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Review Article

ENERGY CROPS FOR BIO FUEL AND FOOD SECURITY

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ABSTRACT
In light of the recent rise in global food prices, much of the publications on crop-based biofuel production focus on the potential impacts on food security. The bio fuels include bio ethanol, bio butanol, biodiesel, vegetable oils, bio methanol, pyrolysis oils, biogas, and bio hydrogen. There are two global biomass based liquid transportation fuels that might replace gasoline and diesel fuel. These are bioethanol and biodiesel. About 60 % of global bioethanol production comes from sugarcane and 40 % from other crops. The central policy of biofuel concerns job creation, greater efficiency in the general business environment and protection of the environment. The use of biofuels decreases the external energy dependence, promotion of regional engineering, increased R and D, decrease in impact of electricity production and transformation; increases the level of services for the rural population, creation of employment, etc. There is considerable controversy about the impact of biofuels on food security in developing countries. A major concern is that biofuels reduce food security by increasing food prices. In this paper we use survey evidence to assess the impact of castor production on poor and food insecure rural households in Ethiopia. About 1/3 of poor farmers have allocated on average 15 % of their land to the production of castor beans under contract in biofuel supply chains. Castor production significantly improves their food security: they have fewer months without food and the amount of food they consume increases. Castor cultivation is beneficial for participating households' food security in several ways: by generating cash income from castor contracts, they can store food for the lean season; castor beans preserve well on the field which allows sales when farmers are in need of cash (or food); spillover effects of castor contracts increases the productivity of food crops. Increased food crop productivity offsets the amount of land used for castor so that the total local food supply is not affected.
Keywords: Biofuel, food security, energy crops, corn, ethanol, biodiesel.

INTRODUCTION

Biomass can be defined as the collection of all organic matter composing biological organisms, but the main components utilized for biofuel production are sugars (starch, simple sugars, and lignocelluloses) and lipids[1,2]. Bio fuels offer one of the best alternative options as they have much lower life cycle GHG emissions compared to fossil fuels. These are liquid fuels derived from renewable biological sources[3-6]. One of the directives of European Union (2009/28/CE) imposes aquota of 10 % for bio fuel sonall traffic fuel until 2020[7]. The most common renewable fuel is ethanol, which is produced from direct fermentation of sugars (e.g. from sucrose of sugarcane or sugar beet) or polysaccharides (e.g. starch from corn and wheat grains)[8]. Food versus fuel is the dilemma regarding the risk of diverting farmland or crops for Biofuels production to the detriment of the food supply. Biofuels are generally considered as offering many priorities, including sustainability, reduction of greenhouse gas emissions, regional development, social structure and agriculture, security of supply stocks is oxygen content. Bio fuels are non-polluting, locally available, accessible, sustainable and reliable fuel obtained from renewable sources[9]. Different scenarios for the use of agricultural residues as fuel for heat or power generation are analyzed. Reductions in net CO_2 emissions are estimated at 77–104 g/MJ of diesel displaced by bio- diesel[6,9]. Climate change consciousness has served as an important additional driver to the embrace of bio fuels because it assists climate change mitigation efforts by displacing fossil fuel consumption[10]. Agriculture is linked to energy markets through both indirect (cost of fossil-based inputs like fertilizer and insecticides) and direct costs (production, processing, and transport), and also through the competition of resources, such as land and water, for production of food, feed or energy crops. The application of first-generation bio fuel conversion technologies have expanded the uses for traditional commodities such as maize, oil seeds, and sugarcane, enabling farmers to market their crops beyond the traditional food, feed or industrial food-processing uses. The bio fuel blending mandates adopted by the E.U. and U.S. are argued to be putting undue pressure on grain and oilseed markets, which is driving up international food prices and affecting human welfare[11].

Bio fuels are gaining importance

Most important energy carriers were cereals (for e.g. feeding horses) based on renewable solar energy. In recent years, the interest in fuels based on renewable energy has been increasing all over the world, mostly due to the problems, which are currently accompanying the use of fossil energy for providing individual automotive mobility, such as:

- growing consumption of fossil fuels;
- increasing greenhouse gas emissions;
- Accelerating import dependency especially from politically unstable countries.

