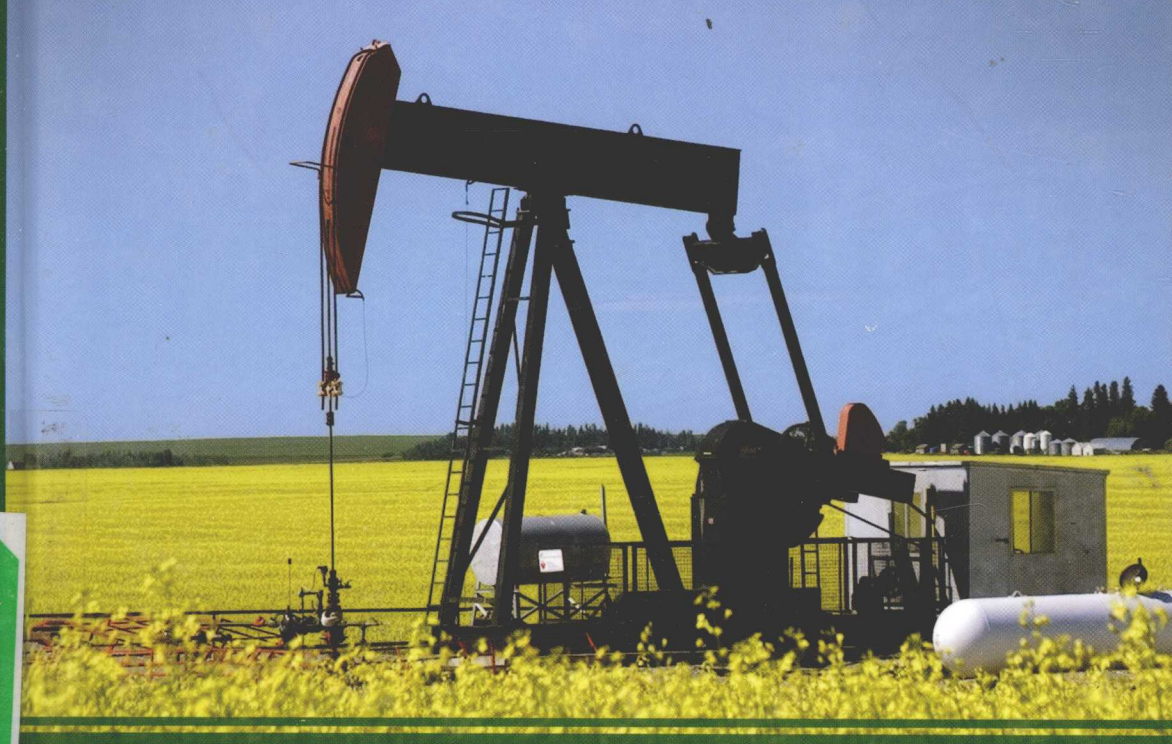
Global Economic and Environmental Aspects of BIOFUELS

Edited by

David Pimentel



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Global Economic and Environmental Aspects of BIOFUELS

Advances in Agroecology

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Foreword

This volume is the latest in a series of books with the overall title *Advances in Agroecology*. The book focuses on an extremely important current environmental, ecological, and sociological issue: the use of biofuels produced from crops and organic waste as an alternative or supplement to oil. The U.S. Department of Energy and many national and international agencies predict that global supplies of petroleum will become increasingly expensive, and many experts predict that they may become exhausted by 2040. Discussions in the different chapters focus on key ecological and economic issues associated with the production of ethanol as a fuel from corn, sugarcane, crop residues, and other organic materials.

The book is edited by David Pimentel of Cornell University, who is an international authority on energy issues. He also contributes to several critical chapters in the book. The various chapter authors address the current and future impact of bioethanol technology on human food production, global malnutrition, human populations, water needs, and soil erosion and assess its global potential. Their overall conclusion is that the production of ethanol from grains, other crops, and crop residues has proven to be costly in both environmental and economic terms.

It has become clear that the potential energy production from bioethanol sources is small to negligible. For example, the 34 billion liters of ethanol being produced from corn provides only 1.3% of total oil consumption in the United States while using 33% of all the corn grown; if *all* U.S. corn were converted into alcohol, this would still provide the country with only 4% of its oil fuel needs. There are a few glimmers of hope for the technology reported in the book. First, the production of biodiesel and ethanol by saltwater algae holds possible future potential, but many technological problems with this process remain to be resolved. There is also a discussion of the economic potential of production of oil from tropical palms in Asia and elsewhere in the Far East, but again the technology needs to be developed.

The overall conclusion from most of the contributors is that green plants—corn, sugarcane, switchgrass, and other kinds of biomass—can convert only about 1% of solar energy into plant material annually. The

authors unanimously conclude that the present and potential environmental and sociological impacts of ethanol production include global food shortages, increased carbon dioxide emissions, intensified soil erosion, and the consumption of enormous quantities of water.

This is a challenging book that brings together the opinions of a number of U.S. scientists with those of experts from Spain, Italy, the United Kingdom, and Brazil. There is remarkable agreement among the contributors that biofuels are not the answer to solving future oil shortages. The book will find a receptive audience among private readers, scientists, and government officials.

