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ENVIRONMENTAL CHALLENGES OF THE 21ST CENTURY

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About The Book

This peer-reviewed edited volume entitled *"Environmental Challenges of the 21st Century"*, presents a wide-ranging scientific overview of environment perspectives and human responses in global context. The different aspects of environment - man's perception, anthropogenic impacts on environment, pollution, conservation and policy issues, environment education and ethics have been explored in this volume. The outstanding papers contributed by the eminent scientists and environmentalists from different parts of the world have given a wonderful profile to this volume.

The wide-ranging perspectives of environment have been portrayed in this scientific volume. In the first seven chapters of the book – pertaining to climate change, biodiversity, land activities, water stress on plants, environmental impact of gene technology, global warming, etc. illustrate some of the most significant concerns in such a way that the readers of all categories find a common chapter to understand the anthropogenic role to affect the natural environment.

The next five chapters on environmental management and sustainable development that further strengthen the ideas of immediate concerns to restore and to conserve the resources through sustainable use, recycling, substitutes and improving variety of food crops under different environment with application of science. Practically, we have to be very careful before we lose much more of our biological and genetic resources in the world.

The chapters 13 to 19 of the book on society and environment illustrates the different forms of solution to the ecological crises, ways of reduction of global risks, implementation

of international environmental laws, sustainable consumption and climate justice, role of women as conservationists, and the teaching eco-ethics to children under societal development in respect of preservation of environment and promotion of human development in the globe.

Chapter-11

BIOFUELS: ENVIRONMENTAL, ECONOMIC AND SOCIAL ASPECTS

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"A country that runs on energy cannot afford to waste it"

Bruce Hannon

ABSTRACT

Biofuels, the generic name given to renewable types of fuels that are derived from various sources of plant material or waste products, have been described as an alternative method of energy to the well established fossil derived fuels. Ethanol, made mostly from sugarcane and corn and biodiesel, made from vegetable oils

and their derivatives; are the most popular types of biofuels today. Many advantages can be named by replacing or supplementing fossil fuels with ethanol or biodiesel: reduction of greenhouse gas emissions, avoiding or minimizing global climate change, increase energy security, reducing the dependence to import oil, avoid oil shortage or increase in oil prices, avoid limit capacity of oil refining, reduction of trade deficit and creation of jobs in many rural areas. Because biofuels are derived from agricultural crops and are inherently renewable, agriculture plays a key role in making biofuel a successful alternative. One major hurdle for widespread adoption of biofuels is the challenge of growing enough crops to meet demand. This possible limitation could lead us to a rising concern: will energy crops replace food crops? For this reason, sustainable biofuels production requires continuous technology progress, in both fields of agriculture and industry. This article describes some of the environmental, economic and social aspects of biodiesel and ethanol production and provides some reviews showing the positive and negative impacts of these biofuels across the value chain and their potential effects on agriculture.

INTRODUCTION

Historically, the first type of fuel that humankind relied on, in large amounts, came from woods, and until the end of the nineteenth century, energy sources all around the world were derived from agricultural products (Duffield 2006). By 1920, petroleum emerged in the scenario of all industrialized countries and because of its low cost and relatively easy availability; it became the dominant energy source (Duffield 2006; Pousa et al. 2007). However, after oil embargo imposed by OPEC (Organization of Petroleum Exporting Countries), causing 1973 and 1979 oil crisis, the world has witnessed a dramatic increase in oil prices.

Although oil prices continues to go up, oil demand growth is surging in new industrialized countries (high demand coming from emerging economies), like China and India, adding to the market enormous pressure to keep oil production up. Many government agencies still believe that there is plenty of oil left, and that higher prices will only open the floodgates (Flavin 2004). In the past, it was assumed that if oil supplies got tight, Persian Gulf countries would

quickly and easily provide whatever oil the world needs. But today, the ability of countries like Saudi Arabia and Iraq to raise production substantially is in doubt. Some of the largest oil fields in the Persian Gulf are aging rapidly (Campbell & Laherrère 1998). As a result, analytical techniques have been improved enormously in many other countries, allowing prospective oil areas to be identified with a high degree of confidence, like in the deep and ultra deep-water oil in Brazil (Bruhn 2005; Cafarelli et al. 2006) or in the oil sands in Canada (Milmo 2006; Woynillowicz et al. 2005). Over the years, also motivated by high prices of oil and an increasing political instability in the Middle East, a gradual change in the automakers industry has been placed, where there has been a demand for the "fuel-efficient" motoring cars.