The biofuel and food price debate involves wide-ranging views, and is a long-standing, controversial one in the literature. Biofuel production has increased in recent years. Some commodities like maize (Corn) Sugarcane and Vegetable oil, can be used either as food, feed, or to make bio fuels. For example, since 2006, a portion of land that was also formerly used to grow other crops in the United States is now used to grow corn for biofuels, and a larger share of corn is destined to ethanol production, reaching 25 % in 2007. Rising world fuel prices, the growing demand for energy, and concerns about global warming are the key factors driving renewed interest in renewable energy sources and in bioenergy, in particular. Worldwide energy consumption is projected to grow by 59 % over the next two decades, according to International Energy Outlook 2001[12], released by the US Energy Information Administration (EIA). One half of the projected growth is expected to occur in the developing nations of Asia (including China, India and South

Korea) and in Central and South America, where strong economic growth is likely to spur demand for energy over the forecast period. Renewable energy use is expected to increase by 53 % between 1999 and 2020, but its current 9 % share of total energy consumption is projected to drop to 8 % by 2020. Oil currently accounts for a larger share of world energy consumption than any other energy source and is expected to remain in that position throughout the forecast period. World oil use is projected to increase from 75 million barrels per day in 1999 to 120 million barrels per day in 2020. Biomass resources are potentially the world's largest renewable energy source – at an annual terrestrial biomass yield of 220 billion oven dry tones. Biomass conversion to fuel and chemicals is once again becoming an important alternative to replace oil and coal. Biodiesel from the rape seed oil methyl ester (RME) produced by farmer cooperatives is about 2000 t RME per year. A large facility of 15000 t RME per year is located at the oil mill at Bruck/Leitha in Austria. RME is excellent substitute for diesel. Already, European countries, mainly France, Italy, Germany and Austria are leading in biodiesel production, nearing 500,000 tons in 1997 out of which 250,000 were produced in France[13]. The production capacity of biodiesel in Germany was fully utilized in1997, the sold quantity amounting to roughly 100,000 t[14]. The technologies for producing bio-oil are evolving rapidly with improving process performance, larger yield and better quality products. The challenge is to develop a process technology which can cope with the significant variation in the composition of the raw material. Another line of action is *Camelina sativa*. This plant was a traditional oilseed in Europe. It is considered a "low input high yield" plant which could enhance the environmental aspect of biodiesel. However, it has a higher Iodine number

Case study Ethiopia

In Ethiopia policy makers have allocated areas with low agricultural potentials or degraded areas for the production of biofuel crops. These areas are often recognized as food insecure areas. For example, one company planted perennial crop trees for biofuel feedstock on 15,000 ha areas of degraded hills in the Northern region of the country called Kola Temben, an area known with a large population living under extreme poverty and food insecurity. Nagesh[15]* studies focused on the contract farming system established by a company in the Southern region of Ethiopia, more specifically in the Wolayta and Gomo Gofa districts which are known to be heavily food insecure. Castor production in the Southern region started in 2008 with castor seed distribution to more than 10,000 farm households in Wolayeta and Gamo Gofa. Farmers traditionally recognize that crop rotation with castor enhances soil fertility, but no one was interested to cultivate it because of its low value as cash crop. The company had to undertake extensive promotion activities to introduce the crop as cash crop. It resulted in widespread adoption (close to 33 %) in the third year of the operation.

Descriptive Statistics for Ethiopia

Ethopia is agriculture based society. The dataset contains 476 households. About 30 % of them are "adopters", i.e. households which allocated land to grow castor and received the necessary inputs in the 2010 cropping season. The incidence of adoption over the sample villages is reported in Table 3. The 24 villages in our sample vary in terms of proximity to towns, infrastructure and other economic activities besides farming. In some villages (such as Fango Sore) that are far-off from towns and constrained by a limited availability of markets for alternative commodities, the adoption intensity is above the average rate (54 %).

Food security indicators

To assess food security, we use two type of measures. The first is the number of"food gap" months. "Food gap" is defined as the number of months that the household runs out of own stock of food (mainly grains and other own livestock food sources) and lacks money to purchase food. The study area is known for its severe seasonal food availability fluctuation problem. Smoothing intra-year food availability at the household level is a prime concern. The benefits from growing castor in areas that have seasonal food gap fluctuation could be associated, first, with the fact that the cash income during the harvest seasons from pre-signed castor contract may prevent farmers from selling food crops at harvest time when prices of food crops decline. Stocking food would prevent them from paying higher prices during the lean seasons. Second, castor beans, once planted can be collected twice a year. They preserve well on the field without easily spoiling like other annual food crops that need to be harvested immediately. This allows piecemeal collection of beans and sales to village level collection centers whenever farmers are in need of cash. For rural farmers where liquidity constrains are vital to food security, flexible access to cash source: harvest and sell whenever necessary protects them from taking suboptimal strategies on investments and crop use. Better access to credit for inputs, combined with limited risk of castor beans (since they require lower land quality than food crops, improve the land quality in rotation with other crops) is another potential channel that participants households benefit from the scheme. Nagesh (2012)* presented micro-evidence on the impact of the cultivation of a biofuel crop - castor on food security by presenting survey data and analyzing the effects on poor households in rural Ethiopia; the study is based on data collected in early 2011 from 478 randomly selected households. We use endogenous switching regression with exclusion restriction to control for endogenous selection issues in consumption and adoption decisions. Our choice of the instrument is based on the eligibility criteria used by the contracting company and the pre evaluation period intensity of the program intervention at the village level. In terms of their impact on food security, our findings indicate improvements in food security (as measured by the "food gap") and food consumption levels. For rural farmers where liquidity constrains are detrimental to food security, castor programs timed to coincide slack seasons can contribute to mitigate seasonal food availability. This is suggestive of the complementarities between "fuel" and "food" at the micro-level in castor production in Ethiopia.

