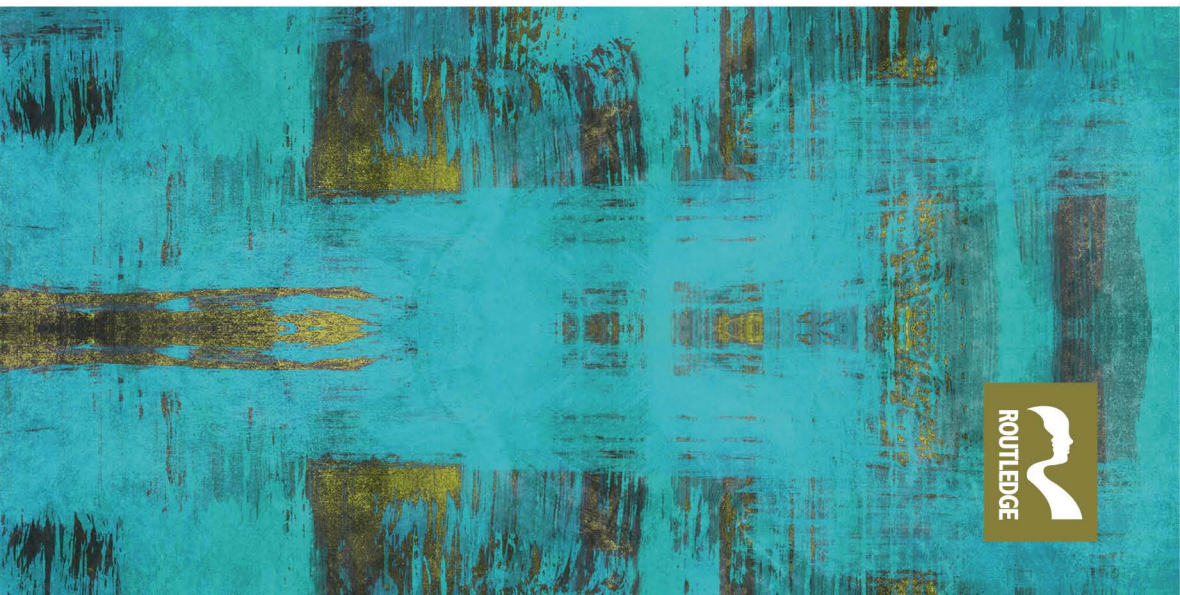
Routledge Studies in Food, Society and the Environment

THE BIOECONOMY APPROACH

CONSTRAINTS AND OPPORTUNITIES FOR SUSTAINABLE DEVELOPMENT

Edited by
Udaya Sekhar Nagothu



'The focus of the book on bioeconomy is highly appropriate at a time when we are faced with the global grand challenges and an ambitious target to meet the sustainable development goals. The book provides an excellent review of the bioeconomy concept, its potentials and constraints, drawing experiences from several countries, covering various disciplines and sectors including agriculture, forestry and fisheries.'

Olaug V. Bollestad, Minister of Agriculture and Food, Norway

'This timely book provides potential pathways for successful implementation of sustainable bioeconomy, through comprehensive coverage of relevant sectors in various parts of the world. This is in line with United Nations University's expectations on bioeconomy to be a resort for environmental, social and economic sustainability.'

Taikan Oki, Senior Vice-Rector, United Nations University, Japan

'This book makes a timely and innovative contribution towards understanding the relevance and practicality of bioeconomy, its concept, principles and best practices, towards achieving Sustainable Development Goals, including Zero Hunger. It deserves to be read and used widely!'

Hans Dreyer, Director, AGP, Food and Agriculture Organization of the United Nations

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The Bioeconomy Approach

This book examines the bioeconomy concept, analysing the opportunities it can generate, the constraints and the potential benefits for society.

