SMART FOOD INDUSTRY

The Blockchain for Sustainable Engineering

Volume II

Current Status, Future Foods, and Global Issues

Eduardo Jacob-Lopes, Leila Queiroz Zepka
Mariany Costa Deprá (*eds.*)

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Volume II - Current Status, Future Foods, and Global Issues

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Preface

Food is fuel for human life on Earth. However, the base for all life depends on a clean and healthy planet.

We move past supermarket shelves and often look for our favorite food products. In a nutshell, most of our decisions are based on convenience, taste, and price. However, unfortunately, sustainability is not always at the forefront of our choices. Even for those of us who wish to live planet-friendly lives.

However, the same fuel that powers humanity also drives it towards global environmental collapse. Currently, it is estimated that the environmental burdens associated with food production are the crucial contributing factor for the ecosystem to approach its planetary limits. Sustainability is no longer a simple trend and has become imperative in the food production chain and industry. There is a resounding call to do good—not just avoid evil.

Notoriously, the food industry is far from sustainable. Nevertheless, options to address these challenges do exist, but they need to be carefully considered. The food industry must strive to go beyond the traditional "do no harm" imperative. While some slight progression—from pure evil to necessary evil—may have been understood in the past, there is a growing expectation and enthusiasm for regenerative and nature-positive food production.

In this transition towards sustainability, we seek to place the food industry in a prominent spotlight. Instead of just being the story rogue, in this new narrative, the food industry—in its most innovative form—takes on the role of a solution, which can reduce food loss and waste, and provide new foods for the future, while becoming environmentally friendly.

Therefore, a more sustainable future applied to the food industries can be achieved, but getting there will not be easy. That is because addressing one sustainability concern can cause another to pop up, leaving food industries playing a never-ending game of "whack-a-mole". Therefore, to win this game, it will be necessary to understand what all the gaps can be filled, considering the levels of commitment of decision-makers, beyond the effectiveness in facing future challenges. After all, the future is uncertain, but to act now, we need to have a good sense of what the world might look like under potentially different paths.

In light of this, this book, *Smart Food Industry: The Blockchain for Sustainable Engineering: Volume II: Current Status, Future Foods, and Global Issues*, reviews the literature and frameworks of sustainable food engineering, aiming to fill the knowledge gap about the future of the food industry. Divided into three parts, this book discusses the (i) status of sustainable food industry; (ii) next generation and future technology for sustainable foods; and (iii) policy, social, economic, and environmental aspects in food industries. Here, the assembled chapters draw on stakeholder input to present a kind of sustainability compass, comprised of a comprehensive set of metrics for food industry assessments. Thus, this book proposes new concepts and strategies to face future sustainability challenges that are on the horizon that can affect and impact future generations.

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Bioeconomy of Sustainable Food Industries

Endang Chumaidiyah, Wuryaningsih Dwi Sayekti* and *Rita Zulbetti*

1. Introduction

World food demand shows an increasing trend—FAO (2018) estimates that food needs for developing countries will increase by 60% in 2030 and double by 2050. The inability to provide global food demand can lead to quite significant problems, namely the food crisis.

Meanwhile, a climate impact study shows that almost half of the world's food production has damaged the environment. The problems resulting from the food production include, among other, the damages to the balance of ecosystems, deforestation, and loss of biodiversity. Therefore, it is necessary to try a new approach of the agricultural system that is less harmful to the environment.

Bioeconomy becomes an approach to achieve transformation towards a more sustainable and equitable food system that seeks to provide healthy and nutritious food, as well as to create livelihood opportunities and reduce environmental impacts. It is in line with the Sustainable Development Goals (SDGs) proclaimed by the UN since 2015 with 17 goals that need to be achieved globally as an effort towards balance in all aspects of the world's people's lives as a whole including the social, economic, educational, health and environmental aspects in a sustainable manner.

2. What is Bioeconomy?

Bioeconomy is defined in various versions: according to the European Union, bioeconomy includes the production of renewable biological resources and their conversion into food, feed, bio-based products and bioenergy. It includes agriculture, forestry, fisheries, food, pulp and paper production, as well as parts of the chemical, biotechnology, and energy industries (European Commission 2012).

Finland, one of the leading countries in the application of bioeconomy, has its own definition. According to Finland, bioeconomy refers to an economy that relies on renewable natural resources to produce food, energy, products and services. This strategy aims to "reduce" the dependence on fossil natural resources, to prevent the loss of biodiversity and to create new economic growth and jobs in line with the principles of sustainable development (MEE 2014).

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In contrast, based on a report titled The Bioeconomy to 2030: Designing A Policy Agenda, OECD countries consider that the application of biotechnology in primary production, health and industry can lead to a new bioeconomy that involves three elements: the advanced knowledge of complex genes and cell processes, renewable biomass, and integration of cross-sectoral biotechnology applications (OECD 2006).

From several definitions of bioeconomy above, it can be concluded that bioeconomy means the sustainable extraction, exploitation, growth, and production of renewable resources from land and sea as well as environmentally friendly conversion into food, feed, fuel, fiber, chemicals, and materials, for being consumed and recycled sustainably (Sillanpää and Ncibi 2017).

According to Biernat (2019), bioeconomy is based on the utilization of renewable resources derived from biological materials to obtain benefits with new characteristics because of:

- Renewable natural resources,
- Resources with low or neutral greenhouse gas emissions,
- Resources that are used repeatedly (cascade) in the production process,
- Resources with high potential for useful properties according to the product's purposes (such as lower or non-existent toxicity, higher stability, higher and stronger durability, limited water consumption, etc.).

This new approach in the field of economics seeks to examine the application of innovation and its combination with industrial biotechnology applications. Activities such as research and innovation, coherent policy and setting bioeconomic strategies at the country and regional level as well as international and cross-sectoral cooperation are indispensable for bioeconomic development. Bioeconomic priorities seek to achieve the economic growth on the basis of traditional and emerging industries. The improvement will be embodied through the creation of new value chains based on the biological origin resources that will deliver the products with high added value to the market.

