Chapter

# Digital Solutions in the Forest-Based Bioeconomy

*Chihiro Watanabe and Nasir Naveed*



## Abstract

This chapter aims to illustrate the potential and significance of forest-based industry to take the lead in the sustainable development of the bio-based economy under digitalization. The digital solutions are transforming the forest-based industry by enabling the real-time end-to-end supply chain visibility, stock level optimization, demand planning, and real-time order status tracking and transparent, speedy, and hassle-free order fulfillment. In addition, increasing diversification corresponds to eco-consciousness, and shift in people's preferences induces the transformation of forest-based bioeconomy into a digital platform industry. Further, this chapter will highlight the circular economy way of thinking that offers the possibility for the use of material to a more efficient level along with creating new, sustainable business models for many industries. The future of many industries lies in cross-industrial collaboration and creation of new value network based on circular economy as in the industrial ecosystems; the side streams generated in the production of one firm may be the input raw material for others. Based on all of these developments, transformation of forest-based bioeconomy into a digital platform industry can be expected.

**Keywords:** forest-based bioeconomy, transformation, digital solutions, creative disruption platform, circular economy

## 1. Introduction



The human activities are depleting available resources that mainly come from the processes such as mining and petrochemicals. At the same time, dependence on the fossil-based resources is increasing the concerns related to the climate change. In future, societies need to manage the resources much more efficiently and increase the dependence on renewable resource. The consequences of this will lead to more sustainable bioeconomy from a traditional fossil economy.

The bioeconomy is considered as the economy relying on the production of renewable biological resources and their use for food, feed, bio-based products, and bioenergy [1]. The major contribution of biomass comes from the forest; therefore it is viewed as important sub-sector of the bioeconomy [2, 3] that can take a lead in the sustainable development of bio-based economy [4]. The transition to a sustainable bioeconomy will not immediately replace the traditional facilities, but the new technologies will be integrated to the existing one. Many leading forest firms have taken major steps in developing the sustainable bio-based innovations and understanding the consumer behavior by linking these efforts to digitalization. For example, Metsä Group invested 1.2 billion euros to develop the next-generation bioproduct mill in Äänekoski, Finland.

The new industrial revolution based on new digital developments will enable the integration of dynamic supply chains, end-to-end supply chain visibility, stock level optimization, elimination of distance between upstream and downstream of the chain, and interaction among different industries and sectors. All these developments will lead forest-based bioeconomy to a consolidated platform ecosystem [5].

The transformation of forest-based bioeconomy can be extended from technological and material processes to cultural, ethical, and wider socioeconomic perspectives [6, 7]. Watanabe et al. [5] propose the following thinking for devising a new business model under digitalization:

1. Recognizing complexity, phenomena-driven policy, and new social dynamics

2. Understanding global interdependencies that require multilevel thinking and knowledge about the significance of the coevolution of technologies, economy, and society

3. Re-understanding traditional regimes and regions as the convergence of several fields in potential industries can possibly emerge in future

The system nature of forest-based bioeconomy has been studied by the different authors. Wolfslehner et al. [4] highlighted the potential use of forest-based indicators in Europe and their development in future. They argue that forest-based industry can take lead in the sustainable development of bioeconomy. Hetemäki et al. [2] and Hetemäki [8] are of the view that European forest-based sector has undergone creative destruction as the production of some of the traditional forest products has declined in recent years. However, at the same time, strong growth is observed in many value-added engineering wood products. Thus, creative destruction emerged as described by the Schumpeter. Further, they discussed that knowledge on economics, politics, markets, and marketing is vital to realize the challenges, barriers, and opportunities as well as to support business and policy strategies. The mega forces such as climate change and resource scarcity are perceived more as opportunities than threats in European pulp and paper industry because pulp and paper industry is diversifying their product portfolio [9] by fostering digital solutions.

This chapter explains the transformative direction of forest-based bioeconomy into a digital platform industry; therefore all stakeholders from different sectors engaged in various roles must be considered [10]. However, consequences of transformation are not yet known.