Bio energy for economic growth

Bio energy is also considered by some to be a potentially significant contributor towards the economic development of rural areas, and a means of reducing poverty through the creation of employment and incomes – and biofuel development is directly or indirectly linked with multiple Millennium Development Goals[16,17]. In order to highlight the ways in which bio fuel policies can better capture the needs of small farmers and the poor, we use a simplified economic framework in which we construct some key indicators and criteria that can help to prioritize national energy policies and show how biofuel production (or other investments in energy technologies) can be responsive to the energy needs of the poor.

Recent trends in bio fuels production

Currently, global production of biofuels is relatively low, but continuously increasing[28] with increasing demand of bio fuels due to environmental concerns and decreasing supply of fossil fuels different food crops are being diverted for production of biofuels. In Europe it was Rapeseed and in USA they relied on soyabean oil. Brazil had sugarcane and USA has maize as a prime source of biomass and biofuels. This obviously required land area, water and energy inputs. The use of food crops for biofuel certainly raised the demand for them in the agriculture sector. Corn prices soared to a higher level in USA but relieved farmers of the financial stress they were facing due to lower prices. Europe and USA cannot be considered an ideal case to argue for or against use of biofuels as each has surplus production of food grains and farm produce[18].

Second generation bio fuels

Second-generation ethanol is produced through the conversion of ligno cellulosic biomass. In contrast to the first-generation ethanol, which is produced from the sugar or starch fraction of the plant (i.e., a small percentage of the total mass), ligno cellulosic conversion processes would enable full use of the ligno cellulosic material found in a range of biomass sources, such as waste seed husks and stalks (making use of plant residues not needed for food production) and fast-growing grasses and trees. Ligno cellulosic biomass is comprised of polysaccharides (cellulose and hemi-cellulose), which are converted into sugars through hydrolysis or chemical (or combined) processes; the sugars are then fermented into ethanol using existing fermentation technology.

Bio fuels production

Global production of biofuels amounted to 62 billion liters (or 36 million tonnes of oil equivalent (Mtoe)) in 2007, which is equal to 1.8 % of total global transport fuel consumption in energy terms. Brazil and the United States together account for almost three- quarters of global biofuels supply. Ethanol production is rising rapidly in many parts of the world in response to climate change and higher oil price, which is making ethanol more competitive, especially in combination with government incentives. Global bioethanol production tripled from its 2000 level and reached 52 billion liters (28.6 Mtoe) in 2007.

Food vs. fuel costs

Commodity prices for grains on the world market increased sharply in 2006-2008, triggering worldwide concern and consumer panic, such as food riots in over 50 countries including Yemen, Morocco, Mexico and Bangladesh and food hoarding in Hong Kong[19]. The expanded market opportunities for key biofuel feedstock crops and their higher prices on world markets is raising the incomes of farmers and generating employment in agriculture and other related processing sectors, –which, from a producer perspective, is a welcome change from the past trends of stagnation or decline in real value that characterized the long-term price dynamics in many commodity markets. Yet this shift towards crop-based biofuel production – combined with concurrent increases in agricultural production costs as a result of escalating energy prices and other pressures to the agricultural sector – is driving up the cost of cereals for food and feed and causing widespread concern in countries who are large net importers of key grains. This upward trend in food prices is sparking a new debate as to whether crop-based energy production is sustainable for countries whose levels of food insecurity and poverty are still significant. Studies have identified linkages between the usage of feedstocks in biofuel production and international food price increases. Corn and wheat are very important feed stocks for bioethanol production. Yet, bioethanol production has been rapidly increasing, especially in the last ten years. And in spite of the increasing use of wheat and corn for biofuels production, it can be noticed that their prices have been relatively stable in the period between 1996 and 2006. In the period between 2006 and 2008 these commodity prices have increased more than 50 %. But after the price spike in 2008, in July 2009 corn and wheat prices were again at the same level as in 2006, as well as 1996. The use of set aside land was made for cultivation of biofuels in Europe and biofuel cultivation gave a breather to the farmers suffering from low prices of corn. The fact that droughts and floods due to climate change conditions have caused a global awakening and from Kyoto to Cancun conferences concern have been raised for global warming. Europe plans to have 20 percent replacement of biofuels. Carbon dioxide emission is projected to grow from 5.8 billion tonnes carbon equivalent in 1990 to 7.8 billion tones in 2010 and 9.8 billion tonnes by 2020. The Kyoto conference agreement last year is not far reaching but indicates the role clean energy sources will play in the future. Biomass is renewable, non-pollutant and available worldwide as agricultural residues, short rotation forests and crops. Thermochemical conversion using low temperature processes are among the suitable technologies to promote a sustainable and environmentally friendly development. This increase is supported by the fact that many countries have set goals to replace a part of fossil fuels by biofuels. In the European Union 5.75 percent of the energy used for transportation should be biofuels by the year 2010. By 2020 10 % of energy used in transport should be from renewable energy source, biofuels in practical terms. In 2007 total production of biofuels amounted to 62 billion liters, which is equal to 1.8 % of total global transport fuel consumption in energy terms. The highest share of biofuels in total transport fuels demand in 2007 was in Brazil and the USA, 20 % and 3 % respectively. Biomass can play a dual role in greenhouse gas mitigation related to the objectives of the United Nations Framework Convention on Climate Change (UNFCC) i.e. as an energy source to substitute for fossil fuels and as a carbon store. Developing countries like Malaysia and Indonesia have resorted to use of palm oil for biofuel production and large areas of forests have been cleared for raising biofuel crops. Cultivation of sunflower for biofuel production was certainly not favored and prices of mustard oil raised to new height due to their use in biofuel production. There can be no denial that biofuel production is having adverse effect on food production and resulting in shortages of food and raising their prices in different parts of the world. Should the use of farmland for biofuel production be banned? This will have its implications in global warming. Use of renewable energy sources like solar, wind, tidal and thermal do no absorb the