The main objective of bioeconomy is to promote economic development, by creating jobs and enhancing the sustainable utilization of bio-resources. A primary driver of bioeconomy strategy, therefore, is the need to respond to the growing population's food and economic requirements. While today research and literature related to bioeconomy are limited, this book presents a unique collection of perspectives on the complex dimensions of the bioeconomy debate. Drawing on the experiences from Europe, Asia and Africa, it presents an international overview. The chapters address a wide range of issues, including coastal-land interactions, ecosystem services, food production, rural development, agriculture, forest management and bioenergy. As a whole, the volume outlines what role bioeconomy can play in contributing to the United Nations Sustainable Development Goals (SDGs) without compromising on the ecological sustainability and equitable distribution of benefits. The book concludes by providing recommendations for developing bioeconomy in respective sectors (agriculture, forestry, fisheries, renewable energy) and directions for planning future bioeconomy programmes and strategies.

The Bioeconomy Approach will be of great interest to students and scholars of ecological economics, development economics and environmental economics, as well as policy-makers and practitioners involved in sustainable development.

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The Bioeconomy Approach

Constraints and Opportunities for Sustainable Development

Edited by Udaya Sekhar Nagothu

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Preface

At a recent UN summit, one of the world leaders asserted: 'For us, sustainability is the navigation instrument, the compass into the future.' Unless sustainability becomes a fundamental criterion in policy and practice in the future, protecting the Earth's resources for future generations will not be possible. We have no other option but to follow the sustainable development path to address the grand global challenges we are facing today. At the same time, we must be optimistic, as it is necessary to sustain and improve the quality of life, mitigate future climate risks, and protect the environment. The sustainable bioeconomy approach has gained importance over the last decade among scientists and policy-makers as one of the most promising alternative paradigms to address the sustainable development goals. However, one must be careful with the environmental and social risks associated with new paradigms. The fundamental premise should be to ensure healthy livelihoods in a healthy ecosystem.

This interdisciplinary book attempts to clarify the bioeconomy concept and analyses the associated risks and opportunities. It further highlights the multi-dimensional benefits of sustainable bioeconomy development, including circular bioeconomy. As the impacts of the bioeconomy spread beyond local and regional borders, a common agenda is necessary to keep a balance between the economic, environmental and social sustainability goals.

The various chapters in the book drafted by 41 experienced researchers and consultants from several disciplines, representing 28 agencies worldwide, bring together diverse experiences. The book covers cases from biomass production from the ocean, agriculture, forestry and bioenergy. Several chapters in the book highlight relevant sustainability indicators, including the Human Development Index, net primary production, the local ecological footprint, soil organic carbon and other ecosystem services that can help in monitoring sustainability impacts of bioeconomy initiatives. The book will be useful to a wide range of audience including scientific community, development agencies and policy-makers.

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I would like to thank all the contributors of the various chapters in the book, particularly the lead authors who have spent time coordinating and drafting the chapters.

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I would also like to thank Dr Takanori Nagano for his support during the compilation of the book manuscript.

Abbreviations

ACISAI	Asian Centre of Innovation for Sustainable Agriculture Intensification
AD	anaerobic digestion
AIT	Asian Institute of Technology
APHRODITE	Asian Precipitation–Highly-Resolved Observational Data Integration Towards Evaluation of Water Resources
ASC	Aquaculture Stewardship Council
AWD	Alternate Wetting and Drying
BBE	bio-based economy
BCDP	the Bioeconomy Community Development Programme
BCR	benefit-cost ratio
BIC	Bio-Based Industries Consortium
BID	bioeconomy domain
BTP	the Bioeconomy Transformation Programme
CASA	Carnegie–Ames–Stanford Approach
CAZ	carbon accumulation zones
Cb	carbon
CE	circular economy
CID	Centre for International Development
CSA	climate-smart agriculture
CSO	civil society organization
DF	discount factor DF
DHA	docosahexaenoic acid
DOM	dissolved organic matter
DST	Department of Science and Technology
EF	Ecological Footprint
EPA	eicosapentaenoic acid and
ETG	Export Trading Group
FAO	Food and Agriculture Organization
Fe	iron
FFS	Farmers Field School
FISP	Farm Input Subsidy Programme
FIT	Feed-in Tariff