## 2. Perspectives on the forest-based bioeconomy

As described earlier, forest-based bioeconomy is the important sub-sector of bioeconomy that holds significant share in this economy. The forest-based products include raw materials (e.g., wood chips) and intermediate products (e.g., pulp) that can be converted to different products to fulfill the customer needs. Forest-based services (e.g., recreation and tourism) are also valuable for local economies [11, 12]. The scope of forest-based bioeconomy is demonstrated in **Figure 1**.

Mubareka et al. [14] argue that resource efficient and sustainable development of products such as biochemical, bioenergy, and biocomposites will not achieve the economic gains only but benefit the environment also by reducing the carbon footprints. The development of green energy, green transport, and other breakthrough

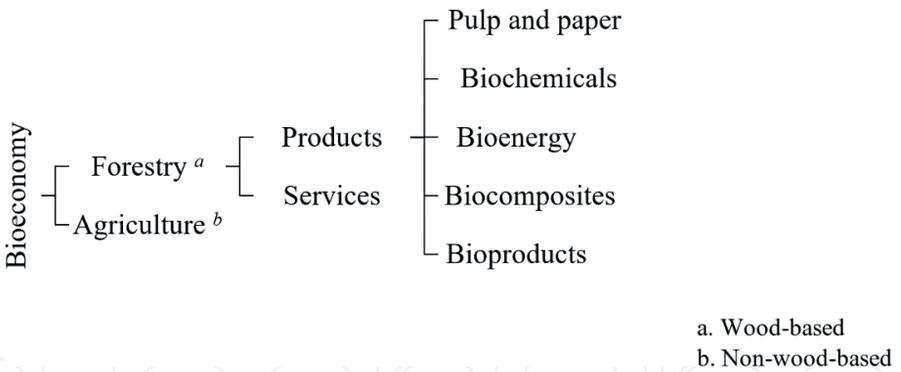


**Figure 1.**
*Scope of the forest-based bioeconomy. Source: Adapted from Watanabe et al. [13].*

technologies is on top priority to achieve a goal of sustainable decarbonized society worldwide [15]. Thus, forest-based bioeconomy is gaining popularity as a real global asset for both industrialized and growing economies as forest industry offers sustainable and recyclable products, reduces dependency on fossil-based nonrenewable materials, and ultimately contributes to the development of decarbonized society.

## 2.1 Structural change in the supply chain

Pulp and paper industry (PPI) is the backbone of forest-based bioeconomy in Europe as big chunk of gross domestic product (GDP) of European Union (EU) comes from PPI. In recent years, the demand for printing and graphic paper in industrialized countries has declined; therefore the forest-based industry is prone to major structural changes, especially in forest-dependent countries. The industry needs to be more dynamic in developing new products, research-related ecosystems, and innovative business models [13].

**Figure 2** demonstrates the geographical structure of production and consumption of paper and paperboard in 2015. Asia is on top in both production and consumption while they are lagging behind in adopting the digital solutions. Conversely, the USA and Europe (particularly Finland) are leading in developing digital solution [16].