Carbon and store in them while plants absorb Carbon and store it for hundred years or more.

Impacts on biodiversity and ecosystems

The effect of biofuel production on biodiversity depends on the type of land utilized. If degraded lands are restored for biofuel feedstock production, the impact could be positive[5,6] Current biofuel crops are especially suited for cultivation in tropical areas, biofuel expansion could convert natural ecosystems in tropical countries that are biodiversity hotspots into feedstock plantations. However to avoid this situation selection of plants for the tropical regions from among the local plants and plants suitable for wasteland has been studied in detail. Global growth in crop-based biofuel production has affected the supply of grains available on international markets. The application of first-generation biofuel conversion technologies have expanded the uses for traditional commodities such as maize, oil seeds, and sugarcane, enabling farmers to market their crops beyond the traditional food, feed or industrial food-processing uses[11] (Ewing and Msangi 2009). Between 2002 and 2007, the production of maize-based ethanol in the U.S. was responsible for 30 % of the increase in global wheat and feed grain use, and, by 2007, nearly a quarter of all maize produced in the U.S. was diverted to ethanol markets (Trostle, 2008). These supply shifts have impacted world grain prices. Since 2002, there has been a sustained increase in food commodity prices, with a 60 % increase since 2006[20]. According to one study, the additional demand for biofuels is responsible for 30 % of the weighed grain price increase from 2000 to 2007[21]. Looking at the longer term impacts of expanded bio fuel production, IEA[12]. Calculates 20 % increase of the price of vegetable oil in the year 2014 as a result of the combined effects of U.S., E.U. and Canadian biofuel blending mandates. Similarly, Rosegrant *et al*.[21] (2008) indicated that price of maize will increase up to 70 % over the baseline year 2000, depending on the scenario, for the year 2020. The production of biofuels has a different dynamic in relation to fossil fuels, being based on agricultural products, where the main input is land. Land for food production could also be diverted for biofuel cultivation in the same poor regions of the world, which could be detrimental to environmental resources and food security. In Southeast Asia, biofuel subsidies have led to increased palm oil production, often at the expense of dwindling rainforests, which have been cleared to create new plantations. In both the developing and developed world competition for water between domestic, industrial, and agricultural sectors is already intense. Large-scale biofuel production will exacerbate this competition for water, especially if the biofuel production relies on irrigated crops as they do in India and China, said de Fraiture. "Chances are that countries that already face water problems, in terms of quantity and quality, may need to rethink their ambitious [biofuel] programs and look for alternatives".

Case study USA

Across the USA's "cornbelt" in the mid- west, rows of maize are beginning to brown and the ears to break open-a sign that this year's harvest is only weeks away. The crop is maturing ahead of schedule and forecasts are for a record crop of 13·1 billion bushels, an 11 % increase from the previous record set in 2004. US agricultural exports are expected to reach a record US$79 billion this year and will be even higher next year, forecast at $83·5 billion. Such staggering production levels should be good news for the world's food stocks and it should be expected to provide some relief to the world's 800 million malnourished citizens. But a growing proportion of US crops are destined for biofuel production, not food, and some experts say the soaring demand for biofuel poses a serious threat to the world's poorest residents. The demand for biofuels in the USA, Europe, and other developed nations is partly driven by the need to replace fossil fuels and lessen dependence on high-priced imported oil. The goals being set are ambitious. At a recent biofuels conference in Brussels, European Commission President José Manuel Barroso said that to meet energy needs and reduce carbon dioxide emissions the European Union (EU) had set targets of 20 % renewable energy and 10 % bio fuels in vehicle fuel by 2020. The UK will require 5 % of petrol and diesel to be derived from biofuels by 2010. In the USA, President George W Bush has called for production of 35 billion gallons of bio fuels by 2017, which would, the White House claims, displace 17 % of projected US petrol consumption. Since it is unlikely that Europe will be able to produce enough biodiesel to meet those targets or that the USA will be able to produce enough ethanol for its needs, developing nations are jumping into the market.

