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SOCIOECONOMIC AND ENVIRONMENTAL IMPACTS OF BIOFUELS

Evidence from Developing Nations

Biofuels are currently in the middle of a heated academic and public policy debate. Biofuel production has increased fivefold in the past decade and is expected to double by 2020. Most of this expansion will happen in developing nations. This book is the first of its kind, providing a comprehensive overview of the biofuel debate in developing countries. The chapters are written by a multidisciplinary team of experts who expose the key drivers and impacts of biofuel production and use. The book covers impacts as diverse as air pollution, biodiversity loss, deforestation, energy security, food security, greenhouse gas emissions, land use change, rural development, water consumption, and other socioeconomic issues. It has a wide geographical focus accommodating examples from countries in Africa, America, and Asia. As such, this book will become an indispensable companion to academics, practitioners, and policy makers who wish to know more about biofuel issues in the developing world.

ALEXANDROS GASPARATOS is a James Martin Research Fellow at the Biodiversity Institute, Oxford University. He has published on a wide range of topics, including biofuels, food security, energy security, ecosystem services, urban biodiversity, and sustainability assessment. He has been involved in several major research projects during his time at Oxford University, the United Nations University (Yokohama, Japan), and the University of Dundee. Dr. Gasparatos is committed to policy-relevant research and has contributed to policy reports that were launched during the Tenth Conference of the Parties of the Convention for Biological Diversity. He has a background in ecological economics (PhD, University of Dundee), environmental science (MSc, Imperial College, London), and chemistry (BSc, University of Patra).

PER STROMBERG is a Visiting Research Fellow at the United Nations University (Yokohama, Japan) and is an environmental economist at the Swedish Environmental Protection Agency. He is a Cambridge European Trust Fellow and holds a PhD and MSc in environmental economics (University of Cambridge and University College, London, respectively) and a BSc in economics (Stockholm University). He was awarded the James Claydon Prize in Economics from the University of Cambridge. Having lectured at universities in Japan and Peru, he was also responsible for the MSc module on environmental economics at the United Nations University. Currently his research focuses on economics of climate change, ecosystem services, and biofuel production, and he has published widely on economic development and the environment. He has been a researcher for the United Nations (UN) Development Programme, the UN Economic Commission for Latin America, the Organization for Economic Cooperation and Development, the economics unit of the Delegation of the European Commission in Mexico, and the International Institute for Environment and Development. He previously headed the Sustainable Development Governance unit at the United Nations University's Institute of Advanced Studies.

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ALEXANDROS GASPARATOS
University of Oxford

PER STROMBERG
United Nations University

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Contents

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Contributors

Ricardo Abramovay is full professor in the Department of Economics, University of Sao Paulo, Brazil.

Bothwel Batidzirai is junior researcher in the Department of Science, Technology, and Society, Copernicus Institute, Utrecht University, Netherlands.

Ryan Blanchard is a PhD student in the Department of Botany and Zoology, Stellenbosch University, South Africa.

Gareth D. Borman is an MSc student at the School of Animal, Plant, and Environmental Sciences, University of the Witwatersrand, Johannesburg, South Africa.

Matteo Borzoni is research fellow at the Istituto di Management of Scuola Superiore Sant'Anna, Pisa, Italy.

Miguel Carriquiry is associate scientist at the Center for Agricultural and Rural Development, Iowa State University, Ames, Iowa, United States.

Mark Elder is principal researcher and manager of the Policy and Governance Team, Institute for Global Environmental Strategies, Hayama, Japan.

Amani Elobeid is associate scientist at the Center for Agricultural and Rural Development, Iowa State University, Ames, Iowa, United States.

Karl-Heinz Erb is associate professor of land use and global change at the Institute of Social Ecology, Alpen-Andria University, Vienna, Austria.

Colin Everson is research fellow in the School of Agriculture, Earth, and Environmental Sciences, University of KwaZulu-Natal, Pietermaritzburg and Extraordinary Professor in the Department of Plant Production and Soil Science, University of Pretoria, South Africa.

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Jacinto F. Fabiosa is codirector of the Center for Agricultural and Rural Development, Iowa State University, Ames, Iowa, United States.

Yan Gao is postdoctoral fellow at the Graduate School of Environmental Science, Hokkaido University, Japan.

John Garcia-Ulloa is a PhD student in the Department of Environmental Sciences, Swiss Federal Institute of Technology Zurich, Switzerland.

Alexandros Gasparatos is a James Martin Research Fellow at the Biodiversity Institute, Oxford University, and a Visiting Research Fellow at the Institute of Advanced Studies of the United Nations University, Yokohama, Japan.

P. Winnie Gerbens-Leenes is assistant professor at the University of Twente, Netherlands.

Mark B. Gush is senior scientist at Natural Resources and the Environment, South African Council for Scientific and Industrial Research, Stellenbosch, South Africa.