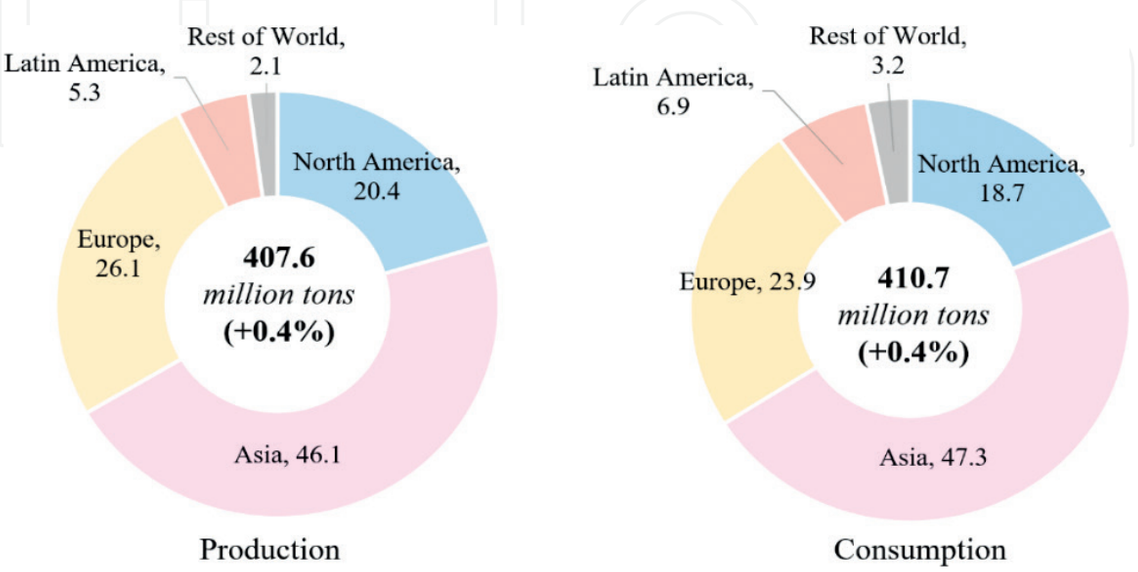


**Figure 2.**
*Worldwide production and consumption of paper and paperboard (2015). Original source: Watanabe et al. [13].*

World pulp and paper industry leaders and their digital ability (2015).

| Production (Wood pulp) | Export (Paper and paperboard) | Consumption (Paper and Paperboard) |
|---|---|---|
| USA (7) | Germany (13) | China (62) |
| Canada (11) | USA (7) | USA (7) |
| Brazil (84) | Finland (2) | Japan (10) |
| Sweden (3) | Sweden (3) | Germany (13) |
| Finland (2) | Canada (11) | India (89) |

*The figures in parenthesis indicate World ICT ranking (WEF, 2015).*

Ojala et al. [17] discussed that forest-based industry was not facing fierce competition until the 1990s and was running under low degree of internationalization with prime focus on business-to-business products while maintaining the long-term business relationships. The forest-based industry is reshaping over time due to new business dynamics, customer needs, global competition, and strategic orientation [18].

Nowadays, the increasing role of Latin America, Southeast Asia, and China has intensified global competition in pulp and paper industry by lowering the production cost for pulp and paper. Thus, many firms in pulp and paper industry need to innovate their business model, product portfolio, services, and processes. Therefore, forest-based companies are introducing the performance improvement programs to cope with the challenges in their value chain ranging from equipment reliability to analytics in commercial operations. The incorporation of digital solutions and internet of things (IoT) potentially delivers significant gains to the industry by focusing on the following areas:

1. Optimization of tree plantation and forestry operations for improved yield and quality

2. Constraints free supply to the downstream processing activities and reduce the supply chain costs.

3. Support skills development and technology transfer across the firm operating in global settings

4. Enable customer retention by improving the customer value and experience

The implementation of digital solutions in the forest-based industry is subject to the formation of a sophisticated global value chain comprising upstream and downstream players interacting each other and having the capacity of embracing digital innovations. **Figure 3** demonstrates the value chain of forest-based bioeconomy focusing on the PPI wherein digital solutions are incorporated in both upstream and downstream of the value chain.

The framework that facilitates the transformation of forest-based bioeconomy through digital innovation is illustrated in **Figure 4**.

## 2.2 Consumer preferences and role of prosumers

While learning about the transformative direction of forest-based bioeconomy, people's preferences cannot be ignored as both demand and supply sides are equally important in forest-based bioeconomy value chain. Wesseler and Von Braun [20] are of the view that customer's preferences are shifting toward eco-friendly products