Prof. Clive A. Edwards
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Preface

People started using oil and coal about 150 years ago. Oil, natural gas, and coal have supported major advances in agriculture, industry, transport, and indeed all aspects of human life systems for more than a century. Fossil energy has allowed us to build up a human population of 7 billion and a massive world economy and agricultural system largely dependent on that energy. Now, world oil supplies have peaked and will slowly decline during the next 30 to 100 years. Some natural gas and coal will be used to replace oil, but this will be economically and environmentally costly. During the next 100 years, we will run out of *all* fossil energy. Then what?

People have been slow to recognize that we must reduce our population and change our economy as we move into a future with dwindling fossil fuel reserves. This book does not attempt to deal with the major changes that we must make, but focuses on the science and technology of biofuels. The focus is specifically on ethanol, biodiesel, and other biological materials that are possible substitutes for oil, natural gas, and coal resources.

Everyone recognizes that biofuels are made from green plants. However, depending on plants places a significant limitation on replacing oil, natural gas, and coal because green plants collect on average less than 0.1% of solar energy annually in the world. It took more than 700 million years for the green plants to collect all the energy stored in current oil, natural gas, and coal deposited in North America and elsewhere. As a replacement, a technology is needed that will collect solar energy at a rate about 200 times greater than what green plants currently do.

In this book, the authors examine various biofuel energy technologies and report on their potential to supply the United States and other nations with needed energy now and in the future. Some chapters examine several biofuel energy technologies and their potential to replace some fossil energy, while others focus on one or several technologies and their potential and limitations. The aim of the contributors to this volume is to share their analyses and for these analyses to be a basis for more research in biofuel energy technologies. Basic to all biofuel technologies is that they must attempt to minimize damage to the environment that supports all life.

Several of the chapters reflect the current lack of agreement in the field, as pressure mounts to explore and develop potential biofuel alternatives. The reader will notice considerable variability in the stated energy inputs and potential energy outputs in some of the studies. This is evidence of the complexity of assessing the large number of energy inputs that go into the production of a biofuel and the extraction of useful energy. As we collectively investigate the issues, we will discover if current analyses and biofuel outputs have adequately considered energy requirements, outputs, and environmental consequences. Hopefully, this research will help guide energy policy makers toward the most viable choices and away from energetically costly missteps.

I commend the authors of each of these chapters, who have done a superb job in presenting the most up-to-date perspectives of various biofuel energy technologies in a highly readable fashion.

David Pimentel

Acknowledgment

I wish to express my sincere gratitude to the Cornell Association of Professors Emeriti for the partial support of our research through the Albert Podell Grant Program. In addition, I wish to thank Mike Burgess for his valuable assistance in the preparation of our book.

About the Editor

David Pimentel is a professor of ecology and agricultural science at Cornell University. He received his bachelor of science in 1948 from the University of Massachusetts and his PhD from Cornell in 1951. From 1951 to 1954, he was chief of the Tropical Research Laboratory, U.S. Public Health Service, San Juan, Puerto Rico. From 1954 to 1955, he was a postdoctoral research fellow at the University of Chicago; in 1960–1961, an OEEC Fellow at Oxford University, and in 1961, an NSF scholar at the Massachusetts Institute of Technology. Dr. Pimentel was appointed assistant professor of insect ecology at Cornell University in 1955 and associate professor in 1961. In 1963, he was appointed professor and head of the Department of Entomology and Limnology. He served as department head until 1969, when he returned to full-time research and teaching as professor of ecology and agricultural sciences.

Nationally, Dr. Pimentel has served on the President's White House Science and Technology Program and the Presidential Commission on the Environment; numerous National Academy of Sciences committees and boards, including chairing the Board of Ecology; and committees in the Department of Health, Education, and Welfare, Department of Energy, Department of Agriculture, State Department, and the congressional Office of Technology Assessment. He also served as president of the Rachel Carson Council and as an elected member of the National Audubon Society and the American Institute of Biological Sciences.

His international honors and achievements have included his fellowship at Oxford University; an appointment as honorary professor of the Institute of Applied Ecology, China; receiving an honorary degree of science from the University of Massachusetts, receiving the Distinguished Service Award from the Rural Sociology Society; and serving on the board of directors of the International Institute of Ecological Economics, Royal Swedish Academy of Science.

Dr. Pimentel has authored nearly 700 scientific publications, written three books, and edited 31 others. He is now serving as editor-in-chief of the journal *Environment, Development and Sustainability.* His research spans the fields of energy, biological control, biotechnology, land and water conservation, and environmental policy.

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chapter one

Biofuels cause malnutrition in the world

David Pimentel

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1.1 Introduction

Global shortages of fossil energy—especially of oil and natural gas—exist worldwide, and an emphasis on biofuels as a renewable energy source has developed globally (Pimentel and Pimentel, 2008), particularly those made from corn grain, soybeans, canola, rapeseed, palm oil, and sugarcane. In developing countries, about 2 kcal is required to cook 1 kcal of food, and most of this energy comes from wood or crop residues (Fujino et al., 1999). The use of crop residues is having a devastating impact on agriculture and food production (Lal, 2009). It is particularly serious because it increases soil erosion, water runoff, and loss of plant nutrients (Lal, 2002, 2009).

Conflicts have developed in the use of land, water, energy, and other environmental resources for food production versus biofuel production.