As a result of this complex and critical context, a surprising increase in the biofuels production has come up into the energy matrix scenario of many countries, and since then, alternative types of fuels, derived mostly from ethanol and biodiesel, have been promoted aggressively (Martinot 2005). Biodiesel was probably the first of the alternative fuels to really become known to the public. The idea of using a vegetable oil as an engine fuel goes back in history, when Rudolf Diesel, in 1900 used peanut oil as liquid fuel in internal combustion engines (Shay 1993). Ethanol has also been used as a transportation fuel since Henry Ford and other transportation pioneers began developing automobiles. In 1908, the Ford Model T was designed with a carburetor adjustment that could allow the vehicle to run on ethanol fuel produced by North American farmers.

As a general definition, biodiesel is the name for a variety of ester based fuels (fatty esters), generally defined as the monoalkyl esters synthesized from new or residual vegetable oils and animal fats from a simple trans-esterification process. It runs on any type of diesel engine without any special modifications. Ethanol is an alcohol-based alternative fuel that is mostly made by fermenting and distilling crops such as wheat, corn, sugar beet and sugarcane. To be a viable alternative, a biofuel should provide a net energy gain, have environmental benefits, be economically competitive, and be producible in large quantities without reducing food supplies (Hill et al. 2006).

Although there may be new sources of fossil fuels, yet to be drilled or explored, like in Brazil, Mexican Gulf, Russia and Venezuela (Mommer 2002), the reduction of greenhouse gas emissions has become a primary focus, since the use of fossil fuels contributes to a number of environmental problems. Strategic energy plans started to advance in many countries, accelerating projects of alternative and renewable sources of energy (Martinot et al. 2002). Creating a sustainable diversified energy strategy, using renewable types of fuel and adopting clean practices and technologies, will increase efficiency of energy production and lower the environmental impacts of present energy sources. Good energy management practices also extend the resources that are already available. Policy-makers should encourage such practices and take these trends into consideration when developing a National Energy Strategy. Research to address environmental problems and to expand energy choices is an appropriate and essential role for government. Consolidation of a diversified energy strategy necessarily goes by political decisions and it implies in a world-wide consensus since it will modify economic and security issues of several countries. The necessity of minimizing environmental impacts of energy use, particularly those with potentially worrisome global effects, is perhaps the greatest challenge resulting from the twentieth century's energy advances.

ENVIRONMENTAL ASPECTS OF BIOFUELS AND FOSSIL FUELS

There has been a world mobilization around the alarming environmental phenomenon known as global warming. A great number of scientists have affirmed that the global surface temperature has increased 0.2°C per decade in the past 30 years, similar to the warming rate predicted in the 1980s, and 0.8°C in the past century, which provoked an increase of 40 cm in the level of the oceans (Hansen et al. 2006). Experts anticipate an increase in the latter of somewhere between 1.4°C and 5.8°C over the period 1990-2100 (McCarthy 2001). The economic, social and political consequences of such changes are potentially dramatic. The conclusion that global warming is a real climate change, not an artifact due to measurements in urban areas or is part of the recurrent elevations of temperature, already proven that happens spontaneously along the eras, is confirmed by surface temperature

change inferred from borehole temperature profiles at remote locations, the rate of retreat of alpine glaciers around the world, and progressively earlier breakup of ice on rivers and lakes (IPCC 2007). One of the most important mobilization, regarding global warming, was the Protocol of Kyoto (1997), which established emission reduction rates of pollutant gases to the atmosphere by industrialized countries, which between 2008 and 2012 must be (on average) 5 % lower than the levels from 1900.

Most anthropogenic sources of greenhouse gases (GHGs) are the result of the extraction and combustion of fossil fuels, like coal, oil and natural gas. Additional causes of human-induced climate change are land-use activities and emissions of certain types of industrial chemicals (Lauber 2005).The main pollutant agents emitted in the combustion of fossil fuels are sulfur and nitrogen oxides, carbon monoxide and suspended particulate matter. The environmental impacts of energy-linked emissions contribute to local and regional air pollution and ecosystem degradation. Human health is threatened by high levels of pollution from fossil fuel combustion. Vehicle emissions are responsible for many of the environmental problems faced by large cities like Mexico City, New Delhi and São Paulo (Goldemberg et al. 2003). Drilling and extracting oil results in spills and fires, occupational injury and disease, and harm to ecosystems. Oil leaks and spills cause serious harm to marine life and fisheries. According to the Oil Spill Intelligence Report of 1999, approximately 32 million gallons of oil was spilled in worldwide waters as a result of 257 transport incidents that year. Petroleum refineries present major health hazards for those who work in and live near them; oil, its byproducts and the chemicals used in the refining process cause air and water pollution, thermal and noise pollution (OEC 2007).