FOLU	Food and Land Use Coalition
GA	Göksu anthroscape
GCF	Green Climate Fund
GDP	gross domestic product
GEF	Global Environment Fund
GFBF	Giant Fish-Breeding Forest
Gha	global hectares
GHG	greenhouse gases
GI	Geographic Indication
GTZ	German Agency for Technical Cooperation
HA	humic acid
HDI	Human Development Index
HNLC	High Nutrient Low Chlorophyll
ICERD	Centre of Initiatives on Community Empowerment and Rural Development
IFES	Integrated Food and Energy Systems
IKS	indigenous knowledge systems
INRAB	Institute of Agricultural Research of Benin
IPBES	Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services
IPM	Integrated Pest Management
IRR	Internal Rate of Return
IRRI	International Rice Research Institute
IUCN	International Union for the Conservation of Nature
IWG	Inter-Ministerial Working Group on Bioeconomy
KBBE	Knowledge-Based Bio-Economy
LE	linear economy
LEDs	light-emitting diodes
LLDPE	linear low-density polyethylene
LMB	Lower Mekong River Basin
MoAIW	Ministry of Agriculture, Irrigation and Water development
N	nitrogen
NASFAM	Commercial National Smallholder Farmers' Association of Malawi
NDVI	normalized difference vegetation index
NGO	non-governmental organization
NPIW	North Pacific Intermediate Water
NPK	phosphorus and potassium mix
NPP	net primary productivity
NPV	net present value
P	phosphorus
PC	protected cultivation
PCA	principal component analysis
PCV	protected cultivation of vegetables
PES	payments for ecosystem services

POPs	persistent organic pollutants
PP	payback period
PPP	public–private-partnership
RIHN	Research Institute for Humanity and Nature
RRI	Regional Rice Initiative
RRS	Regional Rice Strategy
S&G	Save and Grow
SAMIS	Strengthening Agro-Climatic Monitoring and Information System
Si	silicon
SI	Sustainable intensification
SIRP	sustainable intensification of rice production
SME	small and medium-sized enterprise
SNV	the Netherlands Development Organization
SOC	soil organic carbon
SRP	Sustainable Rice Platform
SSA	Sub-Saharan Africa
TOC	total organic carbon
UV	ultra-violet
VC	value chain
VSLG	village saving and loans group
WFD	Water Framework Directive

1 The bioeconomy approach and sustainable development

A review of the concept, opportunities and constraints

Udaya Sekhar Nagothu and Takanori Nagano

Introduction

Global challenges, including climate change, food insecurity, economic crises, lack of jobs and political conflicts are driving people to migrate to cities. Outmigration is already changing the social landscape, the population dynamics and politics in various countries in both the developed and developing world. In the long term, this will lead to distress in rural areas and over-population and unemployment in the urban and peri-urban areas. Urbanization may lead to energy savings, efficient infrastructural investment, increased communication and innovation. Thus, the challenges that stem from the rapidly changing physical and social landscapes must be carefully considered in future planning. To address the growing problems, equitable social and economic development and the creation of job opportunities with minimum impact on the environment should be a priority for planners and government agencies (Beddington et al., 2012).

Population growth and the current patterns of production and consumption are fast exhausting the natural resources, degrading ecosystems, and generating waste and pollution at an unprecedented rate. According to some estimates, there will be a need to produce 50 per cent more food and energy to meet the growing demand by 2030 (FAO, 2016a). The mantra of business as usual will no longer be able to address the growing demands and associated global challenges. Future development must be based on strictly responsible, accountable, and sustainable use of natural resources. This brings 'sustainable development' back onto the policy agenda at both the international and national levels of most countries. The United Nations Sustainable Development Goals (SDGs), defined in 2015, thus, provide political legitimacy to national governments to integrate them into their national development plans (UN, 2015).

The United Nations (UN) Sustainable Development Goals

Since the 1950s, there has been significant technological and economic progress on many fronts, but the development has been highly uneven and unsustainable. Addressing the audience at the UN Summit in New York, where 193 countries agreed to achieve the SDGs, the German Chancellor Angela Merkel rightly said: 'For us, sustainability is the navigation instrument, the compass into the future.' The UN believes that achieving SDGs will bring about equitable development across regions and various social groups (UN, 2015). However, there are critics who do not agree that SDGs and the targets set by the UN are easily achievable and believe that they will not be able to provide any legitimate framework for cooperation (Easterly, 2015). However, others are positive that sustainable use of bioresources can help to achieve most of the SDGs that in turn can improve social, economic and ecological conditions (Dietz et al., 2018).