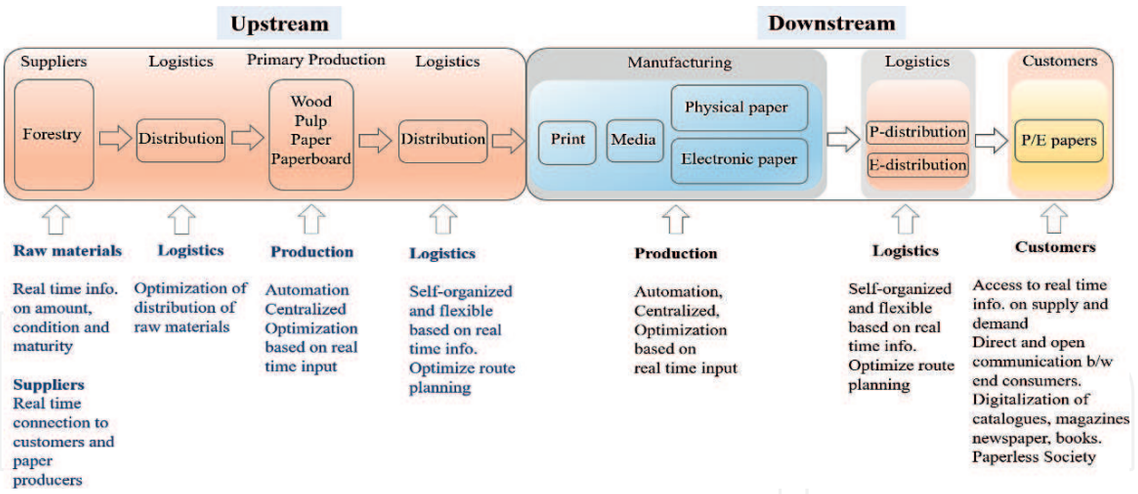


**Figure 3.**
*Value chain structure of the forest-based bioeconomy focusing on pulp and paper industry. Original source: Watanabe et al. [13].*

(bioproducts: food, textiles, composites materials) in both industrialized and developing countries. According to the Ministry of Economic Affairs and Employment of Finland [21], the demand of organic food is steadily increasing in supermarkets. The promotion of bioproducts, tax policies, and regulations are the drivers of shift in customer's preferences. Further, virtual communities are playing their role by sharing their views on what is ethical, sustainable, and eco-friendly by using the power of social media. People follow and take advices online; thus the role of digital technologies has increased in setting the people's preferences, and role of consumers has been changed to the prosumers.

The increased consciousness toward sustainability and environmental issues has made prosumers to appreciate those companies who deliver great customer experience and are more responsible in using the natural resources in their operations. Therefore, companies are trying to find ways to waste less; for example, in 2013, Hennes and Mauritz (H&M) launched a global program for collecting used garments for recycling and transforming those to the new products. Similarly, Amazon is supporting individuals in multiple ways by letting them to offer their services (e.g., book publishing on kindle, cleaning, assembly, and electrician) to Amazon customers by using Amazon's digital platform.

The abovementioned trends indicate that the upstream of the value chain of forest-based bioeconomy is largely driven by the downstream of the economy; therefore all stakeholders in the value chain need to focus on consumer-driven business models and appreciate consumer's involvement in the innovation process to increase the acceptance of newly developed products.

Amazon with its disruptive business strategy triggers the demand worldwide in the retail sector, which in turn stimulates the upstream industries in the bioeconomy chain. Amazon analyzes customer buying behavior by using big data

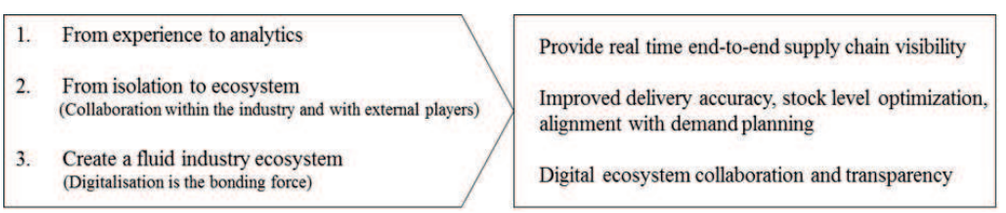


**Figure 4.**
*Transformation of forest-based bioeconomy under digitalization. Original source: Tieto [19].*

| | |
|---|---|
| UPM | Versatile use of renewable wood biomass, combined with innovation, resource efficiency, and sustainability aimed at replacing nonrenewable materials with renewable and low-impact alternatives |
| Stora Enso | Transforming from a traditional paper and board producer to a renewable material growth company by the means of a strong customer focus and new innovation approaches |
| Metsä | Involved in various joint and development and innovation projects focused on enhancing the sustainability of forest operations. In addition, they are continuously developing digital services to help forest owners manage their forests sustainably |
| KaiCell Fibers | Versatile and competitive biorefinery with novel bioproduct applications, optimized capacity based on a local fiber approach, cultivated bioproducts out of chemical softwood pulp, and the bioecosystem of circular economy meeting economical requirements |
| Finnpulp | Digital ecosystem provides advantages related to raw material and delivery chain management, improving the efficiency of the mill's support functions and optimizing production quality and quantity. This concept further improves the facility's occupational safety and environmental performance |