The use of biofuels is largely justified for health and environmental reasons and not only because of depletion of oil reserves and social and strategic reasons (Coelho 2005). One of the main differences between ethanol produced from sugarcane and fossil energy sources is ethanol's lower environmental impact (Strapasson & Job 2007). Biofuels are sometimes even claimed as being carbon neutral and fossil free (Rajagopal & Zilberman 2007),

although serious concern about biofuels benefits has been raised in the literature (Farrel et al. 2006; Pimentel & Patzek 2005). Some scientists argue that, although the carbon released when biofuels are burnt is the same carbon that was captured by the plant as it grew, through photosynthesis; and agricultural production – particularly through the use of chemical fertilizers – can also produce substantial GHGs. It would be appropriate to emphasize here that any type of agriculture has, at some extent, environmental impacts, since it interferes with the natural dynamics of the local biodiversity (Strapasson & Job 2007). So, bringing new land into agriculture also accelerates global warming because the destruction of forests. Converting carbon-rich natural ecosystems to agricultural land for production of biofuels feedstocks would greatly diminish any value the fuels might have in fighting global warming. Consequently, when biofuels production relies on fossil fuels to power the processing plants; the global warming benefits of biofuels decline. However, this does not invalidate the biofuels strategic and sustainable use. Producing biofuels in a more sustainable manner through the reduced nitrogen fertilizers inputs, crop rotations, manures and green manures will significantly improve the energy balance of biofuels (DeLuca 2007). Furthermore, significant nitrogen fixation can be accomplished by different species of nitrogen-fixing bacteria, replacing or decreasing the use of chemical fertilizers and its production (Choudhury & Kennedy 2004). Energy supplies involved in the biofuel production can also be originated from green matter, like the sugarcane bagasse, and used as energy source in the sugarcane-ethanol plants and, biodiesel can also be used as a regular fuel in all farm machineries.

A negative impact observed in the agricultural phase of biofuel is soil compaction when appropriate agronomic techniques are not used. The intense movement of heavy machinery during planting and harvesting can cause soil compaction, which in extreme cases can only be solved through deep plowing or even subsoil ripping or subsoiling. The use of lighter, more modern machinery helps reduce that kind of problem, together with crop rotation and maintaining the straw or stubble over the soil. Crop rotation also contributes to improve the biological balance of the soil by preventing excessive selection pressure on the biodiversity and,

consequently, the emergence of pest and diseases. In addition, crop rotation using leguminous plants promotes nitrogen fixation in the soil through symbiosis between the bacteria and the root system of the legumes (Strapasson & Job 2007).

The adoption of new technologies can also contribute to reduce the environmental impacts of present and new energy sources. Genetic plant breeding of oil plants has been focused so far, on the increase of protein production, without actually focusing on increasing the content of vegetable oil. Reversing this situation, in a long-term period, could increase the concentration of vegetable oil in a vertical way, without increasing the agricultural area. One important environmental policy, which will have major implications for biofuels, is the regulation of biotechnology. Biotechnology offers opportunities for enhancing productivity while at the same time reducing intensity in the use of inputs that are scarce such as land and water or inputs that have environmental externalities like fertilizers and pesticides (Rajagopal & Zilberman 2007).