The SDGs in general provide economic and political legitimacy to introduce sustainable business initiatives, based on natural resources, especially in developing countries (Calestous, 2016). However, conflicting national priorities, particularly in developing countries with limited resources, make it hard to divert investments to promote new initiatives. Countries must see addressing SDGs as an opportunity, where new development paradigms such as bioeconomy can play an important role, and, in the process, support the global consensus and provide an international commitment to sustainably manage Earth's resources.

Bioeconomy: definition, scope and development

The European Commission (EC) defined 'bioeconomy' as 'the production of renewable biological resources and the conversion of these resources and waste streams into value added products, such as food, feed, bio-based products and bioenergy' (EC, 2012). The Food and Agricultural Organization (FAO) defined bioeconomy as 'the knowledge-based production and utilization of biological resources, biological processes and principles, to sustainably provide goods and services across all economic sectors' (FAO, 2016b). Another definition considers 'bioeconomy as the sustainable utilization of renewable resources for economic, environmental, social, and national security benefits' (Golden and Handfield, 2014). These definitions have a common terminology emphasizing the *sustainable use of biological or renewable natural resources*. According to Bell et al. (2017), sustainable bioeconomy has the potential to contribute to climate change mitigation, with oceans, forests and soils being major carbon sinks and fostering negative carbon emissions. This book, and particularly this introductory chapter, will attempt to discuss some of the intriguing questions that scientists and development agencies are facing today in the bioeconomy debate: *Is sustainable bioeconomy the right paradigm to address grand global*

challenges? Will it be able to generate jobs and economic growth without any negative impacts on the environment?

According to the Organisation for Economic Cooperation and Development (OECD, 2009), bioeconomy is a knowledge-driven concept that has the potential to contribute to significant global economic, social and environmental challenges in an integrated framework. Bioeconomy is now the European Union's (EU) response to addressing the key global environmental challenges (European Commission, 2013). If managed in a sustainable manner, bioeconomy can simultaneously provide a wide range of public goods, including ecosystem services, as well as providing jobs and promoting new business opportunities. The concept, however, overlaps with similar approaches, such as the 'green economy', but also differs in the sense that it is more regulatory in its approach, and perhaps emphasizes the technical and economic sustainability more and social sustainability less. Recent studies have identified that bioeconomy is a key component in the global sustainability transition (El-Chichakli et al., 2016; Kircher, 2014). However, to achieve sustainable bioeconomy, technical, economic, and social prerequisites are necessary that the bioeconomy itself cannot create (Pfau et al., 2014). This is a huge challenge for developing countries with limited finances, lack of access to technology and inadequate social preparedness. Overall, bioeconomy development will depend on technology advances and sufficient biomass availability (Scarlat et al., 2015).

There are several factors or drivers, including population growth, climate change, food insecurity, increased demand for biofuels and trade, that have influenced governments to adopt the bioeconomy development path so far. The primary driver of bioeconomy in developing countries is the need to respond to their growing population's food and economic requirements, whereas the primary driver is to reduce greenhouse gas emissions (GHGs) and negative environmental impacts in developed countries, as well as to generate economic growth. A study by Langeveld et al. (2010) concluded that the over-use of non-renewable fossil-based resources, and the serious environmental impact this has caused over the years, have become one of the primary drivers for bioeconomy. According to Dietz et al. (2018), the reasons for adopting bioeconomy could be one or a combination of several that include: (1) reducing use of fossil fuels and replacing them with renewable bio-based resources; (2) increasing productivity in bio-based primary sectors (e.g. agriculture, fisheries, forestry, bioenergy); (3) increasing efficiency in biomass use; and (4) to support value chain enhancement of products that could lead to more job opportunities. One of the main challenges will be the replacement of fossil fuels with renewable energy sources that has been happening at a slow pace and is likely to influence the other factors. This can be attributed to lack of follow-up, lack of technology, poor investments and industrial or political lobbies opposing the reduction of fossil fuels.

