to produce transportation biofuels, power and chemicals from biomass.

[7] Richard Platt, A. B. (2021). *EU Biorefinery Outlook to 2030.* Luxembourg: Publication office of the European Union https://op.europa.eu/en/publication-detail/-/publication/7223cd2e-bf5b-11eb-a925-01aa75ed71a1

functionalities in their useful life. In paper recycling, there are two basic processes with many variations and improvements of the process. Therefore, it is crucial that designers and producers of paper products are aware of the basic processes for the products to be designed before further recycling. There are several examples of guidelines and scorecards to support this.

33. **Standardization is a compelling enabler for the circularity of paper and paperboard**. When products along the value chain are specified according to standards, industry actors know what was produced at the preceding stage of the value chain and what the next stage of manufacture down the value chain requires in terms of product specifications. Standards, such as Scrap Specifications Circular in North America (ISRI) or EN 643 (European list of standard grades of recovered paper and board) are widely used also beyond these regions in the international trade and enable a functioning and transparent market. In the collection of recovered paper, there are several models, each with its advantages and downsides. While it is argued by some that commingled collection generates higher amounts of recovered paper and is easy to use by households, the collection of paper and paperboard separately from other recyclables causes lower sorting costs and lower impurity levels. The European Commission's Guidance for Separate Collection of Municipal Waste[8] concludes that paper and paperboard should be collected as a separate stream to avoid the degradation of the quality by commingling it with other recyclables such as plastics, metal and glass which may be soiled with food.

34. **Paper recycling is a business case**. Paper recycling offers an economically viable alternative to the use virgin fibre for paper production. Therefore, using recovered paper has helped papermakers to significantly reduce their raw material costs and, at the same time, diverting it from landfill and incineration. There has been a strong demand for recycled paper, which in turn has created incentives to collect more, leading to increasing recycling rates. While generally most paper is recycled in the paper industry of the country where it has been consumed, its global demand is able to balance regional and temporary volatilities in supply and demand. Alongside standardized recovered paper qualities, the global demand has contributed to the fact that recovered paper has become a globally traded commodity with a market value representing more than 244 million tonnes of recovered paper.[9] Improvements in circular design, collection and sorting could further support the functioning of this market in many countries and grow it globally to help meet the paper industry's raw material demand.

35. **Environmental performance of paper and paperboard made from virgin fibres and from recovered paper can be compared only case-by-case**. Assessing the overall sustainability of paper and paperboard products goes beyond circularity. Environmental benefits of paper recycling compared to disposal options are obvious. When comparing recycled paper with virgin alternatives, the picture is less clear. Recycled paper production uses less energy than virgin fibre-based paper production, but in many countries, it relies on fossil energy sources. However, although virgin fibre-based paper production uses more energy in total, most of it is from renewable sources (forest residues, black liquor). Therefore, the comparison of the environmental performance of both processes needs to be done case-by-case. The picture could look different with a higher availability of carbon-neutral energy for the whole industry, especially non-integrated mills including recycling mills.

36. **Recycling paper and paperboard extends the raw material base substituting fossil-based products.** The main benefit from increasing paper recycling is the extension of the raw material base for products that offer an alternative to fossil-based products. This is shown by various life cycle assessments (LCA) comparing plastic packaging with fibre-based alternatives. However, case-specific LCA studies on environmental impacts should be carried out for the comparison of individual products. This is needed because despite LCAs

[8] Guidance for Separate Collection of Municipal Waste, Maarten Dubois, Edward Sims, Tim Moerman, David Watson, Bjorn Bauer, Jean-Benoît Bel, Georg Mehlhart, European Commission. Environment Directorate-General, European Economic Community, PlanMiljø, Association des cités et régions pour le recyclage et la gestion durable des ressources, RWA., Öko-Institut, Publications Office of the European Union, 2020

[9] https://www.fao.org/faostat/en/#home

being a widely used tool, they are far from an optimal solution owing to the difficulty of comparing them.

37. **Policy has a key role in creating an enabling environment for circularity in the pulp and paper industry.** Many countries have already put in place regulations guiding the end-of-life management of paper products, moving away from disposal options (landfill and incineration) to achieve higher recycling rates. More policy support is still needed in the improvement of paper and paperboard collection from households as well as from away-from-home and on-the-go consumption. This could be achieved by a more consistent collection infrastructure alongside with clearer sorting instructions for consumers. Policy also has a role to play in increasing the transparency of information on the environmental and carbon footprint of pulp and paper products, including, but not limited to, circularity. Such policies could promote science-based tools to enable a comparison between different products and allowing consumers to make informed choices.

38. Building on these conclusions, the study advocates for the following concrete actions in support of a successful transition to a circular economy in the pulp and paper sector:

(a) Support for sustainable forest management should continue. While there are high recycling rates and they can be further increased in many areas, a steady inflow of virgin fibre will be needed, and it must be sourced from sustainably managed forests;

(b) Waste streams including valuable raw materials such as paper and paperboard should be, as much as possible, diverted from landfills and other disposal options to keep materials circulating and creating added value in the economy;

(c) Paper and paperboard should be collected separately from residual waste and from other recyclables. There should be consistent waste collection programmes at least at national levels, but ideally in wider economic areas to enable the value of secondary raw materials to be maintained;

(d) Sorting instructions for the end consumer of pulp and paper products should be included on the products, next to the legally required information concerning the origin;

(e) Science-based environmental footprint information needs to be publicly available to make sure that claims on products are reliable and comparable for the consumer;

(f) Waste management policies, including collection and sorting, should be linked to the product design and production policies to allow for closed material loops in which products are designed in full knowledge of the recycling processes that keep them in use;

(g) Product support policies (e.g., green procurement) should be further developed to take into account the recyclability of products and the renewability of their raw materials to favour nature-based material over fossil fuel-based ones;

(h) Innovation and access to research and development funding should be encouraged to facilitate product and energy efficiency innovations. This would support the continued development towards biorefineries, which can produce more value-added products from side-streams and other waste;

(i) Paper mills should be encouraged to use their potential for becoming more energy self-sufficient by producing renewable energy onsite using e.g., waste and residues for bioenergy in line with the cascading use of biomass. For the remaining energy needs, access to affordable clean energy is crucial to increase the synergy between increasing circularity and efforts to mitigate climate change;

(j) Cooperation among different actors across value chains and the establishment of industrial ecosystems should be promoted to facilitate exchange along supply chains and make them more circular i.e., turn the supply chains into supply circles;

(k) Various value chains should be analysed by industrial associations and policy makers to identify the potential for increased circularity while keeping in mind all other environmental impacts and sustainability aspects.

39. The Committee and the Commission are invited to:

(a) Review and consider the main findings and action points of the two studies contained in (ECE/TIM/2023/INF.4-FAO:EFC/2023/INF.4) and (ECE/TIM/2023/INF.5-FAO:EFC/2023/INF.5);

(b) Share information on how the circular bioeconomy is implemented in their countries;

(c) Recommend that the secretariat:

(i) Finalize the two studies as United Nations official publications by the end of 2023 and published in 2024;

(ii) Upon availability of resources, share knowledge and build capacity based on the already existing UNECE/FAO studies in this area;

(iii) When possible, and upon availability of resources, mainstream circularity concepts in forest-based industries in ongoing product related work.