*Sources: UPM [22], Stora Enso [23], Metsä [24], KaiCell Fibers [25], and Finnpulp [26].*

**Table 1.**
*Finnish forest-based firms' initiatives under digitalization.*

analytics and offers recommendations to the customers for future buying based on their browsing history. Amazon's business strategy adheres to the shift in customers' preferences and response time to those changes by leveraging digital technologies as source of competence.

Similarly, leading forest firms are putting their efforts in understanding the consumer behavior and developing new products accordingly by using digital technologies and circular economy way of thinking. Examples of such trends are demonstrated in **Table 1**.

## 3. Transformation toward a creative disruption platform

The digital solutions enable the consolidation of upstream and downstream, producers and consumers among the diversified industrial sectors in the forest-based bioeconomy value chain [27]. Consequently, we can expect creative disruption platform as illustrated in **Figure 5**. Digitalization challenges the traditional practices in forest-based industry encompassing low performance production, traditional business models, rules and regulations applicable to non-digital

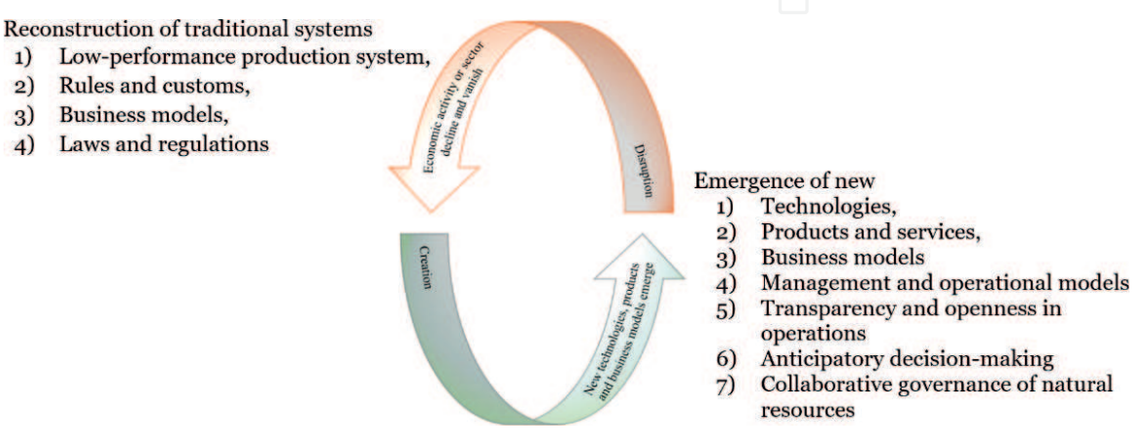


**Figure 5.**
*Creative disruption platform embracing digital solutions. Original source: Watanabe et al. [13].*

economies, and set platform for new business models, technologies, products, and services, collaborative governance of natural resources, visibility and transparency in operations and so on.

With such understanding, Watanabe et al. [13] described the stepwise concept of creative disruption platform as illustrated in **Figure 6**. In the forest-based bioeconomy, the linear value chain from forestry (upstream) to consumption