An associated term, the 'circular economy' (CE) has been gaining importance recently. CE can be defined as 'the value of products, materials and resources maintained in the economy for as long as possible, thus reducing the dependence on new raw materials and the generation of waste minimized' (EC, 2015). Ideally, a CE model reflects the need for the world's population to considerably reduce its material footprint and consumption of natural resources, as described in the UN Sustainable Development Goals (UN, 2015). The two approaches, CE and bioeconomy, are different, but overlap in some respects. CE introduces a differentiation between durable and consumable parts of a product. While durable parts should be maintained in the economy, consumables in the CE should be biological ingredients or at least non-toxic ones, which can go back into the biosphere or be used in the cascade of consecutive uses (Ellen MacArthur Foundation, 2013). CE also demands renewable energy be used to decrease resource dependence (ibid.). The term 'circular bioeconomy' is now being used by the scientific community, business enterprises and policy-makers.

Circular bioeconomy

The 'circular bioeconomy' is defined as the intersection between bioeconomy and CE (Carus and Dammer, 2018). The assumption is that the circular bioeconomy will increase resource use efficiency, reduce waste along the value chain, promote nutrient cycling, and provide access to basic services and decent jobs for a better quality of life (Su et al., 2013; Kalmykova et al., 2018). According to Carus and Dammer (2018), the organic resources and waste from agriculture, forestry, fishery, food and feed sectors can only be integrated into the CE through bioeconomy, while the latter will hugely profit from increased circularity. In the process, integrating and engaging the value chain (VC) actors, from producers, manufacturers, intermediaries, traders and retailers to the final consumer in the production-consumption path, will be crucial. However, the costs may escalate as (bio)economies seek to expand. These involve not only 'circulation costs', in effect, recycling and reproduction costs but also vastly increased transaction costs. Technological advances may reduce both types of costs, but that may take time.

Figure 1.1 broadly illustrates the concept of bioeconomy. Bioresources originate in nature, which means bioeconomy is dependent on the health of various ecosystems. Therefore, sustainable production/harvest from ecosystems and the safe release of waste back into ecosystems are primary conditions for sustainable bioeconomy. Energy and materials are required in large quantities and, thus, they compose the basis of sustainable bioeconomy, mainly replacing fossil fuels. Food, feed and medicine have more value with less quantity. For more value addition, differentiation with knowledge and technology is required. In the sustainable bioeconomy

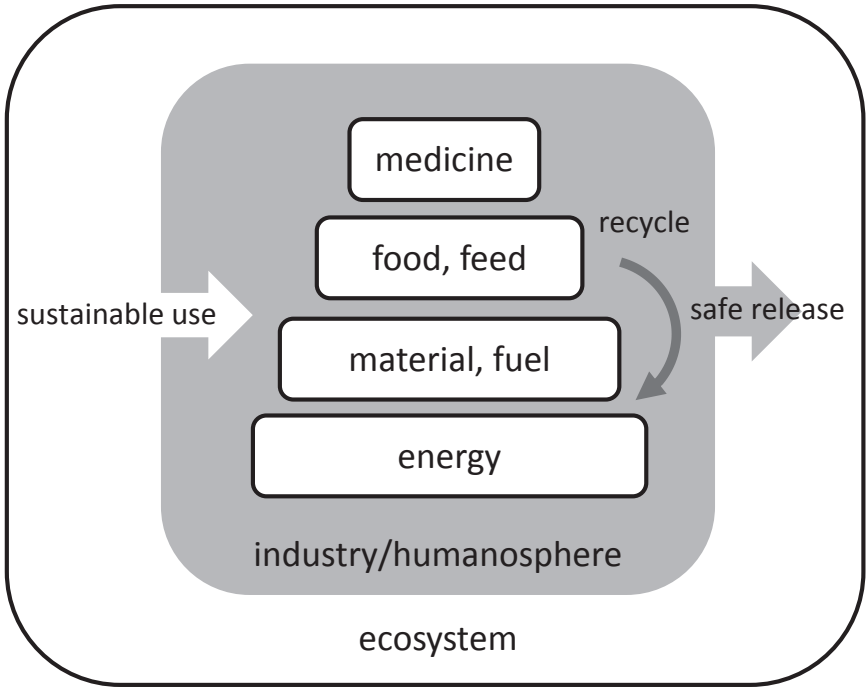

Figure 1.1 The concept of sustainable bioeconomy.

process, some of the waste stream must be recycled and the rest safely released back into the ecosystem.

