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978-1-107-00935-6 - Socioeconomic and Environmental Impacts of Biofuels: Evidence from Developing Nations

Edited by Alexandros Gasparatos and Per Stromberg

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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.

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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, and 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<sup>1</sup> 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.

<sup>1</sup> 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).

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 can 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 discussion 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 jatropha biodiesel. 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 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.

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.

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## 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, 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, have been the subjects 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.

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