Increasing grain prices

The rise in grain prices is impacting food security. Most poor, including rural smallholders, are net purchasers of food. In addition, the poor spend a higher share of their income on food, over 50 % in many cases[22]. For example, in sub-Saharan Africa, Asia, and Latin America, prices for the staple food cassava- the cheapest source of calories in most tropical countries- could increase. In Africa alone cassava is the staple food for 200 million people. But the tuber is potentially a highly efficient source of ethanol and according to Runge and Senauer[23], its price is expected to jump by 135 % by 2020 due to demand for biofuels. Moreover, many developing nations import food to meet domestic demand. In Sub-Saharan Africa, the average percent of total cereal demand that is met though imports averaged 33 % in the year 2000, reaching high dependency levels of more than 80 % in Sudan, The Gambia, and Zambia[23](FAO, 2003). The current trend of high international prices may prohibit countries from importing needed food supplies. If regions with a high population of food insecure begin exporting grains to take advantage of high export prices, or if countries are not able import food due to the high grain prices, then malnutrition and hunger may increase. The results from Rosegrant *et al*.[21] demonstrated the impacts of increased biofuel production on net trade and ultimately malnutrition and hunger within an agricultural sector model. According to the results for the year 2020, Sub-Saharan African countries double export levels over the baseline of maize and cassava while importing less wheat, soybean, and oilseeds. The overall impact on food security shows that malnutrition increases by nearly 3,000,000 children, and calorie availability declines by 8 %. The supply chain for crop-based biofuels for the transportation sector can be divided into feedstock production, pre- and post-processing, conversion and transport. Despite these challenges small-scale biofuel production projects have been launched across Africa and Asia that are providing examples and generating knowledge of the possibilities and constraints surrounding sector development. Demonstration projects being conducted in rural communities in Ghana, Mozambique, Zambia, and Mali are developing supply chains for Jatropha-based biodiesel, including pilot plantations, in order to raise awareness and build capacity[24]. These projects have drawn attention to the range of applications of the Jatropha crop, including electricity and energy generation, soap making, lamp oil, and as an organic seedcake fertilizer. In rural India, a women-led pon- gamia oil project used to run small generators for household electricity is being replicated by the state government in nearly 100 villages[25].

Price and Policy Implications

Strong government support for small producers will be necessary in order to ensure that biofuel production in developing nations is sustainable and brings welfare benefits to rural areas – otherwise, purely commercial interests will always tend towards larger-scale schemes that provide the best return on private investment. The public sector needs to set the legal, fiscal, and institutional framework for biofuel production in order to maximize the complementarities between public and private stakeholders[26]. The prices of key food commodities (corn, soybeans, and wheat) more than doubled and the global price index for food increased 45 % from March 2007 to March 2008. The economic impact was greater in developing nations than in developed nations because unprocessed grains comprise a large fraction of the daily diet in developing nations and commodity food prices account for a substantial fraction of the total cost of food and are a larger percentage of personal expenditures[27,28]. Currently there is no global market for ethanol. The crop types, agricultural practices, land and labor costs, plant sizes, processing technologies and government policies in different regions considerably vary ethanol production costs and prices by region. Ethanol from sugar cane, produced mainly in developing countries with warm climates, is generally much cheaper to produce than ethanol from grain or sugar beet in IEA countries. For this reason, in countries like Brazil and India, where sugar cane is produced in substantial volumes, sugar cane-based ethanol is becoming an increasingly cost-effective alternative to petroleum fuels. Estimates show that bioethanol in the EU becomes competitive when the oil price reaches US$70 a barrel while in the United States it becomes competitive at US$50–60 a barrel. For Brazil the threshold is much lower – between US$25 and US$30 a barrel. Other efficient sugar producing countries such as Pakistan, Swaziland and Zimbabwe have production costs similar to Brazil's. The first, "conventional", aggressive biofuel growth scenario shows dramatic increases in world prices for feedstock crops by 2020. The highest price impacts are seen for oil crops, as well as for sugar crops, followed by staple crops. Part of this differential is due to the relative 'thickness' of markets: markets for staple grains are larger in volume and geographic scale. The relative productivity of irrigated and rain fed grains and sugar crops, compared to mostly rain fed oilseed crops, also contributes to the relative price increases. Thus, such a scenario entails large profits for net producers of the bio energy crop. Environmental groups have raised concerns about this trade-off for several years, but now the debate reached a global scale due to the 2007-2008 world food price crisis. On the other hand, several studies do show that biofuel production can be significantly increased without increased acreage; therefore stating that the crisis in hand relies on the food scarcity. Brazil has been considered to have the world's first sustainable biofuels economy and its government claims Brazil's sugar cane based ethanol industry has not contributed to the 2008 food crisis. A world bank policy research working paper released in July 2008 concluded that"….large increases in bio fuels production in the United States and Europe are the main reason behind the steep rise in global food prices", and also stated that "Brazil's sugar-based ethanol did not push food prices appreciably higher". A newly released report from the Development Prospects Group at the World Bank, concludes that "…the effect of biofuels on food prices has not been as large as originally thought, but that the use of commodities by financial investors (the so-called "financialization of commodities") may have been partly responsible for the 2007/08 spike." John Baffes and Tassos Haniotis[29], authors of the report entitled "Placing the 2006/08 Commodity Price Boom into Perspective", reported that "We conclude that a stronger link between energy and non-energy commodity prices is likely to have been the dominant influence on developments in commodity, and especially food, markets. Demand by developing countries is unlikely to have put additional pressure on the prices of food commodities, although it may have created such pressure indirectly through energy prices."