2.1 The Objectives of Bioeconomy

The objectives of bioeconomy development (e.g., in the European Union) are in line with the Sustainable Development Goals (SDGs), especially for the five objectives as shown in Fig. 1.

Ensuring food and nutrition security

The four pillars of food security from FAO are availability, access, utilization, and stability.

1. Availability: including the indicators regarding food resource supply, food production and storage.
2. Access: including the concept of physical and economic access to food.
3. Utilization: indicators for the sufficient food quality and quantity
4. Stability: indicators of the stability of the above components.

To ensure the food and nutrition security, the four components above must be available in such a way that none of the factors can adversely affect the others. For example, an individual may have adequate economic status but may be at risk of becoming food insecure if an event that reduces the availability of food resources or limits physical access to those resources occurs.

Managing natural resources' sustainability

The second objective refers to the conservation, protection and restoration of ecosystems, as well as the sustainable management of primary production systems, with the aim of maintaining the healthy and resilient ecosystems. The European Union's 2018 Bioeconomic Strategy states that managing natural resources sustainably is more important than ever in today's context of increasing the

Figure 1. The Objectives of Bioeconomy Development. Adapted from (Giuntoli et al. 2020, Wohlfahrt et al. 2019).

environmental pressures and biodiversity loss. Furthermore, actions are needed to avoid ecosystem degradation, to protect natural capital, to restore, assess and enhance ecosystem functions, which in turn can improve food and water security, and contribute substantially to climate change adaptation and mitigation through "negative emissions" and carbon sinks.

Reducing dependence on non-renewable and unsustainable resources

The goal is achieved from various aspects of economic development, policy instruments, community governance, and a special focus on the rural area economy.

Mitigating and adapting to climate change

There are several key components that are indicators of the importance of mitigating and adapting to climate change in all value chains and in all sectors (Giuntoli et al. 2020).

1. Indicators related to climate change mitigation efforts, for example: carbon balancing due to bioeconomy sectors.
2. Indicators related to adaptation to climate change, in natural ecosystems through the specific management actions (for example: species/plant selection as the function of future environmental constraints).
3. Referring to resilience and adaptation in the built environment if it involves a biomass component (for example: urban trees, green roofs, etc.).

Strengthening competitiveness

Bioeconomy support strengthening competitiveness through sustainable production and consumption along the value chain, as well as the principles of a circular economy focuses on the resource efficiency, energy efficiency, waste reuse, and waste treatment.

2.2 Sectors in Bioeconomy

The European Commission lists the sectors that make up the entire bioeconomy. The sectors considered are directly related to the Nomenclature Statistique des activités économiques dans la Communauté européenne (NACE) system.

Bioeconomy industry can be broadly divided into three distinct types of economic activities (Kardung 2019):

1. Natural resource-based activities that directly utilize the biological resources (agriculture, forestry, fisheries) and provide biomass as the input to other industries.
2. Conventional activities to further process biomass from food, feed, tobacco, beverages, wood and wood products, textiles, apparel, leather, paper and pulp, furniture.
3. New activities to further process biomass and/or biomass residues from food, feed, tobacco, beverages, wood and wood products, textiles, apparel, leather, paper and pulp, furniture or to use processing residues from biorefineries, biofuels, chemical based bio, bio-based plastics, and biogas.

For a more detailed description of these sectors, see Table 1.

3. Food and Agriculture

Food is a basic human need, therefore its history is as long as the human life. At first, the human need for food was only met by taking the food around him. The increase in human population resulted in insufficient food supply in nature, and this is where agricultural activities began. Agriculture is defined as the activity of managing biological natural resources with the help of technology, capital, labor, and management to produce agricultural commodities that include plants and animals that are useful for meeting human needs. Formerly, agriculture only discussed how to produce plants and animals. The definition of agriculture is developing, as presented by Zocca et al. (2018) that agriculture includes a very broad sense, and refers to almost all the basic instincts of human life such as the ability to produce food to satisfy hunger and the sustainability of species.

To fulfill hunger and sustain species, agricultural activities focus on food commodities, although in the end also other commodities are needed by humans. In other words, it can be said that human life can continue if agricultural activities exist. The success of agriculture is indicated by the world freedom from hunger as stated as one of the goals of the SDGs, namely zero hunger.

At the beginning, hunger was simply stated as insufficiency to meet the energy needs for human life, but the concept of hunger later developed into the concept of food security. The concept of food security also continues to develop. Starting from only focusing on the side of food production and consumer purchasing power of available food, it then developed on the consumption side and quality of life. The more comprehensive concept of food security is in line with the agricultural objective presented by FAO in 2015 that agriculture does not only grow food crops but also grows healthy and nutritious food to create a well-nourished population. The realization of good resilience is not only providing sufficient food for the community but also how humans can obtain food for a healthy life. Globally, FAO in 2003 stated that food security consisted of four pillars, namely supply, accessibility, utilization, and stability. The linkage among the four pillars of food security can be seen in Fig. 2.

Table 1. Description of the Bioeconomy Sector.