Helmut Haberl is associate professor at the Institute of Social Ecology, Alpen-Andria University, Vienna, Austria.

Jason Hill is assistant professor in the Department of Bioproducts and Biosystems Engineering, University of Minnesota, Minneapolis, Minnesota, United States.

Arjen Y. Hoekstra is scientific director of the Water Footprint Network and professor in Multidisciplinary Water Management, University of Twente, Netherlands.

Francis X. Johnson is Senior Research Fellow at the Climate and Energy Programme, Stockholm Environment Institute, Sweden.

Lian Pin Koh is assistant professor of applied ecology and conservation in the Department of Environmental Sciences, Swiss Federal Institute of Technology Zurich, Switzerland.

Fridolin Krausmann is professor of sustainable resource use and deputy director of the Institute of Social Ecology, Alpen-Andria University, Vienna, Austria.

Christian Lauk is Research Fellow at the Institute of Social Ecology, Alpen-Andria University, Vienna, Austria.

Janice S. H. Lee is a PhD student in the Department of Environmental Sciences, Swiss Federal Institute of Technology Zurich, Switzerland.

Markku Lehtonen is Research Fellow at the Science and Technology Policy Research, University of Sussex, Brighton, United Kingdom.

Omar Masera is professor at the Centro de Investigaciones en Ecosistemas of the National Autonomous University of Mexico, Mexico City, Mexico.

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Andreas Mayer is Research Fellow at the Institute of Social Ecology, Alpen-Andria University, Vienna, Austria.

Siwa Msangi is Senior Research Fellow at the Environment and Production Technology Division, International Food Policy Research Institute, Washington, D.C., United States.

Christoph Plutzar is Research Fellow at the Institute of Social Ecology, Alpen-Andria University, Vienna, Austria.

Stephen Polasky is the Fesler-Lampert Professor of Ecological/Environmental Economics, University of Minnesota, St. Paul, Minnesota, United States.

Jane Romero is policy researcher, Institute for Global Environmental Strategies, Hayama, Japan.

Daisuke Sano is policy researcher and sub-manager of the Policy and Governance Team, Institute for Global Environmental Strategies, Hayama, Japan.

Margaret Skutsch is associate professor in environmental geography, Autonomous University of Mexico, Mexico City, Mexico, and senior researcher at the Centre for Studies in Technology and Sustainable Development, University of Twente, Netherlands.

Julia Steinberger is lecturer in ecological economics at the Sustainability Research Institute, University of Leeds, United Kingdom.

Per Stromberg is Visiting Research Fellow at the Institute of Advanced Studies of the United Nations University, Yokohama, Japan, and economist at the Environmental Economics Unit, Swedish Environmental Protection Agency, Stockholm, Sweden.

Anne Sugrue is a South African National Energy Research Institute PhD Fellow, University of Johannesburg, South Africa.

Theo H. van der Meer is chair of thermal engineering at the Faculty of Engineering Technology, University of Twente, Netherlands.

Graham P. Von Maltitz is senior researcher at Natural Resources and the Environment, Council for Scientific and Industrial Research, Pretoria and a PhD student at the Sustainability Research Unit, Nelson Mandela Metropolitan University, Port Elizabeth, South Africa.

Kristina Wagstrom is postdoctoral researcher at the Department of Civil Engineering, University of Minnesota, Minneapolis, Minnesota, United States.

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Preface

Energy security, economic development, and environmental protection have become three recurrent and closely intertwined policy themes in national and international policy arenas. Presently, fossil fuels are by far the predominant energy carriers driving the world economy. However, their scarcity and uneven geographical distribution can severely affect national economies and international markets. At the same time, fossil fuel combustion is singled out as the most important driver of human-induced climate change, a phenomenon with potentially catastrophic effects in the medium and long term. It is no wonder that the development of copious amounts of cheap, renewable, evenly distributed, and environmentally friendly energy has started featuring prominently in the energy strategies of developed and developing countries alike.

Perhaps the most controversial among the different types of renewable fuel options currently pursued are biofuels, a type of liquid fuel derived from biomass. Biofuels have been identified as potentially viable substitutes for conventional transport fuels. Currently twenty-four countries have enacted the mandatory blending of biofuels with conventional transport fuel (e.g., Brazil, China, the European Union, India, the United States). Several other countries are designing other types of biofuel-related policies (e.g., Indonesia, the Philippines, and sub-Saharan African nations).

Although certain biofuel practices were initially viewed as environmentally friendly, awareness is emerging about the complexity of biofuel chains and their impacts on the environment and society. Studies have confirmed that first-generation biofuels[1] can have negative impacts on biodiversity, ecosystem functioning, the climate, food security, and the inclusion of the poor. Conversely, certain first-generation biofuel practices can be net-energy suppliers, can be economically and socially beneficial, and may emit fewer greenhouse gases and other atmospheric pollutants during their life cycles when compared to conventional fossil fuels.

