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BOOK REVIEW

Agri-Based Bioeconomy: Reintegrating Trans-Disciplinary Research and Sustainable Development Goals

■ Chetan Keswani, editor

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A useful reference for those interested in understanding the role of new technologies and practices in the emerging agricultural bioeconomy. Although the book is wide ranging and covers many facets of the bioeconomy, its main contribution is in highlighting how researchers and producers alike are applying biological solutions to achieve sustainability goals.

The last two decades have seen an increased interest in research on bioeconomy. Prior to the turn of the millennium in 2000, the word hardly appeared in academic publications or popular discourse. According to Google Ngram (a measure of how frequently a word or string is mentioned in printed text), there has been nearly 7,400 percent increase in the use of the term since 2000. Similarly, among publications indexed in Scopus, only one mentions the word in its title prior to 2003.¹

While the word bioeconomy may be relatively new, the concept it seeks to describe has been around for centuries—namely, the use of biological processes and products for economic benefit. What is new is the belief (especially among policymakers) that bioeconomy represents a distinct sector that can be

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1 For the origins and history of the term “bioeconomy”, see [Birner \(2018\)](#)

the basis for future growth based on the principles of sustainability that moves production away from nonrenewable resources. Much of the motivation for the reorientation of an economy toward one that is “bio-based” stems from the increased concerns around environmental degradation, climate change, and food insecurity, as well as inequality and low growth. Under this vision, a bioeconomy that is knowledge-intensive and less dependent on petroleum-based industrialization will lead to high growth and sustainable solutions to these pressing challenges using novel technologies and institutional structures.

The book under review sets out to provide examples of different technologies, approaches, management practices, organizations, and policies that would usher in (and in many instances, already are) the age of the bioeconomy, especially in the context of agriculture. Edited by Chetan Keswani—an agricultural scientist based at the Southern Federal University in Russia—the volume consists of 20 chapters, touching on a host of issues related to what the editor refers to as the “agri-based” bioeconomy. The objectives of the book are quite ambitious in that they seek to understand the agri-based bioeconomy “as a whole;” but also, to look at the specific attributes of the concept. This is accomplished by bringing together researchers from across a number of fields within agriculture and life sciences and also a few social scientists to offer their perspective on policy and the governance of bioeconomy. The target audience is just as broad, although some of more technical chapters are likely too advanced for non-experts.

The chapters in the book do not seem to be organized around any themes, and it is not clear whether the chapters follow a logical sequence. Nevertheless, a common thread does emerge across a few chapters, such as those on waste management (9, 10, 12, and 18); soil health and fertilizers (13, 14, 16, and 20); governance issues and the prospects for agri-based bioeconomy in case study countries (Chapter 3 for Greece and 17 for Turkey); and, more generally, in Chapter 2 where the authors view bioeconomy through the lens of a sociological-ecological system framework.

Three chapters (6, 8, and 11) address various aspects around natural resource management: for example, the Vietnamese Integrated Farming Systems known as VAC (Chapter 6); the Integrated Biocycles Management systems as practiced in Indonesia (Chapter 8); and the conservation and exploitation of habitat for freshwater turtles in Mexico (Chapter 11). Other chapters are a bit more eclectic and cover diverse issues such the role of specific technologies in achieving sustainability goals (Chapter 1 on agricultural biotechnology and Chapter 7 on direct-seeded rice); the relationship of intellectual property rights to bioeconomy and how they can be leveraged to achieve sustainable development goals (SDGs) (Chapter 4); and cross-purpose vaccine development that makes use of plant-derived vaccines. Finally, two chapters describe the specific application and advances in bacteriology and virology (chapters 19 and 15, respectively). Given the breadth and scope of the topics covered, this book has something for everyone, or at least those with interest in the broad topic of bioeconomy. Unfortunately, it makes reviewing the volume challenging as no one person will likely have the expertise and knowledge to critique, let alone understand, all the topics that are presented (certainly not this reviewer).

Sustainability looms large across many of the chapters. Chapter 1, authored by Hefferson, describes how various agricultural biotechnologies can (and in many instances, already do) enable countries to achieve the SDGs. A key pathway by which this has occurred is through yield enhancing crops such as Bt and herbicide-tolerant crops. These not only allow farmers to limit the use of harmful chemicals but also conserve land and eliminate tillage, which has the effect of limiting CO₂ emissions. Genetically modified (GM) crops also have the potential to help achieve nutrition goals of the SDG through the adoption of biofortified crops such as vitamin A-enriched golden rice. Additionally, GM crops with traits such as drought resistance and salt and heat tolerance can help farmers adapt to an increasingly warmer climate.

A defining feature of bioeconomy is the use of biological processes as a way to shift away from chemicals and inorganic fertilizers, which are increasingly being viewed as harmful to the environment and contributing to greenhouse gas (GHG) emissions. Microbial fertilizers have been used to enhance soil fertility for more than 125 years, but their commercial use remains overshadowed by inorganic fertilizer, which tends to be more effective. But as pointed out by Hemati et al. in Chapter 13, biofertilizer can be just as effective if not more given the right conditions and proper application. The chapter provides an overview (albeit brief) of the different types of biofertilizers and the challenges for widespread commercial application. According to the authors, selecting the most efficient bacterial and fungal strains remains a key constraint, as well as use of the right equipment (fermenter) and biofertilizer carrier. The importance of interaction between microorganisms and soil processes is highlighted by the same authors in Chapter 16, which can greatly influence the efficiency of plant growth. Taken together, these two chapters suggest that while biofertilizers have considerable potential in improving soil health and crop productivity, they require specific sets of conditions to be effective.