Broad Sector Code	Aggregated Sector Code	Description
Primary agriculture (Agri)	Cereal	Cereals (paddy rice, wheat, barley, maize, other cereals)
	Veg	Vegetables (tomatoes, potatoes, other vegetables)
	Fruit	Fruits (grapes, other fruits)
	Oilseeds	Oilseeds (rape, sunflower, and soya seeds)
	OilPlant	Oil plants (olives, other oil plants)
	IndCrop	Industrial Crops (sugar beet, fiber plants, tobacco)
	Ocrop	Other crops (live plants, other crops)
	ExtLiveProd	Extensive livestock production (live bovine, sheep, goats, horses, asses, mules)
	IntLiveProd	Intensive livestock production (live swine, poultry)
	OliveProd	Other live animals and animal products
	RawMilk	Raw milk
	Fishing	Fishing
Food processing (Food)	AnFeed	Animal feed, fodder crops, biodiesel by-product oilcake
	RedMeat	Red meat (meat of bovine, meat of sheep, goats)
	WhMeat	White meat (meat of swine, poultry)
	VegOil	Vegetable oils
	Dairy	Dairy
	Rice	Rice, processed
	Sugar	Sugar, processed
	OliveOil	Olive oil
	Wine	Wine
	BevTob	Beverages and Tobacco
	OfoodProd	Other food products
Bio-mass supply (BioMass)	EnergyCrops	Energy crops
	Pellet	Pellets
	Forestry	Forestry, logging, and related service activities
Bioenergy (BioEne)	BioElectricity	Bioelectricity
	Biofuel1	Biofuel 1st generation (bioethanol, biodiesel)
	Biofuel2	Biofuel 2nd generation (biochemical and thermal technology biofuel)
Bio-industry (BioInd)	Wood	Wood products
	Textile	Textiles, wearing apparel and leather
	BioChem	Biochemicals
Nonbio-based activity (NonBio)	NatRes	Natural resources (coal mining, petroleum, and coal, raw minerals)
	Energy	Energy (electricity and gas)
	Manu	Manufactures
	Service	Services

Sources: Fuentes-Saguar et al. 2017

From Fig. 2, it can be seen that food supply for the population can be obtained from production and imports; a region imports food if the food production in the region is insufficient. The adequacy of food production in the region for its population is influenced by various production factors which include, among others, land, labor, capital and technology, as well as infrastructure.

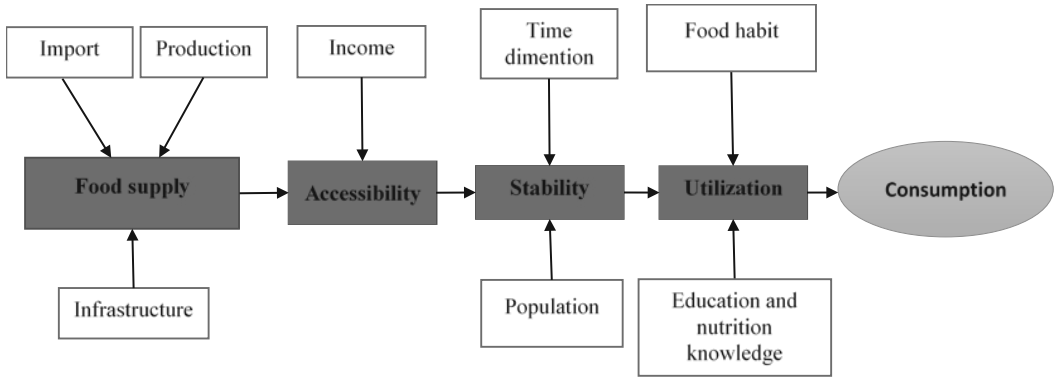

Figure 2. The Linkage of Four Food Security Pillar.

The adequacy of food supply in an area does not guarantee that all residents can access the food properly, as it is influenced by several factors. Accessibility to food can be divided into two, namely physical access and economic access. Physical access is related to the food distribution system-how food are distributed in the entire area. This is related to the transportation system in the area. Economic access is related to the purchasing power of the population, where purchasing power is determined by income and food prices.

The next pillar in the food security system is stability that indicates the ability of the system to maintain its optimum condition over time. In this case, it is related to time which is identical to change, the difference in time will have implications for changes in the system. Therefore, efforts to manage changes with respect to time will determine the assurance of whether the system will run well.

Accessibility to food that is maintained over time will determine the utilization of that food that is manifested in food consumption. Food utilization is influenced by individual factors that determine whether the food that is accessed is used properly. Some of these individual factors include eating habits, education, and knowledge of nutrition.

The aim of agriculture is to grow healthy and nutritious food to create a well-nourished population, then the extent to which this agricultural goal is achieved can be seen from the nutritional state of the population. Carolan (2022) states that based on a measure of calorie/energy hunger, it is known that in 2017 as many as 800 million people (1 in 9) people in the world suffer from malnutrition. The nutritional condition of the world's population is summarized from the FAO report. Richie et al. (2018) state that there are about one billion people suffering from protein deficiency, a third of children under five suffer from stunting, and more than two billion suffer from micronutrient deficiencies. However, there is a paradox as there are more than two billion people suffering from obesity.

The paradox of the nutritional status of the population as described above shows that the world will continue to face the nutritional problems. The problems of undernutrition will be faced by many low-income countries, while high-income countries face nutritional excess. This condition also occurs among the income groups of people in an area.

The OECD (2017) states that the increasing productivity of various agricultural commodities over time in developing countries will result in the increase of production, the decrease of prices, and stimulated consumption. However, the increase in food supply and income has only a small impact on food security, both globally and within ASEAN countries. This fact shows that efforts to achieve the good food security are not enough with the conventional agricultural development approaches.

The conventional agriculture is the agriculture of the past, which is in accordance with the description of most people that when they hear the word agriculture, it is synonymous with the conditions of low education and heavy physical work in cultivating land, but earning inadequate

income. The conventional agriculture then changed globally, where food and agriculture are in a system called the agri-food system. The system includes the Input Sector, Production Sector, and Processing-Manufacturing Sector. Beierlein et al. (2008) mention that the Agri-food System is still working; in the current economic conditions, the system is becoming more interdependent than in the past, and it will continue into the future.

Because of food, energy, and financial crisis in 2008, there is a growing interest in the increasing use of bioenergy and biofuels to reduce pressure on demand for energy from fossils. The researchers further explored the shift towards bioenergy from fossil energy. The shift has wider implications for the transformation of the food system, that is from food-based economy to bioeconomy (Babu and Debnath 2019).

4. Bioeconomy and Food Security

The definition of bioeconomy has been elaborated in the previous section that there are several key words if the bioeconomy is associated with food security. Some of these keywords include: renewable resources, biological technology, conversion into food, feed, and products based on biological resources, and the scope is agriculture, forestry, and fisheries.