Critical considerations on the potential use of biofuels are important, however they are perspectives analyzed on the productive structure of today's system. That's why it is important to consider the competitive and sustainable agricultural advantages of each country. For example, biofuels derived from native grassland perennials mixtures (from USA) as low-input high-diversity (LIHD) can provide more usable energy, greater greenhouse gas reductions, and less agrichemical pollution per hectare than can corn grain ethanol or soybean biodiesel grown on fertile soil with high inputs. Moreover, LIHD biofuels can be produced on agriculturally degraded lands and thus need to neither displace food production nor cause loss of biodiversity via habitat destruction (Tilman et al. 2006). On the other hand, ethanol from sugarcane (also called Brazilian ethanol) offers the highest energy and CO_2 benefits followed by cassava, while ethanol from corn (American ethanol) offers relatively modest energy and environmental benefits. Cellulosic ethanol, however, is expected to deliver higher future net energy gains and reduced future GHG (Rajagopal & Zilberman 2007). Ethanol production from sugarcane in Brazil, is cheaper and more energy efficient than corn ethanol (from USA), because it doesn't need to make the

transformation from carbohydrates to sugar, which is then fermented to make ethanol. So, different results can be obtained in different ecosystems, and one should consider that biofuels are more economic viable in major agricultural countries.

Environmental regulators will face pressures to develop more efficient policies to meet well-established challenges—including targets for air and water quality—as well as new policies to meet emerging challenges such a climate change. Environmental and energy policies sometimes conflict with one another. For example, potential air quality and climate change policies strongly encourage the development of natural gas, while policies restricting energy exploration and facilities would make production and use of natural gas more difficult. Although some conflicts represent inherent public policy tradeoffs, other conflicts can be avoided or reduced through more effective and efficient policy approaches. Policy-makers engaged in developing a National Energy Strategy can reduce these conflicts by developing environmental policies that minimize the cost of achieving specific environmental objectives and by limiting inappropriate interference with market-driven fuel choices (USEA 2001).

The trend toward increasing production of biofuels provides an opportunity to dismantle agricultural subsidies and tariffs in wealthy countries, according to the International Monetary Fund's top economists. Non-governmental organizations and developing country governments have been calling for farm subsidy and trade reform for years, to give producers in the South a chance to develop domestic markets. Biofuels offer an opportunity to bring about this much needed transformation.

To produce sustainable biofuels, it is important to evaluate the entire biofuels production process, from the fields where the feedstock is planted, through the processing plant. Based on this life-cycle analysis, those renewable fuels that provide the highest energy yield, most positive local economic and social impacts, greatest benefit to the environment, and lowest drain on scarce resources should be clearly identified and encouraged. By enforcing adequate management practices and specific environmental criteria

for each crop and region, it is possible to reduce considerably any possible environmental impacts and ensure the sustainability of the medium for future generations (Strapasson & Job 2007).

ECONOMICAL AND SOCIAL ASPECTS OF BIOFUELS

The economic motivation for biofuels is that they are a convenient, low-cost, domestically producible substitute for oil, a fuel that is getting costlier by the day and is also imported from politically unstable regions. The increased demand for agriculture from biofuels can also address the worldwide problem of declining farm income (Rajagopal & Zilberman 2007). Access to cheap energy has become essential to the functioning of modern economies. However, the uneven distribution of energy supplies among countries, and the critical need to widely access energy resources, has lead to significant vulnerabilities. Firewood is the most commonly used fuel in rural areas in many least developed countries. The indoor pollution created by burning firewood has a negative effect on health and impacts on people's quality of life, as women and children spend a considerable amount of time collecting it (Coelho 2005).

Introducing biofuels into a country energy matrix will create a number of new job opportunities. However, a negative impact behind the social aspects of biofuel has come under an increasing concern, and comes from the fact that the greater profits available to farmers from the growing of fuel crops will result in lower yields of food crops - leading to ever higher food prices. The production of crops for non-food purposes ("non-food crops") has increased due, among other factors, to the need to develop renewable energy in order to meet environmental objectives such as climate change. Growing crops for biofuel uses may threaten the world's poor and increase food prices. Still, there were occasions that the production of food around the world overcame the global need, enabling to feed 12 billion people, almost the double of current population. Therefore, hunger in today's world is mostly due to poverty and political reasons than to lack of food. In opposition, expanding biofuels production could also contribute to fight the hunger, generating new economical enterprises and employments in rural

areas, where the largest concentration of people with low income are located (Parente 2007).

Large deforested areas in developing countries could be recovered by sugarcane crops – or any other crops which produces vegetable oils, in order to produce biofuels. In addition to the previous mentioned advantages of biofuels production, it would also have a significant impact on employment opportunities mainly in rural areas (Coelho 2005). The processing facilities required to convert biomass into value-added products create direct and indirect jobs, provide regional economic development, and can increase farm and forestry incomes, particularly in rural areas (Bowyer & Stockmann 2001; Braune 1998). As an example, bioethanol generation in the US has created an estimated 200,000 jobs and $ 500 million in annual tax receipts (Bowyer & Stockmann 2001) which has led to the investment of more than $1 billion (US) over the past decade towards biorefinery research. The potential for Canadian business is similarly positive (Mabee 2006).