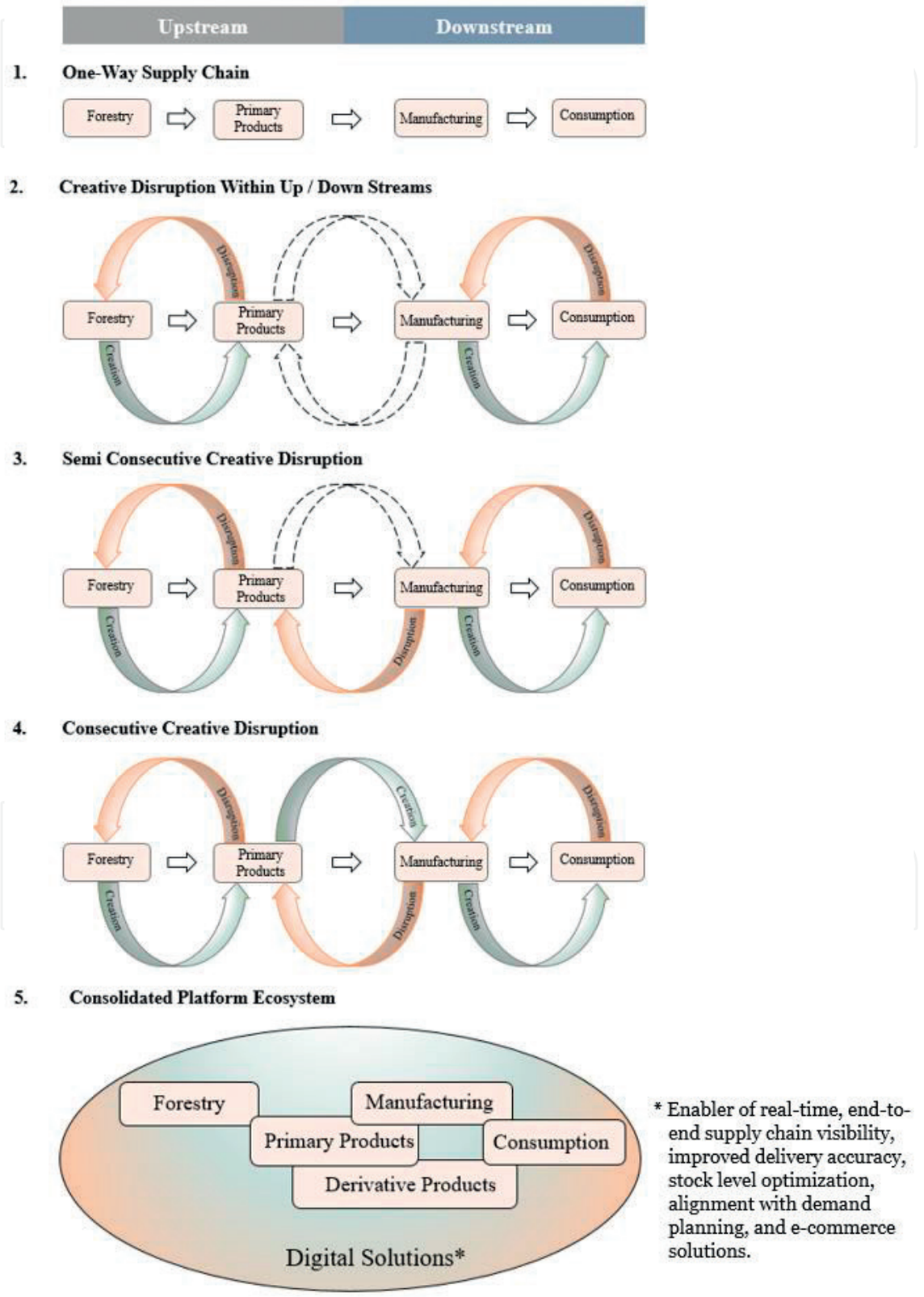


**Figure 6.**
*Steps in constructing a creative disruption platform. Original source: Watanabe et al. [13].*

(downstream) transforms into creative disruption platform. First, the disruption and creation are observed within the upstream and downstream. Further development of digital solutions in the downstream instigates disruption in upstream with the prospect of new developments and consequent creation of new business system in the downstream. Thus, all stakeholders involved in the value chain of forest-based bioeconomy will play different roles and interact each other to accelerate the consolidation of upstream and downstream which will in turn lead to the emergence of creative disruption platform as expected.

## 4. Summary

In the bioeconomy context, the consumer-centric and circular economy way of thinking combined with digitalization leads to a digitalized bioeconomy that satisfies the concerns for eco-consciousness and increases competitiveness across the value chain as illustrated in **Figure 7**.

Digitalized bioeconomy enables (1) bioeconomy monitoring system based on big data analytics, (2) smart design and manufacturing to meet downstream needs across the value chain, (4) collaborative governance of natural resources, (5) decentralized production, (6) efficient management of raw material streams, (7) data-based business models and decision-making tools, and (8) consumer-centric innovations and so on.