Besides having positive potentials for food security, bioeconomy is also known to have negative ones. Bioeconomy problems in food security occur if the use of biofuels causes an unstable food supply, especially if the price of agricultural products results in energy prices to fluctuate rapidly.

The link between bioeconomy and food security can be explained by integrating bioeconomy into the agri-food system and its relation to the pillars of food security in Fig. 3.

The integration of bioeconomy into the agri-food system occurs in two sectors within the system; the food production and the food processing and manufacture sector. The first sector includes the input sector because it is a component of the production sector. Examples of bioeconomy activities in the production sector are the applications of biotechnology and tissue culture in obtaining superior seeds and organic pesticides and the use of organic fertilizers. In addition to that, the hydroponic cultivation is also the application of bioeconomy principles in the food production sector.

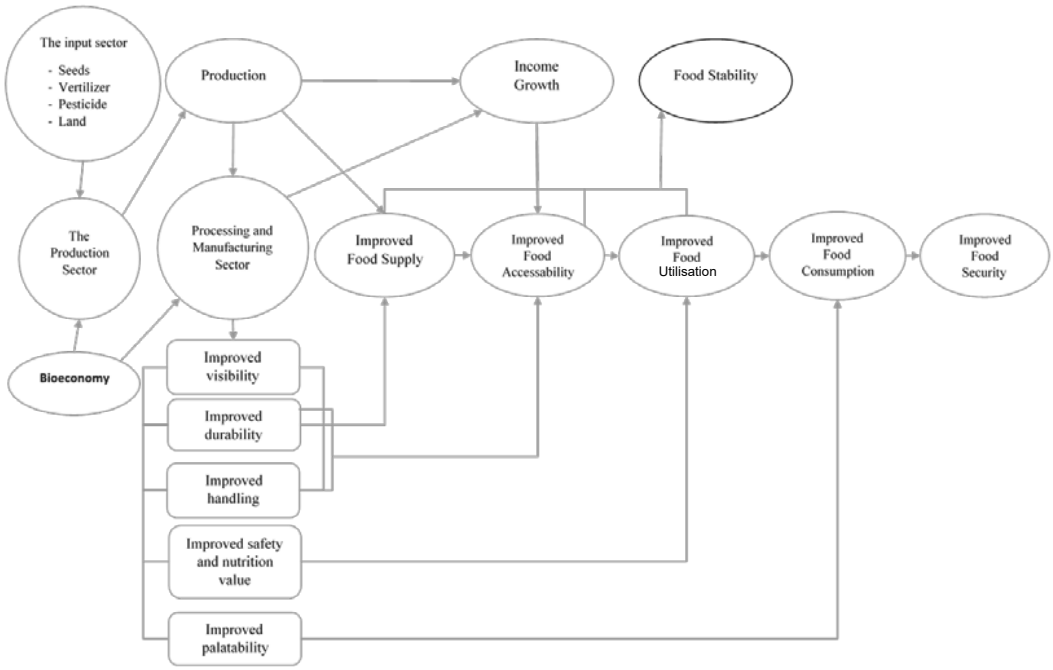

Figure 3. Integration of The Agri-Food System with The Pillars of Food Security.

The application of biological technology will improve the food production both in quantity and quality. The improved food production will directly increase the availability of food, both in the form of fresh food and processed food that results from processing fresh food into intermediate products and final products.

The use of biological technology in food processing, for example, is the use of microorganisms in the manufacture of cheese, yogurt, and the modified cassava flour-mocaf. Food processing will improve food variability, durability, handling, safety and nutrition value, and palatability. Processed food which are easier to handle, more various, and more durable will increase the food availability for the community. The availability of good food will increase people's physical accessibility to food.

In addition to increasing the availability of food in the community, the increase of food production and the improvement of food processing will improve the community's economy. The community economy improvement will increase the purchasing power, and in the end, increase people's economic access to food.

Food processing will improve safety and nutrition value. This condition improvement will provide opportunities for the increasing consumption of this food by individuals. They will choose foods that are considered safe and meet their nutritional needs.

People's food habits have evolved from time to time. This evolution will have implications for changing consumers' food preferences. They will choose the food that is considered adequate to their needs. Good food processing will be able to meet consumer preferences that results in better food consumption.

From the aforementioned description, it is clear that the application of bioeconomy principles in the agri-food system will have an impact on various pillars of food security in the food security system. The stable conditions of food supply, food accessibility, food utilization, and food consumption will have an impact on the food security status of the community.

5. Food Industries

The food industry is one of the sectors in the agri-food system. There are two types of companies in this sector: commodity processors and food manufactures. The food industry will provide food based on the consumers' preferences at the right time and place.

In general, industry is defined as an effort, process or activity of processing raw materials, either raw or semi-finished, so they become goods with better economic value and benefit the community. The term industry is identified with all human economic activities that manage raw goods or raw materials into intermediate goods and finished goods. Raw materials in this case can be various kinds, including food. The food industry is a form of business type in which there is a food production process which includes the selection of raw materials, food processing, food quality testing, packaging, and food distribution activities.

According to Beierlein et al. (2008), food processors take the agricultural products from producers (for example: milk, livestock, wheat) and process them into more acceptable forms by consumers or the food industry (such as pasteurized milk, packed meat, and wheat flour). The characteristics of commodities are generally still visible at the end of the processing. Food manufactures mix the raw (intermediate) agricultural products and process them together into products, for example bread, jam, and corned beef. The purpose of the food industry is to provide food according to the time, place, and form desired by consumers. Zocca et al. (2018) state that the broader purpose of the food industry besides consumers is also aimed at the community, that is to provide safe, healthy, nutritious, economically accessible food, and sustainable food production. Figure 4 illustrates the scope and objectives of the food industry.