More than two billion people in the world do not have access to affordable energy services, and this seriously affects their chances of benefiting from economic development and improved living standards (Karekezi & Kithyoma 2006). Women, older people and children suffer disproportionately because of their relative dependence on traditional fuels and their exposure to smoke from cooking, the main cause of respiratory diseases. Access to electricity through transmission distribution lines is unlikely to happen in many parts of the world for the foreseeable future, so access to modern decentralized small-scale energy technologies, particularly renewables (including biofuels), are an important element for successful and effective poverty alleviation policies (Goldemberg et al. 2004). The great challenge of contemporary world is the conciliation between family and automated agriculture which may allow social and economical inclusion of millions of workers around the planet.

SOME INSIGHTS FROM THE BRAZILIAN EXPERIENCE ON BIOFUELS PRODUCTION

The change in the world energetic matrix, with the growth of renewable energy opens a unique space for Brazil. The size of the

Brazilian territory, its geographical location and the prevailing soil and climate conditions are perfect for the production of energy from agricultural biomass (Abreu et al. 2007). Brazilian agriculture is competitive and more importantly, has high expansion potential. In addition, a good stock of tropical and subtropical technology is readily available. Sugarcane ethanol in Brazil is the cheapest at $ 0.33 per liter of gasoline equivalent, while ethanol from wheat and sugar beets in the EU is more than double the cost of Brazilian ethanol on account of higher feedstock and conversion costs. Ethanol from maize in the United States is cheaper than European ethanol but costlier than Brazilian ethanol because of higher cost of conversion. Brazil leads the world in ethanol production and ethanol use for fuel and the government has decided recently to implement a program to blend biodiesel with diesel. In 2004, the government created the National Program for Production and Use of Biodiesel to reduce Brazil's dependence on imported diesel and to supply a fuel that has low environmental impact. The programme allows the use of 17 other oil sources for biodiesel production.

In Brazil, biodiesel has never been an economically attractive proposition because the market price of vegetable oils has been higher than that of mineral diesel. Now, however, Brazilian government has added a social component. So, the production of the raw material has become an important mean of social inclusion, generating jobs and income opportunities for the poorest among the rural population (Abreu et al. 2007).

Regarding social aspects of biofuels, one of the guidelines established by Brazil's federal government on biodiesel production was to focus on social problems and actions. So, a "social fuel seal" kind of incentive tax was created to bring benefits to family farmers. The purpose of the seal is to encourage partnerships of companies and family farmers, involving the guaranteed purchase of the raw material at pre-established prices (Abreu et al. 2007). The concern with supporting family agriculture is based on several studies carried out by many sectors of Brazilian federal government. The studies concluded that replacing 1 per cent of the fossil fuel consumed in Brazil with biodiesel produced from raw material originated in family agriculture would help create 45,000 jobs in the rural areas (Holanda

2004). Estimating that for every job in the rural areas three jobs are created along the remaining production chain, the studies concluded that 180,000 new jobs would be created for each 1 per cent fossil fuel replaced with biodiesel. It should be emphasize here that large agriculture producers employ, on an average, one worker for every 100 hectares planted, while family agriculture employs one worker per 10 hectares (Abreu et al. 2007).

CONCLUSION

Concerns about climate change, security, and reliability of energy supply and the growing demand for oil are likely to make biofuels ever more attractive. Biofuels has been playing a vital role in meeting the energy need of human beings. There is a strong reason to believe they will continue to do so in the future in a different manner. Traditional or modern, biofuels can make a positive contribution to all three pillars of sustainable development – economic, social and environmental. Along with technological progress, innovative policies will be necessary to ensure a smooth transition to future where modern biofuels can be a significant supplier of energy.

Bioenergy products have to be more than "green"; they also have to be priced competitively and add more value than the competition. Biofuels will prove to be a useful complement to a nation energy mix, but it must only be developed in a sustainable and thoughtful manner considering land limitations and environmental impacts (DeLuca 2007). The world's energy and climate problems are likely to be solved only by a combination of approaches and technologies, including energy efficiency and renewable types of biofuels (Pacala & Socolow 2004).

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