Global bio fuel production

Despite this tremendous growth in bio fuel production, the share of bio fuels in total transport fuel demand was above 2 % in 2004 in just three countries e Brazil, Cuba and Sweden IEA[12] and global output accounted for approximately 1 % of total road transport fuel consumption in 2005. In 2007, ethanol production still only amounted to about 4 % of the global gasoline consumption of 1300 billion liters. Biomass currently supplies about a third of the developing countries energy varying from about 90 % in countries like Uganda, Rwanda and Tanzania to 45 % in India, 30 % in China and Brazil and 10-15 % in Mexico and South Africa. Tropical deforestation is currently a significant environmental and development issue. The annual tropical deforestation rate for the decade 1981-1990 was about 15.4 million ha (Mha). According to some estimates the forest cover is 64.01 Mha accounting for 19.5 % of India's geographic area. At present there is hardly 0.4 % forest cover below the 25 cm rainfall zone and 1.3 % above 30 cm. Since the annual photosynthetic production of biomass is about eight times the world's total energy use and this energy can be produced and used in an environmentally suitable manner and mitigating net CO_2 emission, there can be little doubt that the potential source of stored energy must be carefully considered for future energy needs. The fact that nearly 90 percent of the world's population will reside in developing countries by about 2050 probably implies that biomass energy will be with us forever unless there are drastic changes in the world energy trading pattern.

Land availability and Biomass

Biomass should be used instead of fossil energy carriers in order to reduce i) CO_2 emissions ii) the anticipated resource scarcity of fossil fuels and iii) need to import fuels from abroad. Current commercial and non-commercial biomass use for energy is estimated at between 20 and 60 EJ/a representing about 6 to 17 % of the world primary energy. Most of the biomass is used in developing countries where it is likely to account for roughly one third of primary energy. As a comparison, the share of primary energy provided by biomass in industrialized. Country is small and is estimated at about 3 % or less. Global land availability estimates for energy crop production vary widely between 350 and 950 million hectares[30] (Alexandratos, 1995). An energy potential of about 37.4 EJ/a is estimate based on country specific biomass yield and an average land availability. The worldwide technical biomass energy potential is then estimated at about 104 EJ/a corresponding to approximately one third of the global 320 EJ/a primary energy consumption of oil, gas and coal,[31] (BP-Amoco 1999).

Limitations of Biomass use

Despite the fact that biomass represents about one third of the energy consumption in developing countries; it is not taken very well into account in energy studies; a set of factors explain the slow growth on the biomass utilization; they include:

- High costs of production
- Limited potential for production
- Lack of sufficient data on energy transformations coefficients.
- Low energy efficiency
- Health hazard in producing and using biomass.

In the large scale use of biomass for energy risks are insecurity in raw material supply and prices, doubts about adequate quality assurance and hesitance for a wider acceptance by the diesel engine manufacturers, missing marketing strategies for targeting biodiesel differential advantages into specific market niches and last not least missing legal frame conditions similar to the clean air act in the USA. In the large scale use of biomass for energy risks are insecurity in raw material supply and prices, doubts about adequate quality assurance and hesitance for a wider acceptance by the diesel engine manufacturers, missing marketing strategies for targeting biodiesel differential advantages into specific market niches and last not least missing legal frame conditions similar to the clean air act in the USA.

Development of agro technologies for plants growing in wastelands could protect food vs. fuel crisis

Our field studies in Indian semi arid and arid regions

The work on the development of suitable agro-technology for hydrocarbon yielding plantswas initiated at the University of Rajasthan, Jaipur, India in 1980 with guidance of *Euphorbia lathyris* provided by Professor Melvin Calvin (Kumar, 1984). DST (Later on DNES) granted aresearch project to the principal investigator at the University of Rajasthan in 1982 to work on hydrocarbon yielding plants which was later raised to practical demonstration on 5 ha in 1985 after successful completion of first phase. This area was totally barren degraded and denuded with only one tree asseen in the Figure 1 and 2.