Agricultural products in the form of plants and animals can be consumed in a natural state or need to be processed in the food industry so that they can be consumed or stored for a longer time. Consumers choose food based on a number of factors which are generally included in quality

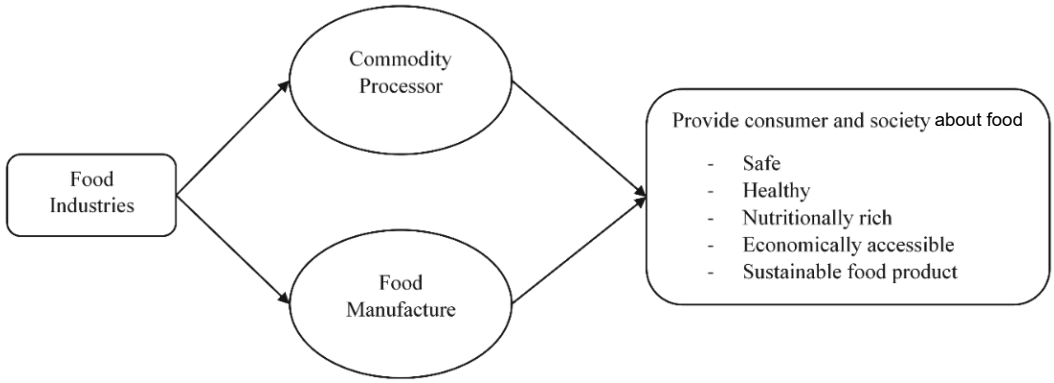

Figure 4. The Scope and the Objectives of the Food Industry. Adapted from Beierlein et al. (2008) and Zocca et al. (2018).

terminology (Tzia et al. 2016). Although the quality is the most essential in the food industry, it is difficult to define it due to the variation in consumers' food expectations. Food preference is determined by many factors including age, religion, culture, social, psychological, and health as well as the expectations of the look, texture, aroma, and flavor. The food processing industry in general is complex, diverse, and requires various techniques to meet consumers' increasingly complex demands. In line with it, the process innovation is compulsory in the food industry.

Food processing can be classified into the chemical, physical, and biological processings. Apart from this, there are also many big issues that affect food processing, including the use of genetic molecules with the use of GMOs (Genetical Molecular Organisms) and the use of animal cloning. The use of biological components in food processing, including the use of GMOs and animal cloning (although it is still controversial) is a bioeconomy implementation in food processing.

Schaschke (2018) says that the main process for producing food that meets biological standards and is acceptable in terms of quality for consumption include mechanical processes, heating, cooling, and fermentation. Fermentation is one of the bioeconomy processes. Several food processing processes are described in the following sections:

5.1 Mechanical processes

Some raw food materials require a mechanical process at the beginning of the process; for example, the process of reducing the size in the cutting process of apples or fruit containing tannins will result in a brown color on the material surface. Another mechanical treatment is filtration and centrifugation, which is used to separate liquid from solid. The last mechanical treatment is protecting packaging like cans, jars, and plastic sachets. They protect food from damage, organisms, dust, and mechanical damage.

5.2 Heating

Heating is intended to eradicate pathogenic and other destructive microorganisms. It is also intended to reduce humidity resulting in physical and chemical changes. Heat treatment and temperature regulation are carried out in various ways, including sterilization and pasteurization.

5.3 Mixtures and Emulsions

Most food is consumed in mixed forms. Mixing is essential to induce the desired reaction. Emulsification occurs when two liquids do not dissolve in each other producing unwanted droplets. To avoid it, an emulsifier is used.

5.4 Novel Food Processing

Novel Food is defined as food that has not received appreciation for consumption or has never been processed before. An example of this new food processing is the use of high pressure. Recently, consumers generally expect high quality food with minimal processing, free of additives, and highly nutritious. Fortunately, this high-pressure processing has unique effects that fulfill the aforementioned consumers' expectation.

6. Bioeconomy and Food Industries

The definition of bioeconomy was presented at the 2018 Global Bioeconomy Summit. Bioeconomy is the production, utilization and conservation of biological resources, including science, technology, and innovation, to provide information, products, processes and services in all economy sectors with the aim of achieving economic sustainability. Although definitions vary in the side of academics, government, and industry, in principle, bioeconomy is an effort to manage biological resources in a sustainable economy for the welfare of the community while preserving the natural environment.

The current world population reaches 7.8 billion in 2022 as reported by the United States Census Bureau. The population will keep increasing every year and this is a challenge, especially in terms of providing food which is the basic need of the world community. Additionally, the increasing population also requires wider land area for the settlement. This results in a decrease in agricultural land due to the function conversion to residential and industrial needs. Population growth, limited land, and the carrying capacity of the natural environment raise not only various problems but also ideas to overcome them and bioeconomy approach is one of them.

Bioeconomy or bio-based economy is related to the use of biological resources and their substitutes to produce energy, food, feed, fiber, and other production goods by applying biological processes (BMBF 2011). It includes various sustainable economy activities in the fields of agriculture, fisheries, forestry, and other biological resources by taking into account the environmental factors. The outputs of the various activities become sources of raw materials for the food industry that produces various kinds of food and beverage products as shown in Fig. 5.

Food and feed production is a top priority in formulating strategies and action plans for the use of natural resources efficiently and sustainably. Efforts to increase agricultural productivity, land management, logistics, and storage techniques can increase the efficiency of the food and feed supply chain. However, they are not enough. Efforts are also needed to utilize the agricultural waste or by-products that can be used as raw materials to produce other products (Trigo et al. 2021) so it leads to zero waste or environmentally friendly processes.

Agriculture, fisheries, livestock and forestry industries are generally located in rural areas where the nature supports these activities. In the production activity, the processing of biological resources involves the surrounding community who work in the field such as a large number of farmers or ranchers who form a community. Being farmers or ranchers are the livelihoods of people living in rural areas. Both are their source of income in meeting their economic needs.

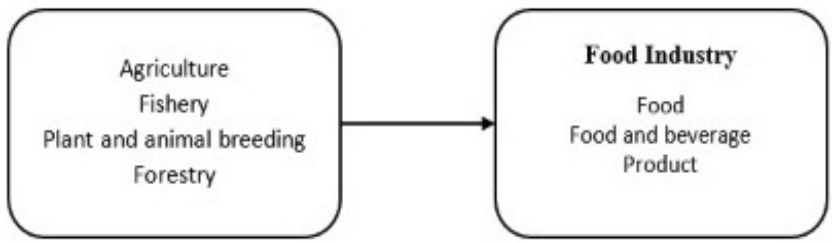

Figure 5. Material Supply Food Industry. Adapted from (Kristinsson and Jorundsdottir 2019, Robert et al. 2020, von Braun 2018, Wohlfahrt et al. 2019).