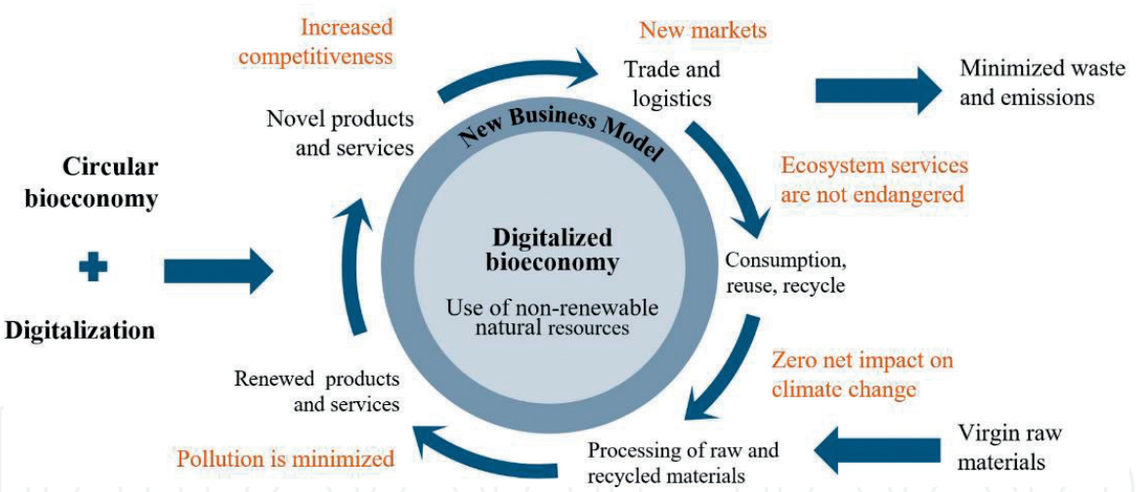


**Figure 7.**
*Concept of digitalized bioeconomy Source: Authors' elaboration based on Watanabe et al. [28] and Mistra [29].*

*DOI: http://dx.doi.org/10.5772/intechopen.84828*





## Author details

Chihiro Watanabe[1,2*] and Nasir Naveed[1]

1 Faculty of Information Technology, University of Jyväskylä, Finland

2 International Institute for Applied Systems Analysis (IIASA), Austria

*Address all correspondence to: watanabe.c.pqr@gmail.com

## References

[1] EC (European Commission). Innovating for Sustainable Growth: A Bioeconomy for Europe. COM(2012)60 Final. Brussels; 2012

[2] Hetemäki L, Hoen HF, Schwarzbauer P. Future of the European forest-based sector and bioeconomy. In: Hetemaki L, editor. Future of the European Forest-Based Sector: Structural Changes Towards Bioeconomy. Joensuu: European Forest Institute; 2014

[3] Scarlat N, Dallemand J, Monforti-Ferrario F, Nita V. The role of biomass and bioenergy in a future bioeconomy: Policies and facts. Journal of Environment & Development. 2015;**15**:3-34

[4] Wolfslehner B, Linser S, Pulzl H, Bastrup-Birk A, Camia A, Marchetti M. Forest bioeconomy—A new scope for sustainability indicators. European Forest Institute. From Science to Policy. 2016;**4**:1-31

[5] Watanabe C, Naveed N, Naveed K, Neittaanmäki P. Transformation of the forest-based bioeconomy by embracing digital solutions. Journal of Technology Management for Growing Economies. 2017;**8**(2):191-214. DOI: 10.15415/jtmge.2017.82005

[6] Pelli P, Haapala A, Pykalainen J. Services in the forest-based bioeconomy: Analysis of European strategies. Scandinavian Journal of Forest Research. 2017

[7] VTT Visions 11. Bittejä ja Biomassaa: Tiekartta Digitalisaation Vauhdittamaan Biotalouteen. Juvenes Print: Helsinki; 2017

[8] Hetemäki L. Role of Sustainable Forest-Based Bioeconomy in Europe. Think Forest. Brussels; 2016