The 'circular bioeconomy', on the other hand, is still a new concept, and how much it can be put in practice is debatable (Carus and Dammer, 2018). Therefore, the need to develop evidence-based approaches must be recognized to acknowledge the benefits of the circular bioeconomy. The EU has developed a new action plan based on the circular bioeconomy approach that will launch several pilot actions across the EU (EC, 2018). Following this, a few countries within the EU, starting with the Netherlands, have already set a target of becoming 50 per cent 'circular' by 2030 and 100 per cent by 2050 (*Independent*, 2019). This book will focus primarily on the sustainable bioeconomy approach and the use of bio-based resources and their potential to ensure sustainable development.

Global initiatives promoting the bioeconomy approach

According to a comprehensive study conducted by El-Chichakli et al. (2016), nearly 40 countries are trying to boost their bioeconomy in various

sectors. The EU and the OECD have been at the forefront in providing the political momentum for the bioeconomy agenda and simultaneously taking initiatives to promote international cooperation (TransNational Institute, 2015). Outside the EU, it is the US that has developed a broad-based bioeconomy agenda. This is a positive development showing that countries are open to change their approach to use and manage biological resources in a sustainable manner. However, bioeconomy and the increased use of biomass will have both negative and positive impacts. How countries will address the constraints or risks arising from bioeconomy development is still not clear. This requires a balanced regulatory framework (both enabling and constraining) to monitor the use of the biomass and check the impacts on the environment on a regular basis. Ultimately, the extent to which the regulatory framework is implemented and monitored responsibly will determine the sustainability of the bioeconomy. A balance between the primary goals of adopting the bioeconomy approach is desirable and must be consciously addressed. Stakeholder engagement should be an integral part of bioeconomy planning and development, as observed in the EU, which could help in balancing the goals and implementing the regulatory framework to check the environmental impacts.

The EU and bioeconomy development

In 2009, the OECD came out with its bioeconomy strategy, but it was narrow in its focus with the emphasis on biotechnology (OECD, 2009). Then, in 2010, Germany became the first country to launch a 'National Research Strategy for Bioeconomy 2030' (Georg, 2018). The EU followed by launching its first Bioeconomy Strategy in 2012, covering various sectors such as energy, forestry, water, agriculture and marine resources (EC, 2012). The Strategy was supported by an action plan containing detailed measures with emphasis on research, innovation and skills, stakeholder engagement and enhancement of markets and competitiveness in bioeconomy. The EC further developed a 'circular bioeconomy plan' (EC, 2015). After a review in 2018, the EC updated the 2012 Bioeconomy Strategy, with an emphasis on scaling up the bio-based sectors, unlocking investments and markets, and deploying local bioeconomy initiatives across the EU, with due consideration to the ecological boundaries (EC, 2018).

The Knowledge-Based Bio-Economy (KBBE) was an offshoot of the EU's life sciences research agenda of the 1990s. KBBE aims to make agriculture and fisheries more sustainable and efficient. The European Commission's research priorities on bioresources are now based on the KBBE, a new political-economic strategy that plays a key role in shaping relevant policies and institutional arrangements with the aim of creating 'sustainable capital' (TransNational Institute, 2015).

Some of the EU member states, including the Netherlands, Belgium, Finland and others, have developed their own national bioeconomy

strategies in line with the EU strategy. Country plans and their implementation are currently supported by funds from the EC in addition to their own national investments. Bioeconomy development, initiated in Germany since 2010, has shown significant success that was possible due to the politically coherent framework developed jointly by the relevant ministries, including Agriculture, Economic Affairs, Environment and Foreign Affairs, and supported by a 2.4 billion Euros investment (Georg, 2018).