To illustrate, a dairy farming community that produces fresh milk in a rural area in West Java, Indonesia involves around 2,600 dairy farmers and manages around 4,000 cows. The farmer community forms a Cooperative to collect fresh milk produced by farmers using Milk Collection Point (MCP) technology to maintain the quality of fresh milk according to the standards set by the Dairy Processing Industry. As a manufacturing company in the field of milk processing, the Dairy Processing Industry produces various dairy products and their derivatives and the raw materials are supplied by dairy farmers. This Dairy Processing Industry is a food industry that supplies dairy products which are one of the basic needs of the community in meeting their nutritional needs.

The processing output of agriculture, fishery, plant and animal breeding, and forestry as the supplier of raw materials is needed by the food industry in producing various food and beverage products. In general, the fields of agriculture, fishery, plant and animal breeding, and forestry involve a large number of farmers, breeders, or others so it tends to be labor intensive, while the food industry is generally managed by several companies as a manufacturing industry with adequate capital and is managed more professionally.

7. Bioeconomy and Food Industries System

The concept of bioeconomy is a comprehensive approach in meeting the increasing world food demand sourced from the renewable resources by taking into account economic and social factors, as well as climate change.

Bioeconomy and food industries are interrelated to form a value chain system starting from natural resources to food and beverage products to meet community's basic consumption needs. The bioeconomy and food industry system as shown in Fig. 6 forms a sub-system that is interconnected with one another to form an integrated supply chain system by also taking economic, social, environment and SDGs factors into account.

Resources are production factors that are used as the facilities and infrastructures in the transformation process from inputs to outputs to create added value. The resources are needed in every transformation in the system, from the bioeconomy process, downstream logistics, food industry, and upstream logistics, before finally arriving at consumption.

The logistic system in the bioeconomy consists of downstream and upstream logistics (Kristinsson and Jorundsdottir 2019, Robert et al. 2020). The bioeconomy and food industry system involve a strong and efficient logistic system as a supply chain starting from raw materials, semi-finished materials, to finished products that are ready to be distributed to meet the community needs. The logistic system consists of downstream and upstream logistics, each forms a supply chain starting from distributors, retailers, agents, to local trading. The logistic system is a series of interrelated activities including planning, implementing, and supervising the process of moving goods.

In the end, all production results in the form of food and beverages will be distributed to meet people's consumption needs. This consumption forms a balance pattern between supply and demand as a price determinant. The increasing world population has resulted in an increase in demand for the food and beverage products as a basic need. The market mechanism will encourage producers with more efficient processing processes to have the opportunity to dominate the market because they can provide lower prices. People as consumers will choose the food and beverage products for their consumption based on the considerations between the offered quality and price.

The bioeconomy and food industry system is in line with the Sustainable Development Goals (SDGs) put forward by the United Nation which was agreed by 193 countries with the targets and indicators published in 2017. The SDGs contain 17 important points, namely: (1) No Poverty, (2) Zero Hunger, (3) Good Health and Well-being, (4) Quality Education, (5) Gender Equality, (6) Clean Water and Sanitation, (7) Affordable and Clean Energy, (8) Decent Work and Economic Growth, (9) Industry, Innovation and Infrastructure, (10) Reduced Inequality, (11) Sustainable Cities

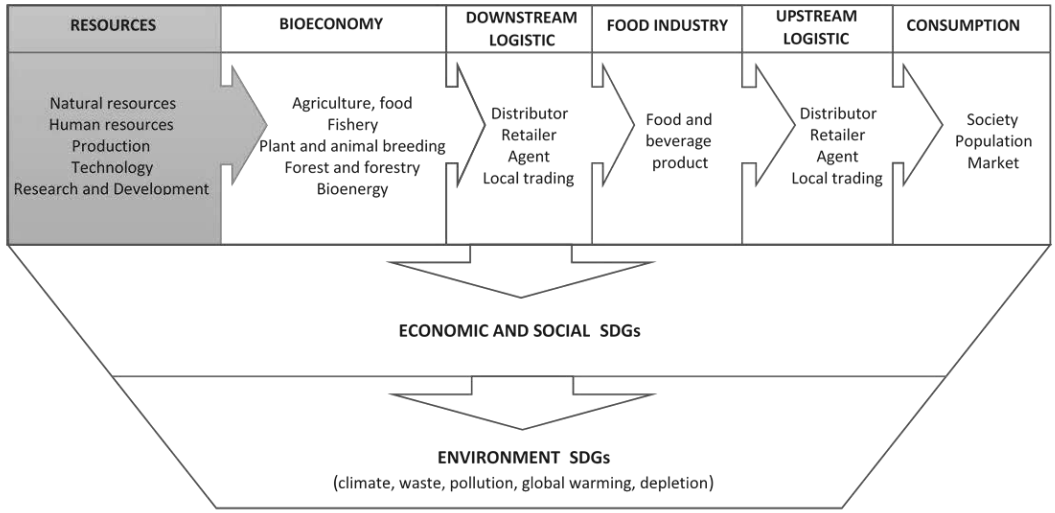

Figure 6. Bioeconomy and Food Industries System.

and Communities, (12) Responsible Consumption and Production, (13) Climate Action, (14) Life Below Water, (15) Life On Land, (16) Peace, Justice, and Strong Institutions, (17) Partnerships for the Goals. All the 17 points in the SDGs are related and aligned with the bioeconomy and industry system.