[1] Biofuels from "sugar, starch and oil bearing crops or animal fats that in most cases can also be used as food and feed" (IEA, 2010a : 22).

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In recent years, the biofuel polemic has started featuring very prominently in academic and policy discussions. The sometimes contradictory and controversial findings of the different studies have further fueled the debate. However, conflicting findings regarding the overall impact of biofuels are unsurprising given that the drivers, impacts, and trade-offs of biofuel production and use vary greatly, depending on the environmental and socioeconomic contexts within which biofuels are produced and consumed.

Although literature on the topic is growing, a consistent and cohesive overview is lacking. Considering the preceding, the present volume critically discusses the main drivers, policies, and, especially, impacts that first-generation biofuels have in different developing nations. The geographical focus reflects the editors' conviction that developing nations will be the biggest winners (or losers) from a shift toward greater biofuel production. The focus on first-generation biofuels reflects the fact that these biofuel practices will make up the bulk of biofuel expansion in developing countries in the coming decade. Despite some discussions about the production of second-generation biofuels (i.e., lignocellulosic biofuels) in developing nations, the fact remains that first-generation biofuels and their impacts will remain highly relevant in these parts of the world in the foreseeable future.

The book is divided into five parts. Part One introduces the key socioeconomic and environmental drivers and impacts surrounding biofuel production and places them within a wider global context (Chapter 1). The major impacts discussed in Part One include energy provision (Chapter 1), rural development (Chapter 1), food security (Chapters 1 and 2), land use change (Chapters 2 and 5), greenhouse gas emissions (Chapter 3), air pollution (Chapter 3), water consumption (Chapter 4), and deforestation (Chapter 5).

The subsequent three parts (Parts Two to Four) provide a rigorous analysis of the preceding (and other context-specific) drivers, impacts, and associated trade-offs in key biofuel-producing developing regions such as Brazil (Chapters 6–8), Southeast Asia (Chapter 9), China (Chapter 10), and sub-Saharan Africa (Chapters 11–13). Contributions span different spatial scales (from the local to the subnational, national, regional, and global scale) and cover a broad range of biofuel production practices, including sugarcane bioethanol (Chapters 6–8 and 12), soybean biodiesel (Chapter 6), palm oil biodiesel (Chapter 9), and jatropha biodiesel (Chapters 10 and 13).

In more detail, Chapter 6 provides a comprehensive overview of the drivers, policies, and impacts of the Brazilian bioethanol and biodiesel programs, while Chapter 7 focuses on the distinct socioeconomic impacts of the bioethanol program (and the power relations that have emerged) in the northeast of Brazil. Chapter 8 explores how global ethanol demand will affect regional land use in Brazil. Chapter 9 shifts the focus to palm oil biodiesel and its impact on biodiversity in Southeast Asia and makes concrete proposals on how to minimize such negative effects. Chapter 10 identifies the main sustainability impacts of jatropha cultivation (for biodiesel) in the Yunnan

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region of China and proposes solutions that can enhance the viability of this biofuel practice. Chapter 11 discusses how biofuel expansion in developed countries might affect African households and proposes a stylized model of household economic behavior to better understand the welfare impacts that are transmitted through biofuel markets to the household level. Chapter 12 looks at the intersection between energy security, agroindustrial development, and international trade in southern Africa and identifies how a regionally integrated expansion of the sugarcane agroindustry (for bioethanol) offers opportunities for improving energy security and competitiveness in the region. Chapter 13 provides a comprehensive overview of the environmental and socioeconomic impacts of jatropha biodiesel across southern Africa.

Finally, in Part Five, the main findings are synthesized. We identify the key lessons learned from the considerable biofuel experience of the countries studied throughout this book (Chapter 14). In our effort to make this work useful to a broad range of readers, we conclude by providing a number of proposals to academics, practitioners, and policy makers that can promote the sustainability of the biofuel economy.

It should be noted that the different chapters adopt highly diverse methodologies to assess and explain the diverse environmental and socioeconomic impacts of biofuels. Methods used in this edited volume range from material balances (Chapter 2) to life cycle assessments (Chapters 3 and 6), water footprint analysis (Chapter 4), remote sensing (Chapter 5), sociological research (Chapter 7), partial equilibrium models (Chapter 8), local interviews and surveys (Chapter 10), econometric models (Chapters 8 and 11), and a number of other field techniques (Chapters 9 and 13).

It is our belief that the wide focus and multiple academic perspectives employed in this book provide a sober, balanced, and cohesive overview of the true potential and real impacts of biofuel expansion in developing countries.