[9] Toppinen A, Patari S, Tuppura A, Jantunen A. The European pulp and paper industry in transition to a bio-economy: A Delphi study. The Journal of Policy, Planning and Futures Studies. 2017;**88**:1-14

[10] Mustalahti I. The responsive bioeconomy: The need for inclusion of citizens and environmental capacity in the forest-based bioeconomy. Journal of Cleaner Production. 2018;**172**:3781-3790

[11] Näyhä A, Hetemäki L, Stern T. New products outlook. In: Hetemäki L, editor. Future of the European Forest Based Sector: Structural Changes Towards Bioeconomy. What Science Can Tell Us. Vol. 6. 2014. pp. 43-54

[12] Pettenella D, Ciccarese L, Dragoi S, Hegedus A, Hingston A. NWFP&S marketing: Lessons learned from case studies in Europe. In: Niskanen A, editor. Issues Affecting Enterprise Development in the Forest Sector in Europe. Joensuu: Faculty of Forestry, University of Joensuu; 2006. pp. 367-403

[13] Watanabe C, Naveed N, Neittanmäki P. Digital solutions transforms the forest-based bioeconomy into a digital platform industry—A suggestion for a disruptive business model in the digital economy. Technology in Society. 2018;**54**:168-188

[14] Mubareka S, Jonsson R, Rinaldi F, Azevedo JC, de Rigo D, Sikkema R. Forest bio-based economy in Europe. In: European Atlas of Forest Tree Species. Luxembourg: Publ. Off. EU; 2016

[15] The Institute for Sustainable Development and International Relations (IDDRI). Developing Decarbonization Strategies in the EU: Insights on Good Practice from National Experiences. Paris: IDDRI; 2017

[16] CEPI (Confederation of European Paper Industries). What Digital Can Do

for the Paper Industry. Brussels: CEPI; 2015

[17] Ojala J, Lamberg J, Ahola A, Melander A. The ephemera of success: Strategy, structure and performance in the forestry industries. In: Lamberg J, Näsi J, Ojala J, Sajasalo P, editors. The Evolution of Competitive Strategies in Global Forest Industries: Comparative Perspectives. World Forests. Dordrecht: Springer; 2007

[18] Toppinen A, Wan M, Lähtinen K. Strategic orientations in the global forest sector. In: Hansen E, Panwar R, Vlosky R, editors. The Global Forest Sector: Changes, Practices, and Prospects. New York: Taylor and Francis Group; 2013

[19] Tieto. Introducing Forest Hub: Digitalizing Wood and Fiber Supply. Espoo: Tieto Corporation; 2017

[20] Wesseler J, Von Braun J. Measuring the bioeconomy: Economics and policies. Annual Review of Resource Economics. 2017;**9**:275-298

[21] Ministry of Economic Affairs and Employment of Finland. Wood-Based Bioeconomy Solving Global Challenges. Enterprise and Innovation Department, Ministry of Economic Affairs and Employment of Finland; 2017

[22] UPM. Ecodesigned Products. 2017. Available from: http://www.upm.com/Responsibility/Product-stewardship/ecodesigned-products/Pages/default.aspx [Accessed: August 2, 2017]

[23] Enso S. A Focused Strategy. Stora Enso; 2017

[24] Metsä. About the Bio-Product Mill. 2017. Available from: http://bioproductmill.com/about-the-bioproduct-mill [Accessed: November 12, 2017]

[25] Kaicell F. Responsible Innovation Serving Mankind and Environment. 2017. Available from: http://www.fi.kaicellfibers.fi/kaicell-fibers/ [Accessed: November 10, 2017]

[26] Finnpulp, The World's First Smart Bioproduct Plant. 2017. Available from: http://www.finnpulp.fi/finnpulp-mill.html [Accessed: November 10, 2017]

[27] VTT. The Making of Bioeconomy Transformation. Helsinki: VTT; 2016

[28] Watanabe C, Naveed N, Neittanmäki P. Digitalized bioeconomy: Planned obsolescence-driven circular economy enabled by co-evolutionary coupling. Technology in Society. 2018. In Press

[29] Mistra. Bioeconomy and Digitalisation. Stockholm; 2017