The transformation of the whole process in the system supports the quality of life activities of social community according to the SDGs (1, 2, 3, 4, 5, 10, 11, 16, 17), and has an impact on the community's economy according to the SDGs (8, 9, 12) especially in the increase of economic growth. In the bioeconomy and food industry system, the interaction among all processes in the system ultimately has an impact on the environmental factors such as the SDGs (6, 7, 13, 14, 15).

The bioeconomy and food industry system is an integrated system that is interrelated among its sub-systems consisting of natural resources, bioeconomy, downstream logistics, food industry, upstream logistics, consumption, economic and social, and environment. Each sub-system in the bioeconomy and food industry system is described in the following sub-chapters.

7.1 Natural Resources

Natural resources are everything coming from nature that can be used to meet the needs of human life. The existence of natural resources is not evenly distributed on Earth—some countries have abundant biological and non-biological resources (Venables and Anthony 2016). However, the wealth of natural resources is often not in line with the economic level of the countries; it happens when they are not able to process them using adequate technology.

Based on their nature, natural resources are classified into renewable and non-renewable natural resources. The renewable natural resources are natural resources that continue to exist as long as they are not overexploited, for example plants, animals, microorganisms, water, wind, and sunlight. Meanwhile, the non-renewable natural resources are natural resources whose formation takes thousands of years so that they are limited in number, for example oil, gold, iron, and various other mining materials.

The food industry is generally related to the further manufacturing processes of agricultural, fishery, animal husbandry products, which are classified as the renewable natural resources. To achieve maximum results, processing with modern technology is required to produce a high level of efficiency.

7.2 Human Resources

Human resources are individuals who work as movers, thinkers, and planners in carrying out organizational activities (Mathis and Jackson 2003). Human resources are the key determinants of business progress and success; therefore, adequate competencies are needed and they need to be trained and developed.

The definitions of human resources can be divided into two: micro and macro. The definition of human resources in a micro sense is individuals who work and become members of a company as employees, laborers, workers and so on. Meanwhile, the definition of macro human resources is the population of a country who have entered the age of the workforce, both those who have not worked yet and who have already worked.

Human resources in the micro sense generally refer to workers and employees who work formally for companies in the fields of agriculture, animal husbandry, and plantations. In downstream logistics, food industry, and upstream logistic companies, workers will be involved to carry out their business activities. Manpower deployment is carried out in accordance with the competencies required by the company which is carried out formally in accordance with the applicable labor laws.

Human resources in the macro sense are partly people of working age who are in the locations where natural resources exist and who have the opportunity to process natural resources in the vicinity. The process of natural resources was initially carried out conventionally and from generation to generation by the people who were in the location of these natural resources with limited competence. Even though they are a source of community livelihood, the process of natural resources is not optimal if the competencies are inadequate. It is one of the reasons why the location of the existence of natural resources is not in line with the income of people with low economic levels.

The increase of human resource competence, especially those around natural resources, is indispendable, so the processing of natural resources can be carried out efficiently and involves the surrounding community such as farmers, breeders, and others. The professions can even be passed on to the next generation in the processing of natural resources. It is a sustainable economic cycle that needs to be developed with a breakthrough in increasing human resource competencies.

7.3 Production and Technology

The production process in the food and beverage industry is currently moving towards the industry 4.0 with the concept of a smart industry where all elements are connected to electronics (Demir and Istanbullu 2020). The production process in the industrial revolution 4.0 is carried out with digital transformation to support more agile business processes with orientation to technological, human, and cultural aspects. The application of the industry 4.0 in the food industry has challenges in converting machines into automations and robotics where the production machines need to be integrated with an Artificial Intelligent (AI) system.

The utilization of modern technology in the natural resource management has been started since the industrial revolution era. Processing natural resources with technology is proven to be able to provide more results in a shorter time. In the fields of agriculture, fisheries, and plantations, the use of technology increases productivity so it has been able to meet the increasing demand for food up to the present day.

Smart Farming 4.0 is a technology-based intelligent farming method that uses several agricultural technologies including automatic watering, drone sprayers (drones for spraying pesticides and liquid fertilizers), surveillance drones for land mapping, as well as soil and weather sensors. The existence of installed soil and weather sensors on agricultural land will assist farmers in obtaining data about their crops. The obtained data from the sensors include air and soil humidity, temperature, soil pH, water content, rainfall, and wind speed. The data can be used to monitor the condition of their land. The precise use of the technology helps farmers improve the quality and quantity of their crops.

Internet of Things (IoT) in agriculture is in the forms of sensor technology for water use, sensors to detect pest attacks, as well as sensors to determine environmental emissions. With the application of such technology, the agricultural output can be increased rapidly and accurately. In addition, IoT can make production areas' monitoring easier since it is connected to smartphones. The use of IoT can make the precision farming and smart irrigation happen. The use of sensors applied in agricultural land allows farmers to obtain detailed information on topography, fertility levels, acidity levels, soil temperature, and can even measure the weather and predict the weather pattern.

Blockchain is a distributed ledger containing several blocks of detailed transaction records that are connected chronologically to form a chain network. The technology can be used in the food and agriculture sectors to record the state of agriculture, inventories and contracts in agriculture accurately. The blockchain technology can trace the origin of food thereby helping to create a trustworthy food supply chain and building trust between producers and consumers. The technology can also be used to store, process and track the transaction data from the suppliers of raw materials, suppliers of semi-finished materials, to product distribution through the distributors and retailers.

7.4 Research and Development

Research and Development (R&D) is a study to develop new products, processes, or improve existing products (Melissa 2017). This is a way to encourage the development of a broad bioeconomy, due to the development of innovations in products, processes, or systems. The results of Research and Development can be a solution to problems in the processing of natural resources related to the social and environmental impacts. Research and Development involves science, high-level scientific expertise and multidisciplinary to solve the complex problem with various perspective of knowledge to get the best result of the research.

Achieving the transition towards the sustainable, low-carbon, resource-efficient, and recycling bioeconomy requires support from the adequate science and technology. The involvement of scientists and researchers from various fields such as chemistry, biology, biochemistry, economics, agronomy, engineering, medicine, and social sciences is necessary for the success of a bioeconomy concept.