Acknowledgments

First, we would like thank all the contributors to this book, whose expertise and diverse academic viewpoints acted as a major source of inspiration during the development of this truly multidisciplinary work.

This edited book has benefited from our continuous interaction and fruitful discussions with several academics. We are particularly grateful for the constant input we received during our involvement in the Biofuel for Sustainable Development program, which was funded by the Japanese Ministry of the Environment and conducted in collaboration with several Japanese academic institutions. We also benefited significantly from the feedback we received during two special sessions on the impacts of biofuels in developing nations during the 2010 Biannual Conference of the International Society for Ecological Economics.

A major component of this book was conceived and undertaken during the editors' fellowships at the Institute of Advanced Studies of the United Nations University (UNU-IAS). We would like to acknowledge the constant support of our UNU-IAS colleagues and particularly of the institute's assistant director, Jose Puppim de Oliveira.

We are also thankful to the Japan Society for the Promotion of Science for providing research funding that enabled this book. Alexandros Gasparatos would further like to acknowledge the support of the Oxford Martin School through a James Martin Fellowship.

Finally, we would like to thank Paloma White for her significant help during the editorial process and our editor at Cambridge University Press, Matt Lloyd, for his understanding and encouragement during the production of this volume.

Foreword

One of the major challenges of the twenty-first century is how to meet growing energy demand in a sustainable manner. Energy demand worldwide has increased with the growth in population and in per capita energy use. Over the past several decades, energy demand has increased most rapidly in developing countries. Even so, per capita energy use in developing countries remains far lower than in developed countries. Energy demand is projected to continue to grow in the coming decades, due to continued population increases and the continued need for economic development.

Where will the supply come from to meet this growing energy demand? Fossil fuels currently supply approximately 80 percent of world energy demand, but overwhelming reliance on fossil fuels is not a sustainable energy strategy. The fossil fuel supply is finite. While peak oil may or may not be reached anytime soon, fossil fuels are an exhaustible resource and cannot be relied on indefinitely. Even if fossil fuels were not an exhaustible resource, continued reliance on fossil fuels causes major environmental problems. Combustion of fossil fuels has been the primary driver of increases in the greenhouse gas concentrations in the atmosphere that intensify global warming. Fossil fuels are also a principal contributor to local and regional air pollution and other environmental problems.

The world needs alternative energy supplies that can replace a substantial portion of fossil fuel use. To be a viable alternative, however, an energy supply source must satisfy three criteria:

- *Energy supply*: be producible in large quantities
- *Economy*: be cost competitive
- *Environment*: have relatively low environmental impact

Renewable energy will undoubtedly be an increasing part of the energy supply picture in the future. Renewable energy in the form of sunlight, wind, and tides is more than sufficient to supply human needs and can be produced in an environmentally sound

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manner. The main challenge with renewable energy, however, will be finding sufficient amounts of low-cost renewable energy.

Biofuels are a potentially attractive source of renewable energy. Biofuels can reduce the reliance on fossil fuels, especially for liquid transportation fuel, and can be produced in an environmentally sustainable manner. Plants absorb carbon dioxide during growth so that biofuels should offer carbon savings relative to burning fossil fuels. In addition, second-generation biofuels derived from perennial grasses and grown on lower-quality soils could reduce environmental impacts and lessen the competition with food production.

Whether biofuels are better for the environment, and whether they are cost competitive, has been the subject of heated debate. The contentious high-stakes nature of the biofuels versus fossil fuels debate has often generated far more heat than light. Some critics of biofuels have made overly broad claims that biofuels starve the poor, only survive because of government subsidies, and are environmentally harmful because of impacts on water supplies (both quantity and quality) as well as causing habitat loss and carbon release from land conversion. Some proponents have made overly rosy statements about the pace of technological improvement, cost competitiveness, and environmental friendliness of biofuels.

Of course, not all biofuels are created equal. For example, the carbon footprint of biofuels generated from residual biomass from lands already in agricultural production differs greatly from that of biofuels generated from biomass grown on land newly converted from native forests. Similarly, the economics of sugarcane ethanol, corn-grain ethanol, and cellulosic ethanol grown from various biomass feedstocks are all different. Furthermore, there are several unanswered questions regarding the potential positive or negative social impacts of biofuels. Whether biofuels are an attractive proposition may depend on the manner in which biomass is grown and converted into biofuels.

This book provides a much-needed balanced and evidence-based treatment of the relative merits of biofuels. The focus on biofuel production in developing countries is particularly needed. The tropics offer the most favorable conditions for growing biomass. Developing countries are also likely to have the fastest growth in energy demand in the coming decades. The book provides a wealth of detailed evidence on the specific impacts of biomass production, conversion into biofuels, and subsequent use in different regions. This book is a welcome addition to the literature and one that promises to add much-needed light to the subject.

Stephen Polasky
University of Minnesota