Another way to achieve a sustainable bioeconomy is through repurposing of agricultural waste for a variety of uses. This has led to the emergence of another term to describe the interconnection between renewable resources, production, and consumption—the circular economy. The circular economy takes on a system-wide approach with the goal of limiting the use of raw materials, as much as possible, while expanding the reuse and recycling of waste. Four of the chapters provide examples of how this can be achieved in the context of agriculture. In Chapter 9, Nepomuceno and colleagues describe how various forms of agricultural waste (or byproducts) can be used for various purposes. Consider the case of rice where for every kilogram of rice produced, 1.2 kg of dry agriculture waste is generated primarily in the form of rice straw. Rice straw

(also corn stover and sorghum straws) are among the major lignocellulosic residues that can serve as substrate for several types of mushrooms. Rice straw and other cellulosic matter can also be used in the biosynthesis of nanomaterials. Agricultural waste can also be utilized to produce bioenergy as discussed in Chitara, Chauhan, and Singh in Chapter 18. The anaerobic digestion of such waste results in biogas production, which in turn results in multiple environmental benefits (e.g., reduction in waste, generation of energy through a renewable resources, and limiting emissions of GHG). However, the production of biogas on large scale remains a challenge given the delicate microbial system that is required to maintain stable anaerobic digestion system.

The use of organic material (not simply biofertilizers) to improve soil fertility is another important feature of bioeconomy. De Corato in Chapter 10 describes the use of different forms of compost to improve horticultural cropping systems. Green compost can act not only as a plant stimulant but also as a protective agent against plant diseases. Since composts is generated as a byproduct of on-farm activities, costs are generally considered low.

To truly appreciate the potential for sustainable practices and technologies in a modern bioeconomy, a system-wide approach is needed, one where various production and consumption activities are viewed as an integrated scheme. In Chapter 8, Agus et al. describe an integrated biocycle farming system (IBFS) that seeks to optimize the relationship between physical and environmental resources (land, water, and climate) with biological resources (animals, plants, humans, and other living beings). The authors use the example of agroforestry in Indonesia to highlight the key attributes of IBFS, particularly its emphasis on whole system output that takes precedence over its constituent elements. Unfortunately, the practicality and operationalization of IBFS is not discussed in much detail and the chapter's wordiness and pomposity obfuscates the points it seeks to make.

Another example of an integrated farming system is the Vuon-Ao-Chuong (VAC), which is widely practiced in the Red River Delta of Vietnam and highlighted in Chapter 6 by Anh and Schneider. VAC is the Vietnamese name for the integration of crop, aquaculture, and livestock. It is a highly bio-intensive model with each component of the system related to the other but primarily through the supply of feed to the animals/fish and manure to the crops. The chapter discusses a number of variations and of the basic VAC model, which can achieve not only sustainability goals but also allows for higher incomes, thereby, reducing poverty and incidence of hunger.

These are just a handful of technologies and management practices that form the basis—and evoke considerable enthusiasm—for bioeconomy. While the various contributors go to great lengths describing the benefits of the technology in question, very limited attention is given to the financial and economic aspects. No matter how sustainable (from an environmental perspective) a technology is, its success and viability will ultimately depend on profitability for the farmer and how well it fits into existing production practices and value chains. Productivity of agriculture based primarily on bio-based inputs (such as organic agriculture) tends to be lower than high-input chemical-based systems that they seek to replace. A careful analysis of some of the economics from adoption of these would have been very informative.

The book also falls short in assessing the policy and regulatory aspects that will be needed for a successful bioeconomy. The exceptions are the two country case study chapters (Greece in Chapter 3 and Turkey in Chapter 17); but here, the emphasis is primarily on the potential and challenges facing the bioeconomy of the two countries. For example, in the chapter on Greece, the authors simply list in bullet points the key features, problems, and opportunities facing a number of subsectors of the bioeconomy (such as agriculture, forestry, aquaculture, bioenergy, etc.) without providing much context or the type of government intervention that may be needed to take advantage of the opportunities. Chapter

17, authored by Kalyaci on the prospects for a sustainable bioeconomy, outlines some proposals that could help achieve this goal. However, these proposals are less about support for the bioeconomy but, more generally, for the agricultural sector. Some proposals seem to be in contradiction, leading to somewhat unclear messaging. For example, the author lists eight “action proposals”, one of which is the very sensible “an economic development strategy based on the bioeconomy and/or biotechnology should be designed and implemented.” Yet, at the same time, for the action proposal on extending credit to the agriculture sector, it is stated that “banks should be wary of farmers producing fruits and vegetables within the scope of cancer-causing ‘genetically-modified crop’ (GMOs) and act according to an ethics committee report.” This reviewer is unaware of any cancer-causing genetically modified organisms (GMOs) and such statement does little to inform readers about the safety of GMOs and the stringent biosafety and regulatory processes they are subjected to.

Nevertheless, the volume as a whole takes on a pragmatic approach toward biotechnology. And as outlined in the first chapter, it sees biotechnology playing an important role in meeting contemporary environmental and developmental challenges. There is much to be achieved through the integration of different types of biotechnologies (GMOs, gene-editing, etc.) with conventional and organic agriculture, and as emphasized by a number of authors, requires a holistic and system-wide approach.

To conclude, the volume is a useful contribution to the burgeoning literature on the bioeconomy with interesting examples and country case studies. Since the authors of the volume are primarily biological and agricultural scientists, the details provided on the technical aspects for some of the underlying technologies is quite informative. However, the book does not devote enough attention to policy, regulatory, and socioeconomic issues; a comprehensive treatment of these issues can be found in the edited volume by Lewandowski (2018) as well as the article by Zilberman et al. (2019).

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