Research and Development activities support the innovations in all processes in the bioeconomy and food industries system, starting from the processing of resources, bioeconomy, downstream logistics, food industry, upstream logistics, to consumption. The produced findings and innovations can be in the forms of big concepts, structural changes, quality improvement, efficiency, and productivity in the whole processes in the bioeconomy and food industry system.

7.5 Economic and Social Impact

Various definitions of bioeconomy link the sustainability of processing the natural resources with economic, environmental and social perspectives; especially from an economic perspective, they are clearly defined by the words 'bio' and 'economy'. The transformation of the whole processes in the bioeconomy and food industry system has the main goal of increasing economic growth. This can be used as a way to increase the sustainable economic growth of a country and this has been studied in the United States, Finland, Germany, Netherland, United Kingdom, and China (Sillanpää and Ncibi 2017).

The implementation of bioeconomy in the food industry requires the investment costs and operational costs which will be calculated by the size of market demand and product prices (Wright and Brown 2007). The economic indicators of the invested capital will be seen from the calculation of the resulted ROI, the profit, net present value, and sensitivity analysis. There are 3 economic aspects related to the SDGs, namely Decent Work and Economic Growth (SDGs 8); Industry, Innovation and Infrastructure (SDGs 9); and Responsible Consumption and Production (SDGs 12).

Social factors are of particular concern in increasing industrial growth, including the food, agriculture, fisheries, and plantations industry. It appears as the reflection of corporate social responsibility on all stakeholders including employees, buyers, investors, government, community (Aguilera et al. 2007), and the environmental sustainability of future generations.

Socially sustainable industries are those that have limited negative impacts on society during production, utilization, recycling and final disposal. Success indicators are related to social dimensions including food security, energy security, employment, inequality, and social welfare (Fleurbaey 2015, Dempsey et al. 2011). Other social aspects also include the respect for land rights, and social acceptance.

In the bioeconomy and food industry system, the social factor is one of the main goals of all processes in the system. It is in line with the SDGs that has 9 points that are mostly related to the social dimension in the bioeconomy and food industry system. The social factors on the SDGs that have the most impacts (9 points) on the ecosystem of bioeconomy and food industry system are as follows: No Poverty (SDGs 1), Zero Hunger (SDGs 2), Good Health and Well-being (SDGs 3), Quality Education (SDGs 4), Gender Equality (SDGs 5), Reduced Inequality (SDGs 10); Sustainable Cities and Communities (SDGs 11); Peace, Justice, and Strong Institutions (SDGs 16); and Partnerships for the Goals (SDGs 17).

7.6 Environment

The environmental impact is a decrease in the quality of the human environment caused by human activities. The processing activities of natural resources including food, agriculture and animal husbandry are one of the causes of the environmental problem emergence. Therefore, it is necessary to make efforts to maintain environmental sustainability. In the bioeconomy and food industry system, the efforts to protect the environment are one of the considerations in the transformation process at the end of the system.

The environmental quality can be monitored from the air quality, pollution, climate, soil, water, solid waste and wastewater processing, gas emissions of greenhouse, biodiversity and wildlife conservation, energy, waste, global warming, and depletion (Ruiz et al. 2012, Tanzil and Beloff 2006). The production and transformation processes need to be carried out in an environmentally friendly manner so they do not cause a decline in the carrying capacity of the environment. It is in line with the SDGs; there are at least 5 points related to the bioeconomy and food industry system, namely Clean Water and Sanitation (SDGs 6), Affordable and Clean Energy (SDGs 7), Climate Action (SDGs 13), Life Below Water (SDGs 14), and Life On Land (SDGs 15).

8. What is Sustainability?

Sustainability is an ability to survive and adapt to changes. In the context of ecology, it means that biological systems are still able to sustain unlimited biodiversity and productivity. This is achieved by means of not utilizing and exploiting natural resources to damage the ecology or ecological balance in the area.

Earth provides food, energy, and materials for the survival of living. For decades, the dependence on fossil resources and derived fuels, chemicals, and materials has resulted in unsustainable economic models that have created complex situations around the world. The demand for raw materials continues to increase, and the depletion of most resources requires humans to think and operate in a holistic sustainable manner, especially by managing abundant fossil resources in an efficient and environmentally friendly manner, especially coal whose reserves are estimated to be available until the end of the 21st century (Mohr and Evans 2009).

Sustainability is basically the result of balancing human needs with available resources to meet the current and future needs without depleting them. Overall, sustainable development is a paradigm built to meet human needs economically, environmentally and socially. In this regard, bioeconomy,

as an economic model based on the utilization and conversion of biomass to produce commodities, is the core of a global sustainable economic strategy.

9. Circular Economy

According to the European Union Parliament, the circular economy is a model of production and consumption which consists of sharing, leasing, reusing, repairing, refurbishing, and recycling existing materials and products. In this way, the product life cycle is extended (European Parliament 2015). In practice, the circular economy implies reducing waste to minimum. When a product is at the end of its use, the product can be reused as productively as possible so as to provide added value. The circular economy is a regenerative system that minimizes the uses of resources, waste, emissions, and excess energy by slowing, closing, and narrowing the energy and material cycles (Geissdoerfer et al. 2017).

The circular economy is important to maintain the availability of raw materials for industry in the midst of the increasing human population, where the raw materials available from nature are limited. In addition, the circular economy can also reduce environmental impacts due to the smart use of raw materials, is able to reduce carbon dioxide emissions, and benefits the economic growth (Hysa et al. 2020).

The bioeconomy has similarities with the circular economy. Some of the similarities are increase of resources with the higher eco-efficiency and lower Green House Gas (GHG) effects. In addition, they also reduce the demand for fossil carbon and lead to the valorisation of waste and side streams (Carus and Dummer 2018).

However, the circular economy is a broader cross-sectoral concept when compared to the bioeconomy. The circular economy strengthens the eco-efficiency processes and uses recycled carbon to reduce the use of additional fossil carbon. Bioeconomy replaces fossil carbon with bio-based carbon from biomass.

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