The Horizon 2020 programme, one of the most elaborate global research and innovation programmes promoted by the EC, supports innovative research in bio-based economy (EC, 2013). The programme supported research on food security, sustainable agriculture and forestry, marine, maritime and inland water research with a focus on topics such as blue growth, rural development and bio-based materials (EPRS, 2017). The programme encouraged science-business linkage, public-private partnerships in different sectors and capacity-building within scientific institutions and business enterprises. Under this programme, several pilot actions were initiated in rural, coastal and mountainous areas for sustainable food and farming systems, forestry and bio-based products and these are proving to be successful. The successful initiatives are now being scaled up across the EU and beyond. Research and innovations from the EU initiatives can provide a learning curve to other countries who have initiated bioeconomy strategies.

The Nordic Bioeconomy Strategy

The Nordic Bioeconomy Strategy combines environmental, social and economic ambitions for a sustainable region (Nordic Cooperation, 2018). The strategy further emphasizes applying a cross-sectoral approach to optimize the use of resources. The Nordic Bioeconomy Strategy follows the EC approach in many ways, particularly the promotion of public-private partnerships involving industry, government agencies and research institutions that is crucial in creating a successful bioeconomy model (Nordic Cooperation, 2017). To put the strategy into practice, governments in the Nordic member countries are simultaneously mobilizing investments at the county and municipality levels to boost bioeconomy to promote rural growth and create new jobs. The Nordic countries have simultaneously designed research and innovation programmes, where business enterprises involvement is strongly encouraged.

In addition, the Nordic Bioeconomy Panel is pushing for fundamental changes to production systems, aspiring to eliminate waste entirely and avoid negative impacts on the climate and the environment (ibid.). The Panel, together with other agencies, has catalogued 25 successful cases of bioeconomy so far, and the lessons learnt from these cases were further used in preparing a joint Nordic strategy for bioeconomy.

Bioeconomy development in Japan

In 2008, the Cabinet Office in Japan released a national strategy called 'Drastic reform with effective and agile movements for biotechnology innovation in Japan' (Cabinet Office of Japan, 2008). This strategy proposed: (1) the creation of new industries through prompt implementation of excellent basic research results; (2) the promotion of public awareness of research and development of genetically modified crops to solve food problems; and (3) research and development on the use of biomass to solve environmental problems. These were set as the priority issues to be addressed (ibid.).

There was a long silence before the latest strategy was released in June 2019 (Cabinet Office of Japan, 2019). It was named 'Bio-strategy 2019' and the aim of this strategy is to realize the most advanced bioeconomy society by 2030. The three elements that will enable the strategy's implementation include: (1) creating an environment where biotechnology can be pursued, addressing ethical, legislative and societal problems; (2) promotion of transdisciplinary and international communities and cooperation, which attract human resources and funding for research and innovations; and (3) bio and digital data to be recorded and integrated to form a database. Five goals have been set to realize this plan for society:

1 targeting the proper market;
2 integration of bio and digital data;
3 formation of international research hubs;
4 reinforcement of knowledge rights and genetic resource protection;
5 addressing ethical, legal and social implications.

However, the new strategy is rather inclined towards biotechnology and related innovations and lacks a proper notion of rural community and ecosystems.

There are several promising technology-dependent innovative bioeconomy cases emerging in Japan, for example, complete aquaculture of high-value fish, such as tuna (Aquaculture Research Institute, 2019), controlled environment sericulture (Silk on Valley, 2019) and the Euglenophyceae factory (Euglena, 2019), which are already commercialized. A comprehensive national strategy to link individual technology cases to rural welfare and ecosystem management is awaited.

Bioeconomy in South and South-East Asia

The concept of bioeconomy is rather new to the region. So far, in the region, only Malaysia and Thailand have a dedicated bioeconomy strategy, whereas others such as India, China, Sri Lanka, Indonesia and South Korea have relevant policies that only mention bioeconomy-related activities with