Figure 1 and 2: Totally barren, degraded and denuded land taken for bio fuel cultivation

After the successful demonstration of the second phase a project called Energy Plantation Demonstration Project for 50 has was granted in which a three tier system was followed asper the details of the work given below. A 50 ha Energy Plantation Demonstration Project Center (EPDPC) in the semi- arid region of Rajasthan, India was used to conduct the investigations. Liquid and gaseous transport fuels derived from a range of biomass sources are technically feasible. They include methanol, ethanol, dimethyl esters, pyrolytic oil, and distillate and biodiesel from (i) *Jatropha, Pongamia pinnata, Salvadora persica, Madhuca longifolia* and (ii) hydrocarbon from *Euphorbia* species. Biomass energy is experiencing a surge in interest in many parts of the world due to a greater recognition of its current role and future potential contribution as modern fuel in the world energy supply, its availability, versatility and sustainable nature; a better understanding of its global and local environmental benefits, perceived potential role in climate stabilization, the existing and potential development and entrepreneurial opportunities. Technological advances and knowledge which have recently accumulated on many aspects of biomass energy; e.g. greater understanding of the possible conflict of food versus fuel etc. A recent World Bank report concluded that "Energy policies will need to be as concerned about the supply and use of biofuels as they are about modern fuels (and) they must support ways to use bio-fuels more efficiently and in sustainable manner[32]. Biomass resources are potentially the world's largest and sustainable energy source a renewable resource comprising 220 billion oven dry tones (about 4500 EJ) of annual primary production. The annual bio-energy potential is about 2900 EJ though only 270 EJ could be considered available on a sustainable basis and at competitive prices. Most major energy scenarios recognize bio-energy as an important component in the future world's energy. Projections indicate the biomass energy use to the range of 85 EJ to 215 EJ in 2025 compared to the current global energy use of about 400 EJ of which 55 EJ are derived from biomass problems in global perspective[33]. A large number of hydrocarbon yielding plants are able to grow under semi-arid and arid conditions and they also produce valuable hydrocarbons (up to 30 % of dry matter) which could be converted into petroleum like substances and used as fossil fuel substitute. During the last 20 years investigations have been carried out on the optimization of yield and production of hydrocarbons by such plants at the 50 ha EPDPC of the University of Rajasthan, Jaipur, India. Their yield could be increased several fold making their commercial cultivation feasible[6].

Hydrocarbons from plants

Some of the laticiferous plants identified and were investigated in detail at Jaipur, India (Kumar[3,35,41] and review Kumar *et al*[34]). Certain potential plants were selected and attempts were made to develop proper agro technology for their large scale cultivation. Initially work was initiated at 5 ha and subsequently extended to the 50 ha EPDPC.

Methodology employed

Certain potential plants were selected and attempts were made to develop agro-technology for their large scale cultivation[36-42]. A 50 ha bio-energy plantation demonstration project center has been established on the campus of the Universityof Rajasthan to conduct the experiments on large scale cultivation of selected plants with theobjective of developing optimal conditions for their growth and productivity, besides conserving the biodiversity.

The work done included

i) Hydrocarbon yielding plants, ii) high molecular weight hydrocarbon yielding plants, (iii) non edible oil yielding plants

Hydrocarbon yielding plants included

1. *Euphorbia lathyris* Linn.,
2. *Euphorbia tirucalli* Linn.
3. *Euphorbia antisyphilitica,* Zucc.,
4. *Euphorbia caducifolia* Haines.
5. *Euphorbia neriifolia* Linn,
6. *Pedilanthus tithymalides*Linn,
7. *Calotropis procera* (Ait.) R.Br.,
8. *Calotropis gigantean* (Linn) R. Br.

High Molecular Weight Hydrocarbon Yielding Plants

Parthenium argentatum Linn.

Non edible oil yielding plants

1. *Jatropha curcas*
2. *Simmondsia chinenesis*

Considerable work has been carried out on these plants[6] Biofuel cultivation is good for wasteland development also.

Next generation biofuels

It is universal fact that only plants and biomass cultivation and biofuel production can result in greenhouse gas mitigation but at what cost? Now what alternatives could be suggested;

- Use of next generation biofuels includes use of lingo cellulosic waste material and agricultural wastes along with forest residue and also peat moss.
- Use of Algal biomass using long tubes of glass as has been done in Germany.
- Biotechnological advances on improving biomass production and conversion technology.
- Nano technology for biofuel production and synthetic biology.

The bio-oil consortium of the UK received huge grants (1.16 million pounds) to enable thecommercial production and testing of an integrated bio-oil and electricity generating plant. UK´s energy minister Peter Hain ascribed “high priority to research and development of sustainable energy sources”. Commercial processing plants for the medium scale production of biodiesel from inter-esterification of triglycerides have been developed in France, Germany (CARMEN), Austria (ENERGIA Biodiesel Technology) USA (Ensyn Group Inc.) and in the EU (Eubia).

Economic policies

Currently, governments in the U.S., E.U. and Brazil, as well as in lower income countries, have adopted a menu of biofuels support policies, such as producer tax incentives, national blending mandates and import tariffs[43]. The combination of ethanol tariffs, blending mandates and direct support to biofuel producers in the form of tax credits can, in some cases, lower both the prices of ethanol and the gasoline that it is blended with, thereby encouraging the consumption of fossil fuels[44].

Future projections

Given the numerous and high level of uncertainties regarding future bio fuel supply, demand, and technologies, the paper examines three alternative scenarios: a conventional scenario, which focuses on rapid global growth in biofuel production under conventional conversion technologies; a second generation scenario, which incorporates a ‘softening’ of demand on foodcrops due to 2nd generation, ligno-cellulosic technologies coming online; and a ‘second generation plus scenario’, which adds crop productivity improvements to the second generation scenario, which essentially further reduce potentially adverse impacts from expansion of bio fuels[6].

DISCUSSION

The modern discussion in the international community on the possible competition for land use between energy and food basically dates back to the 1970s, as a consequence of the adoption by some countries of alternative energy sources to petroleum. Among these initiatives to diversify national energy sources, perhaps the standout was Brazil’s Proalcool (Alcohol Program) for production of ethanol from sugarcane, which began in 1975 in response to the first oil shock. Despite some ups and downs depending on later oil price levels, this program laid the foundation for the country’s status as one of the two world’s leading producers and users of ethanol as a motor fuel (second only to the United States). In the United States, however, the option has also been for ethanol, although this initiative is more recent and limited in relative terms[45]. There, due to edapho-climatic factors, the preferred base crop is corn, which has a lower energy yield than sugarcane[46]. Currently, macro-economic assessments of the impact of biofuel expansion on income and welfare – and thus poverty reduction – are not well represented in the literature. This fact makes it difficult to predict the net welfare benefit that bio fuel production may have on job creation, export earnings, and fuel and food import bills. Further research into the effects on socio-economic welfare is needed in order to capture the agriculture–food security linkages[47]. But even if bio fuel production brings prosperity to the developing world, it is likely to bring prosperity to relatively few—the few who own the land and have the means to achieve large-scale production. There are several reasons for bio fuels to be considered as relevant technologies by both developing and industrialized countries. They include energy security reasons, environmental concerns, foreign exchange savings, and socioeconomic issues related to the rural sector. Biofuels are of rapidly growing interest for reasons of energy security, diversity, and sustainability benefits. Biofuels offer significant benefits for energy security. Biofuels also offer the promise of numerous benefits related to energy security, economics and the environment. Results from the analysis show a potential food and water-versus-fuel trade off if innovations and technology investments in crop productivity are slow and if reliance is placed solely on conventional feedstock conversion technologies to meet future blending requirements (or displacement) of fossil fuels with biofuels. This situation changes considerably with increased investments in bio fuel conversion and crop productivity improvements. To mitigate potentially adverse impacts from aggressive increases in biofuel production therefore requires a renewed focus of crop breeding for productivity improvement in wheat, maize and even sugar crops. While some crops may be more favorable from the perspective of profitability, they may encounter

binding environmental constraints, in particular water, for example, for sugarcane in
India and wheat or maize in Northern China. And even where water might be available, other natural resource constraints, such as land availability can constrain expansion, such as in Southern China. Impacts of global bio fuel development and growth on rural poor can be both positive andnegative. Biofuel crops do not necessarily crowd out food crops, at least not under the alternative Scenarios examined here. Instead there is room for complementarities and synergy and rural agricultural development and socioeconomic growth can go hand-in-hand with enhancement of bio energy production capacity. The prices of feedstock crops – which comprise the largest share of biofuel production costs – are also subject to fluctuations in increasingly volatile and tight global agricultural markets. Rising world fuel prices, the growing demand for energy and concerns about global warming are the key factors driving renewed interest in renewable energy sources and in bio energy, in particular. Henry Ford's seemingly prescient outlook is thus becoming much more relevant 80 years on. Within a global context, fossil fuel consumption still dominates the world energy market.

CONCLUSIONS

It has been our goal to provide a broader examination of the tradeoffs concerning welfare and food security related to biofuel development, especially when pursued in food insecure regions. In order to assist with sector development that maximizes welfare gains, we have suggested some useful indicators that might be used in classifying what types of biofuels uses might be best suited for different countries – depending on where the bulk of their energy needs lie, and what their human welfare status is, with respect to hunger, in particular.

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